UNIVERSITY OF CAPE COAST

NUTRITIONAL COMPOSITION AND CONSUMER ACCEPTABILITY OF AFRICAN LOCUST BEANS FRUIT PULP BISCUITS IN WA MUNICIPALITY

MATILDA LENIA

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BY

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Thesis submitted to the Department of Vocational and Technical Education of the College of Education Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Master of Philosophy degree in Home Economics

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: .... Date: ....

Name: Matilda Lenia

Supervisors' Declaration

I hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Supervisor's Signature: .... Date: ....

Name: Prof. Jacob Setorglo

ABSTRACT

The African locust bean (*Parkia biglobosa*) is one of the most important and common trees of the legume species in Northern Ghana. The study was performed to determine the nutritional composition of the Parkia pulp flour mixture. The Parkia pulp flour was obtained from the sweet yellow fruit pulp of *Parkia biglobosa*. Flour and biscuits were formulated from ratios of 100, 50:50, 75:25 and 25:75 for wheat and African locust pulp flour, respectively, with flour and biscuit from 100% wheat used as the control sample. Samples were analysed for their proximate composition. Proximate composition of flour indicated that dietary protein (12%), fibre (6.2%), dry matter (92.59%) and ash (1.9%) was higher in locust pulp flour compared to the control sample except for fat and oil. Minerals such as phosphorus (1678 µg/g), calcium (0.975 µg/g) and sodium (974.6 µg/g) were high in locust pulp flour compared to control sample. Similarly, the composite biscuit had higher nutrient composition compared to the control sample. The nutrients were significantly ($p < 0.001$) high for sample 25/75 compared to the control and 50/50 and 75/25. Mineral content was significantly ($p< 0.001$) different among composite biscuits. Phosphorus, calcium, sodium, and magnesium content increased with increased locust pulp flour, with sample 25/75 recorded the highest mineral content. The overall acceptability was higher for sample 25/75 (25% flour and 75% pulp flour) although all treatments and control were comparable to each other. Biscuits from Parkia pulp flour enhanced the sensory characteristics of the products.

Keywords: African locust bean, nutrient composition, proximate analysis.

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DEDICATION

This work is dedicated to my Children: Miriam Baawerapuo, Danita Sungbawiera Baba, Darryl Kaasung Baba, Deston Sungkaa Baba, and Lenia's family who eagerly waited for this achievement.

TABLE OF CONTENTS

Content **Page**

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

Background to the Study

Food is a thing that can be eaten so that it will supply nutritional support to the body for growth and development (Meyer-Rochow, Gahukar, Ghosh, & Jung, 2021). United States Food and Drugs authority (2017), has defined food as a substance that is edible such as products in ice form, beverages, or component which individuals consume or planned for sale in whole or in part including chewing gum. Food, therefore, has varied meaning and definitions since it can give the consumer some sort of satisfaction to the hunger of the individual concerned.

Nutrition in general is studying the impact of food and drink on living things and the nutrients that are found in such foods. Feeding is essential since it is the normal or usual way foods and drinks are taken into the body to assimilate nutrients into the living tissues. Nutrition therefore cannot be done away with when it comes to growth and healthy living. Nutrition in humans is to help an individual grow and get the needed energy to function in his/her environment. Proper feeding is therefore non-negotiable for humans and other living creatures.

Optimal nutrition is necessary for human development and economic progress. Malnutrition, on the other hand, remains a public health issue in low- and middle-income nations, such as Ghana (Saaka, Larbi, Hoeschle-Zeledon, & Appiah, 2015). Human nutrition in most cases, does come with diseases when not properly handled. According to Willet (2007), due to the high prevalence of food diseases, consumers are becoming more sceptical about what they consume and how to consume a particular food to avoid illnesses.

Nutrients are available in meals in various forms and degrees, and consuming foods that lack these nutrients leads to malnutrition. Malnutrition is described as a cellular imbalance between the body's demand for nutrients and energy for growth, maintenance, and specific functions, and the body's supply of those nutrients and energy (Tierney, Sage & Shwayder, 2010). Malnourished individuals can therefore not function well in society given the challenges they would be confronted with. Malnutrition can lead to negative economic situations for the individual, family, community, and even nation.

The greatest and most common form of malnutrition is Protein-energy malnutrition in Africa which has affected over 100 million of the population and an estimated number of 30 to 50 million people among below 5years of age (Jildeh, Papandreou, Mourad, Hatzis, Kafatos, Qasrawi, hilalithis & Abdeen, 2011). Protein deficiency is also a Ghanaian problem since it is part of the African continent, and some of her citizens may not be in the position to eat a balanced diet which comes with a cost. A study indicated that malnutrition is prevalent among children and pregnant women in Ghana (USAID, 2018). The study further showed the relationship between malnutrition and the country's economy (USAID, 2018).

Protein is gotten from animals and plants sources, and protein from either source provides what the body needs to function well.

The protein intake from diet of the population can be elevated through an important wide range of essential protein sources such as bean, soybean, and peanut. However, people within the low-income areas, particularly in rural areas, usually find it difficult to afford these protein foods (Dahouenon-Ahoussi, Adjou, Lozes, Yehouenou, Hounye, Famy, Soumanou, Sohounhloue, 2012).

Although legumes are eaten all around the world, they are especially popular developing country countries like Ghana, where animal protein consumption is limited owing to economic, societal, and cultural considerations (Byga & Balslev, 2001). A lot more people could be consuming legumes for their protein supplements in view of its cost and fat/oil content in the animal base. In the case of Ghana, legumes might be consumed more because it abounds and are less expensive to buy.

According to Maroyi and Cheikhyoussef (2017), a large proportion of resource poor rural households in southern African communal areas are dependent on wild edible fruits to meet part of their daily nutritional needs In the case of Ghana, and the Upper West region in particular, the citizens make use of wild fruits and herbs as part of their diets. Wild edible fruits consumption was found to be underutilized, and this has called for concern to many stakeholders in health and research. Essential eatable wild fruits are vital to human nutrition, and their importance cannot be overstated in terms of optimum health, food security, and income generation (Aworh, 2015; Bvenura & Sivakumar, 2017).

Studies are pointing to the fact that wild fruits have the potency of curing multiple disorders that relate to blood circulation, digestion and urinary tract disorders because of their rich fiber and antioxidant components (Alissa & Ferns, 2017; Egea, Sánchez-bel & Romojaro, 2010; Shaheen, Ahmad & Haroon, 2017). This is why health practitioners keep encouraging their clients to take more fruits in view of their usefulness to the human system when fruits are consumed.

The United Nations' Food and Agricultural Organization (FAO) has endorsed the use of biodiversity for nutrition and agriculture as a method to improve dietary diversity (Bach-Faig et al., 2011; Burlingame, Charrondiere, Dernini, Stadlmayr, Mondovì, 2012; Charrondière, Stadlmayr, Rittenschober, Mouille, Nilsson, Medhammar, Olango, Eisenwagen, Persijn, Ebanks, et al. 2013).

The African locus bean tree, parkia biglobosa, is an important leguminous plant that may be found in many West African countries and is still one of Northern Ghana's most popular trees (Zakari, Hassan & Ndife, 2015). The African locust beans pulp taste sweet and that is the indication of the presence of natural sugars as well as potential energy source (Sackey & Kwaw, 2013). The yellow colour is believed to be due to the presence of carotenoids which is a phytonutrients and vital antecedents of retinol (Vitamin A).

Parkia biglobosa contains very rich source of Vitamin C (ascorbic acid) (Akoma, Akinsulire & Sanyaolu, 2001). The bean contains about 67.3% carbohydrate which is a good source of getting energy for the body. *Parkia biglobosa* also has an appreciable source of dietary fibre, which makes it vital in preventing no communicable diseases including obesity, diabetes and cancer of the colon (Sackey & Kwaw, 2013).

The macronutrients and micronutrients in the fruit pulp are abundant. It is high in easily digestible carbohydrates and natural sugars (Gernah et al., 2007), which contribute to its sweet flavour, dietary fibre, vitamins, and minerals. Despite its importance, commercial use and knowledge on *Parkia biglobosa* fruit pulp exploitation are limited, aside from its application in cooking local delicacies (Adeloye & Agboola, 2020). As a result, the yellow pulp of African locust beans has been underutilized, with just a few uses for porridge and fresh meals (CampbellPlatt, 1980).

In the Upper West Region, fruits of different kinds do exist and are consumed. The use and benefits of the fruits also differ. The consumption of wild fruits for its benefits often depends on the availability of the fruits to the consumer eg it availability in markets and shops in the city. The challenge of the fruits not being close to the consumers in the urban areas could be resolved by making them available from the hinterland. Also transforming some of them into new products such as biscuits and drinks. Africa is blessed with a lot of wild fruits and cereals.

Biscuits are a type of confectionary with a low water activity and a long shelf life. Biscuits, as a baked product, are widely used as a snack food item by both children and adults worldwide, particularly in poor nations (Florence et al., 2014). If made available in the population, they can be served as a source of important nutrients. (Florence et al., 2014). As a result, biscuits are valued for their nutritional value, palatability, compactness, and ease of use. There are so varieties of biscuits available on the market. Biscuits available or sold in Ghana mostly made from wheat and white, devoid of critical amino acids such as lysine, tryptophan, and threonine (Golden & Williams, 2001). However, when biscuit flour is supplemented with locust pulp, the nutritional quality of baked goods such as biscuits may be improved. Composite flour is made up of non-wheat flour concentrations derived from grains, legumes, roots, and tubers, or a mix of non-wheat flours.

Composite flours have a lot of advantages because it is supplemented with some essential amino acids (lysine, tryptophan and threonine) in the flour from other sources which is deficient in the wheat flour with (Ikuomola et al., 2017). Hence it is seen as enhancing or complementing the nutritional and functional properties of the juice when two or more flour are blended. Consumption of underutilized local fruit will significantly improve when they are incorporated into popular recipe it is combined with a popular recipe. This can clearly be seen in the case of initiating the legume seeds and other cereals due to the high cost of some type of protein like the animal protein its economic value (Sadik, 2020). Despite the African locust bean's inherent potentials, there is inadequate knowledge on its use in many culinary formulations. Organizations like the Food and Agricultural Organization (FAO) and the United Nations Refugee Feeding Programs have pushed for a strategic increase in the use of low-cost local commodities (Awogbenja & Ndife, 2012).

In order to address the issue of poor nutrition in developing countries, it will be necessary to mix fruit pulp flour of African locust beans into a prepackaged cooked snack, such as biscuits, which are primarily prepared with wheat flour, which is deficient in certain essential amino acids such as lysine, tryptophan, and threonine (Golden & Williams, 2001).

Problem Statement

Biscuit consumption of late seemed to be associated with children given its taste and how handy it is. However, in recent times, both adults and children consume biscuits at least twice a week. In preparing biscuit, the ingredients are obtained from the environment. The demand for biscuits, perhaps worldwide, is putting pressure on the environment.

The environment, agricultural land, water resources, fish and meat supply, biodiversity, and nutrient requirements are all projected to face increased strain. (Awobusuyi et al., 2020). This indicates an urgent need to reassess some approaches to obtaining nutrients that are unconventional, especially protein (Durst et al., 2010).

Food insecurity has been identified as a major underlying issue to nutritional status of the poor of the population of northern Ghana. The most affected regions that have food insecurity, according to World Food Programme (2016a), include Upper East, Upper West, Northern, Brong Ahafo, and Volta region. The study further found that 16 per cent of households in the identified regions were severely confronted with food insecurity. Food insecurity is defined as a family's inability to produce enough food to meet basic needs due to poor soil quality, harsh weather, restricted input availability, and a lack of financial means to boost production (World Food Programme, 2016).

According to Doku and Neupane (2015), Ghana had been found as one of the developing countries experiencing malnutrition and a high prevalence of undernutrition. The study had made it clear that overweight/obesity comes along with the nation's challenges in nutrition. Food security and its nutritional influence on the citizens is still on the issue that needs to be address.

According to USAID (2018), nutrition low nutrition of food is linked to economic factors, which are more prevalent in the Northern Region of Ghana. Therefore, improving nutrition in the Northern Region is very necessary to the individuals and the nation as a whole. To improve the nutritional needs of the people, many measures need to be undertaken. One of such measures is to use underutilised nutrition natural plants and animal’s products in the locality to alleviate the issue of malnutrition in the area.

Humans' use of fruits in general helps protect the body from minor diseases, which really does not need medication to resolve it. Also, it is generally known that /regularly helps fruits to improve the skin of consumers. According to Paravina (2018), paying much attention to a particular food for its nutrients, protein and vitamins would benefit individuals' skin. The consumption of fruits that give vitamins and other nutrients to the body does not necessarily satisfy hunger but to care for the skin.

Many legumes, such as soybean, bean, and peanut, are high in protein and can thus help people get more protein in their diet. Low-income people, especially those in rural areas, may not be able to buy these protein sources (Dahouenon-Ahoussi et al., 2012). African locust bean (*Parkia biglobosa*) is a leguminous tree species common in Northern Ghana (Zakari et al., 2015), and is primarily utilised as a cheap source of protein. However, information about the commercial applications and exploitation of the fruit pulp is lacking except for the purposes of local dish preparation. (Adeloye & Agboola, 2020).

While African locust bean seeds are popular and research on them has increased, little attention has been paid to the yellow powdery fruit pulp, which is often is washed off during processing despite being an excellent source of macronutrients and micronutrients (Adeloye & Agboola, 2020). The African locust bean pulp is edible and non-toxic, it is eaten raw or used in making local drinks and sometimes as sweeteners in beverages. It is very rich in vitamin C, with a value of 200mg/100g (Akoma et al., 2001; Muller, 1988). There are yellow pigments within this plant, possibly carotenoids, precursors to retinol (vitamin A) (Gernah et al., 2007).

Given its readily availability, nutrition and health benefits, African locust pulp flour must be incorporated into most of the food products, such as biscuits. Several workers have experimented with using composite flours to increase and improve the protein content of bread, cakes, buns, and biscuits. Furthermore, a number of scientists have concentrated their efforts on composite flour for biscuits, buns, cakes, and bread (Ikuomola et al., 2017).

African locust pulp flour as composite flour in preparing cookies to improve their nutritional value was therefore carried out to determine the nutritional quality and consumer acceptance of biscuits prepared from African locust beans pulp powder composite flour.

General Objective

The study's main objective was to assess the nutritional composition and consumer acceptability of African locust beans fruit pulp biscuits in Wa Municipality.

Specific Objectives

Specifically, the research sought to:

1. determine the nutritional composition of African locust bean pulp powder composite biscuits
2. formulate composite biscuits from African locust beans pulp
3. assess consumer acceptance of composite biscuits

Significance of the Study

To address consumers' increased needs for high-quality, organic, and nutrient-dense foods, food manufacturers must develop new nutritious and low-cost foods (Gernah et al., 2007). Combining underutilized local fruits with popular recipes will provide consumers with the nutrition they crave. Thus, the malnutrition issue of most developing countries could be addressed if composite flour is used to boost and improve the protein level of bread, cakes, and biscuits. Supplementation of wheat flour with locust fruit pulp powder could improve the quality of nutrition of baked products and bring diversity into baked products on the market.

The use of locust fruit pulp powder would significantly reduce the importation and dependency on imported wheat flour, create variety and increase the utilisation of pulp. Additionally, knowledge about diverse uses of parkia as well as the role it plays during in achieving food security during grain shortage will be of paramount importance in the phase of feeding ever increasing human population hence, commercialization, in turn, will boost their promotion. (Gernah et al. 2007). Results from this study would provide fundamental knowledge which will provide information on solving the nutritional requirements of people more particularly children in low endowed areas of Northern part of Ghana. Furthermore, results from the study would serve as a benchmark for future nutritional studies as well as creating new jobs opportunities in the future.

Delimitation

The study focused on assessing the nutritional and proximate composition of parkia and sensory evaluation of African locust beans fruit pulp within the Wa municipality. The study was limited to staff and students of the Wa Senior High School.

Limitation of the Study

The study focused on the Wa municipal of Ghana, making it difficult to generalise the study results for the entire country. Accessibility of the main raw material, African locust pulp, had delayed the data collection by six months since the fruit was a seasonal one, and the tree only fruit in August-September every year. Although these challenges were obvious, it was difficult to control the delay in the data collection process. However, none of the limitations that have been encountered did affect the result in any way.

Organisation of the Study

The research was broken down into five sections. The study background, research topic, significance, and general and specific aims were all described in the first chapter. The study's second chapter examines the literature on the subject at hand. In chapter three, the study's materials and methodology are described in detail. This chapter gives a detailed description of the research design, study area, method of flour preparation and blending, sampling procedures adopted for the study, instrumentation for data collection, protocols for proximate analysis and statistical analysis used for the study. Results and discussion of study outcome are presented in chapter four. Finally, in chapter five, the important results, conclusions, and applicable recommendations based on the findings of this study are summarized.

Chapter Summary

The chapter describes the scope and magnitude of malnutrition among Ghanaians. Additionally, the chapter highlighted the role leguminous plants play in solving poor nutritional problems highlighting the nutritional and health importance of *parkia* despite its limited consumption as a source of flour in Northern Ghana. The chapter highlighted the role *parkia* flour will play in solving malnutrition among people in Northern Ghana when used as flour to prepare confectionery such as biscuits since it is mostly consumed among various age groups.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter of the thesis discusses the appropriate theoretical and empirical literature available for the study. The literature reviewed covered themes like the origin of the African locust bean, use of parkia pulp, physicochemical properties of parkia pulp, physicochemical properties of Parkia Pulp, wheat and nutritional composition of wheat flour and dietary fibre. Other areas the literature covered include the importance of fortification of food, the effect of composition on physicochemical properties, baking of biscuits, changes that occur during the baking of flour mixtures, Kneading and forming of biscuits and sensory evaluation of food.

Origin and distribution of African locust bean

The African locust bean tree (*Parkia Biglobosa*) is a perennial tree in the Leguminosae family that belongs to the mimosodee subfamily. Leguminosae has been renamed fabaceae (Akande, dejumo, Adamade & Bodunde, 2010). In the savannah region of West Africa, locust bean trees grow in populations of two or more despites not being commonly cultivated (Teklehaimanot, 2004). There are two or more trees of this species in Nigeria's savannah region where it's commonly cultivated (Schnell, 1957).

This tree is usually farmed, however in Nigeria's savannah region, it can be found in groups of two or more (Schnell, 1957). Locust bean trees can be found in the Senegal region through Sudan (Dalziel, 1963; Keay, 1989). The trees mainly inhabit savannah lands and are found in Sahelian and eco-zones around Sudan. All these areas where the trees are found are local farmlands, and the farmers leave the trees knowing their economic importance.

In North Central Nigeria, locust beans can be found in Benue, Kaduna, Kwara, Kogi, Nassarawa and Plateau States (Tee, Ogwuche & Ikyaagba, 2009). African locust bean tree is also found in the Northern part of Ghana and some other areas where the forest cover does not exist.

According to available material on the African locust bean tree, it can live for up to 30 years and still give fruit. Quansah, Mahunu, Tahir, and Mariod (2019) has reported that the tree can give fruit five to seven years after it is planted. The tree can reach a height of 7 to 20 metres and produces pods in huge bunches that range in length from 120 to 300 mm. Every year, from December to March, the African locust bean tree bears fruit. The African locust bean tree is shown in Figure 1.

Figure 1: African locust bean tree with fruits. Source: (Lenai, 2021).

Use of Parkia pulp

Parkia trees play a vital ecological role in nutrient recycling from deep soils by holding soil particles together with their roots to prevent soil erosion. Farmers benefit from the shade provided by the trees (Campbell-Platt, 1980). Pestles, mortars, bows, hoe handles, and seats are all made from the Parkia tree (Howariot Hagos, 1962). The fruit can be used to produce a variety of stews, soups, and sausages for cereals that are baked and saved for later use, or it can be used to make several traditional drinks (Muller, 1988). The fruit pulp is employed in rural Africa during emergencies, toxicity (Akoma et al., 2001) when grain reserves are empty, suggesting its edibility, according to the literature.

According to Ikhimalo (2019), the fruits of African locust bean was mostly regarded as a condiment. However, further study to explore the use and benefits of the fruits had shown that the fruits serve more purposes than what it was formally thought. African locust bean is useful for diverse issues across medication and other uses. The fruit and trees are used as a genital wash to cure urinary tract infections, as a supplement to infant food formulae, as a mosquito repellant, to manage obesity, and to treat asthma (Ikhimalo, 2019). The fruit tree has anti-inflammatory, and wound healing properties including antibacterial, probiotic, hepatoprotective, antidiabetic, and antihypertensive, as a binder and thickening, pesticide and herbicide (Ikhimalo, 2019).

Animals also need to be fed to grow well for humans to consume for their protein needs. However, due to the cost of rearing animals for protein source. Some farmers now focus on using several potential leguminous vegetable protein sources for human usage due to the high cost of animals (Esenwah & Ikenebomeh, 2008). Grain legumes are a major source of dietary protein among plant species. Dietary protein helps in digestion and free bowel movement hence less constipation. However, animal protein is known in the literature to have many side effects (Chen, Xu, Zhang & Wang, 2018).

Dawadawa is made from fermented African locust bean seeds, which are abundant in protein, a delightful food condiment that adds protein to protein-deficient diets and enhances the flavor of soups and stews (Ikenebomeh & Kok, 1984; Odunfa, 1986; Dike & Odunfa, 2003). The seeds of the African locust bean are used for a variety of purposes. The pods, fruit pulp, and leaves are all edible and can be utilized in cooking or drinks. The tree's seeds, which can ferment, are particularly valuable. They are fermented to make a condiment known as "soumbala," "dawadawa," "netetu," or "afinti," which has a pungent flavor similar to French cheese (Heuzé, Thiollet, Tran, Edouard, & Lebas, 2019). The condiment made from the seed of the African locust bean tree abounds mostly in the local areas where the trees are found.

Physicochemical properties of Parkia Pulp

Nutritional composition

Protein insufficiency in diet caused by the high cost of animal protein may readily be replaced with a plant legume made from Parkia pulp in areas where the fruits are available. According to Koura *et al*., (2011), plant sources could supply not only low-priced and alternative sources of protein but other nutrients required by man through foods that are consumed. The seeds of Africa locust bean could supplement the protein need for persons with protein deficiency to make up for the loss in poor diet Koura *et al*., (2011).

Minerals such as calcium, iron, magnesium, sodium, copper, potassium, phosphorus, manganese, and zinc have been found in African locust beans (Ogunyinka et al. 2017; Oluwaniyi & Bazambo, 2016; Ijarotimi and Kashinaro, 2012). It has been shown that the African locust bean is a good source of macronutrients, vitamins A and C, and carotenoids (Marcel et al., 2015; Dahouenon-Ahoussi et al., 2012).

African locust bean was studied to determine its nutritional composition and the result showed several nutrients. Moisture content was 8.41%, protein was 6.56 percent, fat was 1.80 percent, crude fiber was 11.75 percent, ash was 4.18 percent, and carbohydrate was 67.30 percent. Total carotenoids were determined to be 49,175ug/100g, and ascorbic acid (Vitamin C) was found to be 191.20mg/100g (Gernah et al., 2007). A comparable study showed that the African locust bean pulp and seeds contain vitamins B, C, D, and E. (Termote, Odongo, Dreyer, Guissou, Parkouda & Vinceti, 2020).

The bright yellow colour of African locust bean pulp indicates the presence of phytonutrients, most likely carotenoids, which are key retinol precursors (vitamin A). When unripe, it has a sour taste, indicating that it contains ascorbic acid (vitamin C) (Gernah et al., 2007). The carbohydrate content of powdered fruit pulp is higher than that of seeds, including primary reducing sugars, non-reducing sugars, and extra complex carbohydrate. According to Gernah et al. (2007), the fruit pulp contains 67.3 percent carbohydrate, which is equivalent to lentils and Bambara nuts, both of which have 65.0 percent carbohydrate (Muller, 1988). Parkia fruit pulp had a sugar content of 4.27 mg/g, a starch content of 151.88 mg/g, and a protein level of 5.25 mg/g, according to Bello et al. (2008).

Parkia fruit pulp has a vitamin C level of 191.20ug/100g, according to Gernah et al. (2007), while locust bean yellow pulp has a value of 200mg/100g, according to Muller (1988). Vitamin C is abundant in fruits and vegetables, which provide the majority of the daily consumption for the average person in underdeveloped nations (Falade et al., 2004). Parkia fruit pulp has a vitamin C concentration of 215mg/100g, according to Bello et al. (2008). When compared to the daily requirement of 30mg/65kg bodyweight adult human, the seed contains 191.20ug/100g of vitamin C (ascorbic acid), which is more than the most widely consumed meals and acceptable when compared to the daily requirement of 30mg/65kg bodyweight adult human (Olson, 1987). Collagen formation, iron absorption, and glucocorticoid biosynthesis all require vitamin C.

Chemical properties

Sugar functions as a preservative by preventing bacteria from gaining access to water when it is present in large amounts in food. It's a quick source of energy because it's digested and absorbed faster than other complex carbs (Gernah et al., 2007). The pH of 5.22 indicates that the African locust bean fruit pulp is a somewhat acidic dietary item, implying that enzymes and microbiological activities are suppressed to some extent, influencing protein stability positively (Gernah et al., 2007). They also reported an amount of 49.175jul/100g carotenoids is contained in Parkia pulp. In the small intestine, carotene is converted to retinol (vitamin A), and its colour makes meals more appealing to the eye.

This concentration of carotenoids means that the Parkia fruit is a potential source of vitamin A, given that the daily need for adult humans is 750ug/100g/65kg. Muller (Muller, 1988). The pulp of the African locust bean was found to possess 7.96 percent crude protein, 2.56 percent crude fat, 6.97 percent crude fibre, 2.69 percent ash, 7.14 percent moisture, and 72.68 percent carbohydrate, by Arinola, Oje and Omowaye-Taiwo (2019). The study of Arinola, et al. (2019) further found that the pulp had 4.1 pH, 4.98g/g swelling power, 4.80ml/g water absorption capacity, 2.40ml/g oil absorption capacity, 8.00% least gelation concentration, 1.22 mins wettability and 0.36g/ml bulk density of the pulp.

Insufficient peak viscosity (85cP), trough viscosity (80cP), and end viscosity (122cP) were found in the pulp, by indicating low starch content and a poor pasting profile. Phytochemical examination revealed the presence of tannin (5.53 mg/g), flavonoid (4.72 mg/g), steroid (18.37 mg/g), terpenoid (10.35 mg/g), alkaloid (45.02 percent), and cardiac glycosides (8.22 mg/g). The findings show that African locust bean pulp could be used as a food and functional material in the food processing industry. The chemical composition of Parkia pulp, according to Bello et al., (2008); Kwari and Igwebuike (2002) is presented in Table 1.

Table 1: Chemical composition of Parkia Pulp

Nutrient	%	g/100g
Dry matter	88.70	96.00
Crude protein	6.70	5.688
Ether extract	3.00	18
Crude fibre	8.00	12.00
NFE	58.00	68.75
Total ash	3.00	4.00
ME/Kcal/kg	3079.14	3496.42

Source: (Bello et al., 2008; Kwari & Igwebuike, 2002). Where, NFE = Nitrogen Free Extract and ME = Metabolizable Energy

Anti-nutritional factors of Parkia pulp

According to a study on nutritional composition, a phytic acid composition of 60.00mg/l00g is the appropriate level of anti-nutrient (Gernah et al., 2012). Parkia pulp has a phytic acid concentration of 60.00mg/100g, according to Gernah et al. (2007). In human volunteers administered 2.00g of phytate, McCance and Widdowson (1935) found no impact save that up to 50% of dietary phytate phosphorus was rendered inaccessible to the body and was excreted unchanged. Parkia fruit pulp was found to have 0.20 mg/g Phytate, according to Bello et al. (2008). The problem with phytic acid in foods is that it can bind to a variety of key mineral elements in the digestive tract, resulting in mineral deficiency. The bioavailability of minerals in monogastric animals is lowered when they eat a high-phytate diet for a long time by Thompson (1993).

Calcium, zinc, manganese, iron, and magnesium are among the minerals that are transformed to indigestible phytic complexes, decreasing their bioavailability for absorption. Because non-ruminant animals lack the inherent phytase required to hydrolyse the phytic acid complex, phytic acids have a deleterious impact on amino acid digestibility. The presence of phytic acids, on the other hand, is beneficial since it may serve as an anti-oxidant and anti-cancer agent in the diet (Turner et al., 2002).

Because of the presence of phytate, a naturally occurring chemical, plant phosphorus supplies are limited. It has about two-thirds the phosphorus of cereal grain and soybean meal, both of which are important parts of the poultry diet. Phosphorus and other minerals that interact with phytic acid become unavailable in people, birds, and pigs, as has been demonstrated (Thompson, 1993). Parkia pulp has a saponin content of 17.80 mg/100 g, according to Gernah et al. (2007), which may contribute to the fruit pulp's foaming properties. Lima beans had a value of 24.50mg/100g and millet had a value of 19.47mg/100g according to Osagie and Eka (1998). Although saponin has been found to be very poisonous in laboratory settings, acute poisoning in humans and animals is uncommon (Tannenbaum, 1979). Anti-nutritional factors/toxins analysis of parkia pulps revealed phytic acid content of 60.00mg/100g, crude saponins of 17.80mg/100g, tannins of 81.00mg/100g, total phenols of 204.60mg/100g, and hydrocyanic acid (HCN) content of 17.30mg/100g (Gernah et al., 2007). When ripe, the African locust bean pulp tastes sweet, indicating natural sugars and hence a possible energy source.

Gernah et al. (2007). found an 81.00mg/s100g concentration of tannin in Parkia fruit pulp. According to Osagie and Eka (1998), several regularly consumed legumes, such as lima beans and pigeon pea (100.00mg/100g), have a tannin content of 140.00mg/100g (1998). Fruits contain tannins, which have an astringent flavour that inhibits food intake and, as a result, body growth. Tannins are known to inhibit digestive enzyme activity, and their nutritional effects are mostly dictated by how they interact with protein. Tannin-protein complexes are insoluble, and they impede protein digestion (Carnovale et al., 1990).

Parkia fruit pulp has a tannin concentration of 1.08 mg/g, according to Bello et al. (2008). Excess tannin in the diet reduces protein and carbohydrate digestibility, reducing growth, feeding efficiency, metabolisable energy, and amino acid bioavailability, according to a study (Aletor, 1993). In terms of medicine, polyphenols, which include tannins, have been found to act as antioxidants by preventing oxidative stress, which has been associated to diseases such as coronary heart disease, cancer, and inflammation (Tapiero et al., 2002).

Dietary tannins reduced protein digestion and energy usage, lowering daily weight growth and diminishing feed efficiency according to Gernah et al. (2007). Parkia fruit has a total phenol concentration of 204.60 mg/100 g, according to Gernah et al. (2007). Lima beans, on the other hand, have a phenol level of 12160.00mg/100g according to Osagie (1998). Gernah et al. (2007) reported that, parkia fruit pulp contained 17.30mg/100g of hydrocyanic acid. According to Osagie (1998), a deadly dose of hydrocyanic acid for men is 50-

60mg/kg body weight/day. According to Bello et al. (2008) found trypsin inhibitor concentration in Parkia fruit pulp was determined to be 15.55TIU/g.

Rats, chickens, and other experimental animals have been known to grow slower when trypsin inhibitor is added in raw animal feed for a long time (Omoruyi et al., 2007). Trypsin inhibitor, which is heat labile, can be inactivated by heat treatment such as steaming or extrusion frying (Liener, 1994). Oxalate is a subject for worry because of its negative impact on mineral availability. An increased risk of renal calcium absorption and kidney stones have been linked to a high-oxalate diet (Chai & Liebman, 2004). Parkia fruit has an oxalate concentration of 0.093g/100, according to Bello et al. (2008). According to Munro and Bassir (1969), the danger of oxalate poisoning from eating native fruits and vegetables in Nigeriais as low compared to other parts of the world. Spinach with 19.72g/100g Oxalate can only be toxic if there is a calcium oxalate interaction in the body.

Parkia fruit pulp has a high calcium concentration of 11650mg/kg, according to Bello et al (2008). The recommendation daily calcium intake recommendation is 800mg (FNB, 1974), hence 68g dry weight of Parkia pulp fruit would meet this requirement. They also indicated that, the magnesium content of Parkia fruit pulp is 7000mg/kg (2008). Magnesium helps asthma patients breathe easier by relaxing the muscles that run along the airways to the lungs. Magnesium deficiency in human's results in severe diarrhoea, headaches, hypertension, cardiomyopathy, arteriosclerosis, and stroke, and it is thought to be required for the structural integrity of nucleic acid intestinal absorption (Appel, 1999).

Bello et al. (2008) found parkia fruit pulp to have a potassium content of 3945 mg/kg, a sodium content of 1795 mg/kg, and a manganese level of 661.56 mg/kg (2008). Manganese is important in energy synthesis and cell reproduction, as well as immune system support and blood sugar regulation. It aids blood coagulation by collaborating with vitamin K. Manganese can help with stress management when paired with B-complex vitamins. If a pregnant mother does not acquire enough of this essential nutrient, birth abnormalities might occur (Anhwange et al., 2004).

The study of Bello et al. (2008) reported the iron content of parkia fruit pulp to be 1814 mg/kg Iron is said to be crucial in the diets of expectant women, nursing mothers, children with convulsions, and the aged in order to prevent anaemia and other health issues. According to Bello et al. (2008) the zinc content of Parkia fruit pulp is 437.52 mg/kg. Zinc is required for the synthesis of proteins and nucleic acids, as well as normal bodily development. It is required for growth and development, especially during periods of fast growth such as childhood, puberty, and the recovery from sickness. Zinc deficiency has been associated with excessive phytic acid levels in meals, which has been connected to poor growth, immunity, and death (Umeta et al., 2005).

Bello et al. (2008) found parkia fruit pulp to have copper content of 447.48 mg/kg Copper deficiency has been linked to heart disease, anaemia, and bone and nervous system disorders (Mielcarz et al., 1997). According to Reddy and Love (1999) these important components are required for growth, such as the production of bones, teeth, hair, blood, nerves, skin, vitamins, enzymes, and hormones. Neuronal transmission, blood circulation, fluid management, cellular integrity, energy production, and muscular contraction are all governed by important components, with too little of any key element causing disease and too much of any necessary element posing a risk.

Wheat (*Triticum aestivum* L)

Wheat is a grass that is frequently farmed for its seed, and the genus 'Triticum' contains many species. It is a cereal grain that is utilized as a staple food all across the world (Isitor et al., 1990; Olabanji et al., 2004). Wheat emerged from wild grasses, and its origins were thought to be in the Tegri-Euphatis drainage basin in South Asia. Depending on the variety of wheat grown, harvesting might take anywhere from 60 to 150 days. Figure 2 shows a wheat field.

Figure 2: Field growing wheat. Source: (Shewry & Hey, 2015)

Wheat is the most widely grown grain crop in the world, covering around 237 million hectares each year and yielding 420 million tonnes (Isitor et al., 1990; Langer & Hill, 1991; Olabanji et al., 2004). At least one-fifth of all calories absorbed by humans comes from wheat (Shewry & Hey, 2015).

Wheat is a cereal that comes in a variety of varieties. Taylor et al, (2005) created six classifications based on distinct genetic traits in order to make studying and comprehending the attributes of cereals easier. Hard Red Winter, Hard Red Spring, Soft White, Soft Red, Durum, and Hard White were the classifications. Kusuma (2015), for example, has identified three varieties of wheat that are extensively used in the world for bread, biscuits, and pizza, among other things.

There are many different varieties of wheat (*T. Aestium*), Soft Wheat (*T. Compactum*) and Durum Wheat (*T. Drum*). Hard Wheat (*T. Aestium*) contains 12-18% of protein and has a brown peel and tough seed. Hard Wheat is good at absorbing high among of water. In view of the particular nature of this wheat, it is the most preferred variety for baking bread, croissants and pizza (Kusuma, 2015). A photo of the Hard Wheat is in Figure 3.

Figure 3:Hard wheat Source: (Shewry & Hey, 2015)

Soft Wheat or *T. Compactum* contains a lower protein content (7-12%) than hard wheat. Thus, the gluten content of soft wheat flour is also lower. The seed is soft and white and red colour. The flour from soft wheat is suitable for making cake, because the dough produced from it has low of absorbent water level (Kholipah, 2016). Figure 4 shows the white and red colour of the soft wheat.

Figure 4: White and red wheat. Source: (Shewry & Hey, 2015)

The third type of wheat is Durum Wheat (*T. Drum*). Durum wheat is a unique variety of wheat and is one of the most important grain species, with over

17 million hectares under cultivation and a global yield of 38.1 million tonnes in 2019. (Agriculture and Agri-Food Canada, 2019).

Durum wheat is yellow, unlike the other wheat and has harder seed and brown skin. The wheat is usually used to produce pasta. Despite its high protein content, it is not a strong *wheat* since it lacks the strength to dough through the formation of a *gluten* (Kusuma, 2015). A photo of Durum wheat is shown in Figure 5.

Figure 5: Durum wheat Source: (Shewry & Hey, 2015)

Burggraa (2016) reports that wheat grain has 85 percent endosperm (flour body), 13 percent bran (different layers), and 2% germ. The chemical composition of the wheat grain varies according to its nutrients. Burggraa (2016) found the carbohydrate (starch and sugar) content in the whole grain to be 59%, the moisture 14% and protein content 13%. The dietary fibre in the whole grain was 10%, fat 2% and minerals 2% (Burggraa (2016).

Wheat flour

Flours are defined as "results of grain, legume, or other seed crushing or milling" (Food Standards Australia New Zealand, 2020). Flour provides structure to baked goods such as cakes, biscuits, pastries, and bread, and is available in a variety of protein levels to suit the purpose and desired output (Hughes, Vaiciurgis & Grafenauer, 2020). Higher-protein flours create a higher proportion of gluten and a stronger dough for bread, but the opposite is true for cakes and cookies.

Wheat flour maybe treated as white flour i.e. containing only the endosperm of the grain or as whole wheat or wholemeal flour i.e. containing all portions of the grain are for home baking. Wheat flour may also be treated as plain flour i.e. all-purpose flour or self-rising flour with added raising agents (Hughes, Vaiciurgis &Grafenauer, 2020). Wheat is prepared into flour after harvesting from the field. The harvesting of the wheat take place during the autumn (Burggraa, 2016). The wheat when harvested needs to be threshed and this may break the grains especially when it was not fully dried before harvesting. The processing of the wheat into flour is carried out in flour mills but also can be done using the traditional methods.

Wheat grains need to be stored first after harvesting before cleaning of the wheat. The motive behind the cleaning of wheat is to make sure all impurities are removed to make the grains are save for consumption. According to Burggraa (2016), the wheat grain has to be subjected to six different stages to get rid of all impurities during cleaning. The stages include sieving, magnet, separator (Aspirator), destoner, trieur (Triage) and scouring.

The traditional approach in processing wheat into flour, according to Oyewole (2016) is as follow: Harvesting→Threshing →Winnowing → De-stoning (sorting to remove stones and foreign materials →Cleaning in water to remove adhering soils → Draining →De-hulling in mortar →Winnowing to remove bran →Washing de-hull grains →Sun-drying →Milling.

Milling wheat into flour for meal varies depending on the kind of the meal and the flour. Meal kind depends on the texture of the flour produced having in mind the meal to be produced out of it. According to Burggraa (2016), the flour quality depends on the protein content and how it is to be used. According to Burggraa (2016), flour with a low protein level of less than 10% is suitable for use in confectionery items such as biscuits and cakes.

Furthermore, flour with a protein content of 10 to 15% is suitable for baking bread, but rusk is made with flour with a higher protein content, such as 15% or more. Wet milling flour is mostly made from dry-milled hard wheats in North America and soft wheats in Europe (Lindhauer, 1997, Maningat & Bassi, 1999; Lindhauer & Bergthaller, 2002).

Nutritional Composition of Wheat Flour

Wheat flour has nutritional composition that is very essential to human beings and even lower animals. According to Arnarson (2019), wheat flour contains calories, water, protein, sugar, fibre and fat. Glutenin and gliadin are two major gluten-forming proteins found in the endosperm of wheat kernels (Mdová

& Rysová, 2022). Glutenin and gliadin produce strands of gluten when flour is mixed with water, and is vital in the structure of baked foods.

Wheat is the only common cereal grain that has enough glutenin and gliadin to produce high-quality gluten for bread production (mdová & Rysová, 2022). The wheat germ is the plant's embryo. Protein, lipids, B vitamins, vitamin E, and minerals are all abundant in wheat germ (Oso & Ashafa, 2021). As the germ sprouts, the nutrients are critical. While germ protein does not produce gluten, it is of excellent nutritional value.

Dietary Fibre

Fibre which in the cell is a thread found in a natural food. Therefore, dietary fibre which is fibre in a food, helps in the digestion process after consuming of the food. Dietary fibre which is called roughage at times helps to prevent indigestion. Edible plant components or equivalent carbohydrates that are resistant to digestion and absorption in the human small intestine but ferment entirely or partially in the large intestine are referred to as dietary fibre (American Association of Cereal Chemists [AACC], 2000).

Dietary fibre is made up of polysaccharides, oligosaccharides, lignin, and other plant components (AACC, 2000). Dietary fibre, according to the British Nutrition Foundation (2015), is a set of components found in plant-based diets that cannot be entirely digested by human digestive enzymes. Waxes, lignin, and polysaccharides like cellulose and pectin are among the enzymes found in humans. Dietary fibre contains cellulose, noncellulosic polysaccharides such as hemicellulose, pectic compounds, gums, mucilages, and the non-carbohydrate component lignin, which are resistant to enzymatic digestion (Dhingra, Mona, Rajput, and Patil, 2012). Fiber-rich foods, such as cereals, nuts, fruits, and vegetables, are good for health because they've been linked to a lower risk of a variety of ailments (Dhingra et al., 2012).

Dietary fibre is made up of polysaccharides, a type of non-digestible carbohydrate found in plant-based foods. Diet has developed over time to mirror Western cultures' shift away from local hominid forebears, with consequences for our co-evolved gut bacteria (Barber, Kabisch, Pfeiffer & Weickert, 2020). Changes in food shape to emulate western foods or diets has resulted in an increase in ultra-processed foods, which are frequently poor in dietary fibre, and a decline in fibre-rich plant-based meals (Barber, et al., 2020).

Carbohydrates are classified chemically based on their molecular size Polysaccharides with more than 10 monomers are usually indigestible, but sugars with 1–2 monomers and most oligosaccharides with 3–9 monomers. Despite being technically a type of carbohydrate, their indigestibility gives the quiddity of dietary fibre (Hijova et al., 2019).

The Western world's diets are lacking in fibre, and therefore missing on the health advantages of dietary fibre (Barber et al., 2020). Dietary fibre consumption has been connected to overall metabolic health (through essential pathways like insulin sensitivity) as well as a range of other disorders like cardiovascular disease, colonic health, gut motility, and the risk of colorectal cancer. Consumption of dietary fibre has also been connected to mortality. The positive benefits of dietary fibre, such as appetite management, metabolic activity, and chronic inflammatory pathways, are all influenced by the gut bacteria (Barber et al., 2020).

Dietary fibre is often referred to as roughage component of carbohydrates that are not digested by enzymes of the gut and they may be either soluble or insoluble (Vinik & Jenkins, 1988). Dietary fibre helps to retain water and has been shown to alter insulin levels in the blood and improve postprandial glycemic response by regulating a variety of metabolic hormones (Vinik & Jenkins, 1988). Studies are still ongoing to establish the mechanism of action of dietary fibre, certain mechanical influences such as low energy density and the bulky feeling they produce in the GIT lead to increased satiety with a reduced calorie intake (Leeds, 1987). An earlier study on guar reported the beneficial influence of fibre on glucose tolerance of the next meal (Trinick, Laker, Johnston, Keir, Buchanan & Alberti, 1986).

Insulin sensitivity and HDL cholesterol were found to be favourably linked with dietary fibre intake using the homeostasis model. After multivariate adjustments, dietary fibre consumption was linked to a lower prevalence of abdominal obesity, hypertension, and metabolic syndrome (Fujii et al, 2013). After multivariate adjustments that included protein intake, dietary fibre consumption was linked to a reduced prevalence of albuminuria, a lower estimated glomerular filtration rate, and chronic kidney disease. These correlations remained unchanged after accounting for obesity, hypertension, and metabolic syndrome (Fujii et al, 2013).

Fibre was compared to placebo in a study, and the results showed that the overall mean difference between fibre and placebo was a drop of 0.85 mmol/L (95 percent CI, 0.46 – 1.25) in fasting blood glucose (Robert, Arch, Dana, & Simpson, 2012). According to Robert et al. (2012), dietary fibre had an effect on HbA1c when compared to placebo, with an overall mean difference of 0.26 percent (95 percent CI, 0.02– 0.51) decrease in glycosylated haemoglobin. This finding suggests that by consuming a high-fibre diet, blood glucose levels can be kept under control.

More than 30 years ago, a potential role for fibre in diabetes prevention was hypothesized, and a high intake of cereal fibre has continuously been linked to a lower risk of diabetes (Willett, Manson & Liu, 2002). For example, a major prospective study of about 42 000 males followed for almost 12 years revealed an inverse link between wholegrain intake and Type II diabetes. After correcting for confounding factors, men with the highest consumption compared to those with the lowest had a relative risk of 0.58. (Fung, Hu, Pereira, Liu, Stampfer, Colditz, Willett, 2002). Similar results have been reported in women (Liu et al., 2000; Meyer, Kushi, Jacobs, Slavin, Sellers, & Folsom, 2000).

Over nearly a 10-year period, 4000 Finnish men and women were evaluated for their whole-grain and fiber intake, as well as the incidence of Type II diabetes. Wholegrain consumption was found to be inversely related to the risk of Type II diabetes, with an RR of 0.65 between the highest and lowest quartiles of wholegrain consumption, meaning a 42 percent reduction in risk. Cereal fibre has also been associated to a reduction in the risk of Type 2 diabetes (RR 0.39).

(Montonen et al,, 2003). Fiber-rich foods, such as cereals, nuts, fruits, and vegetables, are good for your health because they've been linked to a lower risk of a variety of ailments (Dhingra, et al., 2012).

The use of more dietary fibre base has been advocated over the years, especially health personnel knowing its significance to the human body when consumed. It helps in digestion, after which all the waste that need not be in the body would be passed through stool. Various functional meals, such as pastries, drinks, beverages, and animal products, can all benefit from dietary fibre. Different processing procedures (such as extrusion-cooking, canning, grinding, boiling, and frying) have an impact on the physicochemical properties of dietary fibre and improve their functionality (Dhingra, et al., 2012).

Importance of fortification in improving nutritional composition

Food fortification is an essential nutrition strategy used in many low- and middle-income countries to address micronutrient insufficiencies and reduce their prevalence (Chadare et al., 2019). The most efficient strategy to avoid micronutrient deficiency is through food fortification (Bhagwat et al., 2014). For many years, food fortification has been used to prevent vitamin deficiencies at a reasonable cost (Method & Tulchinsky, 2015). In order to develop food fortification in developing nations, extensive research has been carried out (Akhtar et al., 2011; Mishra, 2011).

Wheat is a major ingredient in bread, biscuits and other confectioneries. In improving the strength of nutrients in wheat, it has to be fortified to meet the need of the need of daily use. According to Alrayyes (2018), the United States of

America is a world leader in the field of food fortification and folic acid has been added to wheat flour since 1938, while niacin has been added to bread since 1938.

Cereal fortification has proven to be incredibly advantageous because cereals are the most extensively consumed food products on the planet. Cereal-based products are a low-cost energy source to which almost everyone has access (Alrayyes, 2018). Legumes are a high-protein food that can enhance the diets of millions of people (Singha & Muthukumarappan, 2018).

Basic foods, seasonings, and condiments can be fortified to increase the content of critical micronutrients like vitamins and minerals, hence increasing nutrient consumption (Mannar & Gallego, 2002). Incorporating synthetic micronutrients into diets is one method to fortify them (Zimmermann et al., 2006). Many of the most commonly consumed foods in underdeveloped nations, such as oils and fats, milk, sugar, salt, rice, wheat, or maize flour, are employed as fortification vehicles (Chadare et al., 2019). Folic acid was added to flour on a mandatory basis in over 60 nations to prevent neural tube congenital defects (Liyanage & Zlotkin, 2002; Oakley & Tulchinsky, 2010).

Fats and oils, tea, cereals, flour, monosodium glutamate, and fast noodles, as well as milk or milk powder, whole wheat, rice, salt, soybean oil, and baby formulae, are all fortified with vitamin A. In Asia, red palm oil was used to supplement other edible oils with vitamin A. (Solomons, 1998). Fortification with vitamin A is presently being considered in 29 developing nations (Mason et al., 2014).

Vitamin A, iron, zinc, folic acid, thiamin, niacin, vitamin B, and riboflavin have been added to maize meal and wheat flour to improve the growth and micronutrient status of Africa's undernourished children. In Benin, native food resources such as moringa leaves, fruit (pawpaw, mango, plantain), seeds (from watermelon), and legumes (soybean) are often used to supplemented deficient foods such as gari, tapioca, and wheat flour bread (Chadare et al., 2019).

When young women in Burkina Faso ate a meal consisting of maize paste and iron-enhanced leaf-based and traditional amaranth sauce, their iron absorption improved. As a result, simply increasing the amount of green vegetables in a meal may not be sufficient to provide more accessible iron. A fortifying diet's major purpose is to make up for nutritional, sensory, biological, and physical deficiencies. Energy, proteins, lipids, fibre, carbs, phosphorus, iron, zinc, potassium, manganese, salt, calcium, and vitamin C are all commonly added to foods.

Effect of composition on physiochemical properties

Due to rising demand for high-quality and healthful bread products, the baking industry faces a challenge in producing products with improved nutritional, physicochemical, and sensory attributes (Mariotti et al., 2014). Bread quality is influenced by colour, specific volume, and texture which in turn can be influenced by other factors such as flour type, additives, and other ingredients (Dall'Asta et al., 2013). When wheat flour is partially substituted with flour from locally cultivated cereal grains, the iron and calcium content of composite bread increases (Oladele & Aina, 2007).

During a study, the bulk density of composite flour declined as the amount of finger millet flour increased, ranging from 0.45 g/mL (60% wheat flour and 40 percent finger millet flour) to 0.48 g/mL (60% wheat flour and 40 percent finger millet flour) (Mudau et al., 2021). With increasing finger millet flour substitution levels ranging from 31.20% to 36.08%, the proximate composition of bread samples fell significantly. According to Oladunmoye et al. (2010), the composition of composite bread had a substantial impact on the physicochemical qualities, with the sample (85% wheat, 10% cassava, 5% cowpea) having the highest moisture content protein.

Protein content of orange juice rose from 1.35 to 12.37% (pure orange) 75 Parkia and 25% orange due to the high protein content. Parkia biglobosa belongs to the Leguminosae family, which could explain this. The protein content of parkia-orange juice was equivalent to parkia pulp extracts in the study of Bot et al. (2013), whereas other researchers reported lower values (Afolayan et al., 2014; Sotolu & Byanyiko, 2010).

The ash content of food has an impact on its quality; a high ash content suggests a high mineral content (Nielsen, 2017), whereas fat content adds energy. The parkia-orange juice mixes had ash values of 0.76 to 2.65 percent and fat levels of 0.25 to 3.05 percent, respectively. Adeloye and Agboola (2022) reported that orange, apple, and mosambi juice mixes had similar fat content. Locust bean had a crude fibre level that was much higher than 3.19%. At 50 and 75% parkia juice ratios, parkia pulp is produced. Fruit juices are notorious for being poor in protein. In the current study, however, Parkia biglobosa juice, a readily available plant protein source, appears to increase the nutritional composition of the mixtures.

Crude fibre is a type of dietary fibre that is required for normal bowel movements (Yang et al., 2012). According to Adeloye and Agboola (2020), crude fibre content increased significantly at 50 and 75% parkia juice percentage ratios in their study on bioactive properties, chemical composition, and sensory acceptance of juice blends from orange and African locust bean (Parkia biglobosa). They also discovered that 50 percent orange and 50 percent Parkia had higher carbohydrate content and calorie value.

Baking of Biscuits

Baking is done with heated air, as well as the oven floor and trays. The hot air evaporates the moisture on the food's surface, resulting in a dry crust in items like bread and many biscuits (Datta & Ni, 2002). Most ovens have a temperature range of 120 to 260°C (250-500°F) for cooking. (Fox & colleagues, 2011). After kneading biscuits are baked on sheets made from a metal that transmits heat rapidly and evenly. Therefore, the size, shape and material from which the baking pan is made affect the quality of the finished baked products.

Baking sheets, rather than cake pans, are more efficient for baking most cookies, according to Cauvain and Young (2008), because there are no high sidewalls to hinder heat circulation. Cookies baked in pans with high side may cook well but brown little or non-on top. Bar cookies are usually baked in cake pans with sides. Rombauer et al. (2019) reported that tin or aluminium is better suited to baking muffins and biscuits than are iron or glass. Also, round pans give more browning than pans with square corners. The product may be browner at these corners than on the crust of the area, the size of the baking pan should be suited to the amount of batter and the shape of the product. To improve the volume, pans are oiled only on the bottoms.

Temperature and time of baking also affect the quality of finished baked products (Figoni, 2010). Oven temperatures recommended for baking flour mixtures depend upon the nature of the ingredients used in preparing the mixture, the size and the shape of the unit of dough. When a flour mixture contains large proportions of sugar, the baking temperature must be low enough to prevent too much browning and burning. Oven temperature used for baking all flours mixtures should be such that the outer layer of dough does not congeal or coagulate before optimum leavening has been achieved. If that occurs, expansion becomes insufficient, with flatness and heaviness produced in the product.

If gas is created at a high enough rate, the top may crack open, creating enough pressure to breach the surface at its weakest point. Heat penetration is usually determined by the oven temperature as well as the size and form of the dough units. Heat must penetrate the centre of small amounts of dough in a relatively short period of time.

Larger units, however, should be baked at lower temperature to provide sufficient time for heat penetration to the centre (Gavahian & Tiwari, 2020). The optimum baking temperatures depend on the type of pan used and the results desired at various times or with different products might include; complete cooking without browning, which requires a low temperature; rapid expansion of steam, which requires a high temperature. If the temperature is too high and a hard crust forms on the surface before the gases have completely expanded, the pressure of the expanding gas may break the crust and cracks will be formed. In some cases, the unclosed centre of the dough may flow out through the cracks (Gavahian & Tiwari, 2020).

The faster baking pans give products with larger volumes and better crumb quality, but have a slightly inferior appearance with regard to the shape of the top. 425-450°F (218-232°C) for 10-15 minutes is the best temperature and time for baking biscuits. Gavahian and Tiwari (2020) reported that, since biscuits are relatively small, they are quickly baked so that a high temperature is used (400-425°F), for 10 to 12 minutes. Large size will require longer times and, often, lower temperature than the small biscuits. Wu et al. (2015) reported that a hot oven of 426 to 450°F for about 15 minutes is satisfactory for baking biscuits. Biscuits produced from wheat flour or wheat and sorghum composite flours are baked for eight and half minutes in an electric oven at 205°C, according to Ahmed (2015).

Kneading and forming of biscuits

Kneading is a stretching and folding operation for dough. The gluten fibres are stretched as a result, and the dough's consistency becomes smooth. Kneading is often done by hand, however if a big quantity is being prepared, a motorized kneader may be chosen (Pagani et al., 2007).

According to Vaclavik et al. (2021), kneading is a folding and turning process in which, the dough is worked by hands. Biscuits require only 10 to 20 folds to obtain a satisfactory product with flaky layers.

Kneading lightly, using ten to thirty strokes (depending on the amount of stirring used to mix the dough), produces biscuit of fine texture that sheets when broken rises to larger volume than unkneaded biscuits. Also kneading gives better external appearance e.g., biscuit with smooth top crusts. Biscuits made from patted or rolled biscuit dough are tender and have crisp crusts, although they are coarse in texture, small in volume, and have a little rough crust (Willard, 2011). Over kneading produces a compact, toughened product (Bolenz et al., 2014). After kneading, the dough has to be formed into the desired shape (Bolenz, et al., 2014). Crisp and tender dropped biscuits may be used as topping for desserts, meat pies, or shortcakes bases. Biscuit dough is rolled out and cut using either a knife or a shaped biscuits cutter.

Changes that occur during the baking of flour mixtures

Several changes occur during baking which causes hardening of the mixture and results in the fixing of the structure. Steam or water vapour is produced from the water or liquid used in the mixtures. Carbon dioxide from the baking soda source; there is expansion of all the leavening gases, including air incorporated during beating of eggs, sifting of flour and mixing (Lai & Lin, 2006). There is coagulation or congealing of protein substances such as gluten and egg, in the mixture with heat (Lai & Lin, 2006). The gluten and egg proteins coagulate, which causes a loss of water and a hardening that results in a fixation of the structure (Han et al., 2019).

The gelatinization of starch in the flour. Starch attracts water when it is in storage, retains 10 percent moisture when mixed with cold water, and forms a suspension that is not sticky. If the cold water is heated, the starch granules or units begin to absorb water and to swell when the temperature reaches about 20 to 30°C (68- 86°F). When the heating is continued, the suspension thickness (gelatinisation) and increases and this is recognized by a change in the appearance of the heated suspension. It becomes translucent or semi-transparent because of other substances present in it. The complete gelatinization of starch needs the presence of a sufficient amount of water and a good supply of heat with sufficient time for heating.

The higher the temperature at which the heating is done, the faster gelatinisation takes place, and the lower the temperature the longer the time needed to achieve gelatinisation (Bauer & Knorr, 2005). The plasticity of sorghum flour is mostly due to starch gelatinisation when the dough is formed in hot or boiling water, and the stickiness of the cooked flour is also a result of starch gelatinisation.

Cold water dough has weak adhesion and is difficult to roll out thin. As a result, the rolling capabilities of the dough are determined by the heat modification of the starch when the dough is formed with hot water. Heat treatment of starch in a little amount of water causes granule expansion and partial gelatinisation of the starch with very little loss of soluble material. Not-inthermodynamic-equilibrium gelatinization of starch. The process of recrystallization is known as retrogradation, and it might diminish starch digestibility (FAO, 1998).

Proportions of ingredients

These factors affect not only the finished product, but also some mixing procedures. Baking powders, for example, contain different salts, each of which has a specific effect upon the rate the gluten absorbs water. The combination of sulphate-phosphate powders takes up the water rapidly and this cause dehydration of gluten (Vaclavik et al., 2021). The net result is that batters in which these powders are used are less easily over mixed than those that contain other powders. The effects that variations in the composition of ingredients have upon the finished product should be considered when substitutions in recipes are made.

All-purpose flour is used in smaller amounts than cake flour, and mixing should be decreased because all-purpose flour absorbs more water and has more and stronger gluten than cake flours have (Lai & Lin, 2006), or if honey is used as a substitute for sugar, it should be remembered that it contains liquid and therefore the liquid content of the recipe should be decreased and a lower temperature used in baking to prevent off flours from overheated honey. The proportion of ingredients influences method of mixing, amount of mixing which is optimum, baking time, and keeping qualities of the finished product. Sugar and fat in large quantities cause a delay in the development of gluten and therefore products that contain large amounts of fat and sugar must be mixed longer than products with lesser amounts to obtain sufficient gluten strands for structure (Wilderjans et al., 2013).

Sensory Evaluation of Food

Sensory evaluation is a scientific means of assessing foods, materials and other phenomena by way of smell, touch, sight, taste and hearing to give judgment on how a person or group of persons know about that particular thing. Sensory assessment is a measurement discipline that emphasizes precision, accuracy, and sensitivity in order to avoid erroneous conclusions (Sharif, Butt, Sharif & Nasir, 2017). In conducting sensory evaluation on foods, the use of the human senses is the tool of measure that is used. Sensory evaluation is possible when the person doing the evaluation is well trained on how to apply the senses for what is supposed to measure of evaluate. Descriptive sensory evaluation is a set of methods for differentiating between a variety of products based on all of their sensory qualities and determining a quantitative description of all sensory properties discovered, not just defects (Drake, 2022).

According to Sharif, Butt, Sharif and Nasir, (2017), the first technique involves experienced evaluators determining a product's hedonic reaction, whereas the second way involves customers in the evaluation process. Hedonic analysis is the most cost-effective and optimal way for determining the impact of changes in ingredients, manufacturing, packaging, or shelf life.

Sensory professionals are frequently confronted with difficulties that demand a wide range of abilities from a variety of disciplines, such as biosciences, psychology, and statistics, and are frequently obliged to collaborate with other specialists in these fields. Sharif *et al.* (2017) further noted that working with a human as 'measuring instrument' is challenging due to great variability since humans' sense being used could change due to environmental and psychological circumstances. Any of the sense used for sensory evaluation can be influenced at any given time. Sensory analysis is the act of analysing a product with one's senses (sight, smell, taste, touch, and hearing) to check for numerous quality features such as appearance, flavour, aroma, texture, and sound (Sharif et al., 2017).

Different methods or procedures have been identified for food sensory evaluation. Sensory evaluation methods, according to the Institute of Food Technologists (1981), can be split into two categories: affective and analytical methods. In order to have more trust in the interpretation of the results, affective approaches use consumer panels or trained panellists with a large panel size (Zoecklein, 2018).

The most common analytical methods of sensory evaluation are discrimination (or difference) and descriptive methods (Zoecklein, 2018). According to Spence (2015), food colour, flavour, aroma and texture are powerful determinants used in food acceptability. In the case of the current study, Spence (2015) identified sensory evaluation would be used.

Studies by Zakari, Ajayi, and Hassan (2013) reported that, wheat flour and African locust bean fruit pulp flour were combined to make biscuit flour. For all of the measures studied, the sensory panellists gave the products high scores. According to Zakari, Ajayi, and Hassan (2013), the biscuit with 10% replacement was rated second only to the control (100 percent wheat biscuits) in all metrics among the five formulations examined. As a result of the investigation, the control biscuit did contain several characteristics that the panelists couldn't easily discover in the new formulation.

In order to determine the physicochemical and sensory quality of cookies made from composite blends of wheat flour (WF) and African locust bean fruit pulp flour (LBFPF), the nutritional value and acceptability of cookies made from composite blends of wheat flour (WF) and African locust bean fruit pulp flour (LBFPF) were assessed. In the ratios of 90:10, 80:20, 70:30, and 60:40, four distinct composite blends of WF and LBFP were created, with 100 percent WF as the reference product (Gernah, Akogwu & Sengev, 2010). Cookies were then made using a standard technique from the various mixtures, according to the study. With the exception of the 90:10 mixtures, which was the most favoured among others, the sensory evaluations of the cookies revealed a significant difference (p0.05) in cookies flavour, texture, and overall acceptability in all mixes when compared to 100 percent WF.

According to Sadik (2020), African Locust bean (Parkia biglobosa) fruit pulp, also known as "Dozim" in Ghana's Northern Region, was combined with wheat flour to make shortbread biscuits. A random sample of 50 untrained panelists judged the product's colour, texture, flavour, mouthfeel, and overall acceptability during the sensory evaluation. The "Dozim" shortbread biscuit was loved by 90% of respondents because of its taste, texture, colour, flavour, and appearance.

Summary of the Literature Reviewed

The African locust bean tree produces fruit, which has been discovered to be a good source of plant protein and other nutrients for human use. The bean is a leguminous crop that grows abundantly in Africa and Ghana's northern regions. The tree can grow as tall as 20 metres and live up to 30 years. The pulp from the fruit according to literature can be used for several food and can be used as a flour for other food base formulation.

Calcium, Iron, Magnesium, Sodium, Copper, Potassium, Phosphorus, and Manganese are among the nutrients found in parkia pulp. The fruit also contains macronutrients, vitamins A and C, as well as carotenoids and zinc. The fruit has a high natural sugar content and the pulp flour a good swelling power, water absorption capacity and oil absorption capacity.

The literature review has shown that wheat has six different types, but three of such types are mostly used to bake bread, biscuit, pizza and other related confectioneries. Flour is milled out of whole grain wheat with different textures depending on the type of food it would be used for. The milled flour does contain a lot of nutrients such as calories, water, protein, sugar, fibre and fat. Wheat is fortified to help prevent malnutrition that is caused by micronutrient deficiencies. According to literature, fortification of food is common in developing countries.

Wheat is the major ingredient used to prepare bread, biscuit and other related foods. Though wheat has good nutrients that could help fight malnutrition and its related diseases, composite flour with the use of African locus pulp has been used in other studies. In previous studies sensory panellists have accepted composite flour biscuits to some extent. In most cases, through the control wheat flour biscuits have higher acceptability scores compared to the composite flour biscuits.

CHAPTER THREE

MATERIALS AND METHODS

Introduction

The Chapter discusses the methodology used in approaching the entire study. In this chapter the study area, research design, formulation of blends, sources of raw materials, preparation of locust bean fruit pulp flour, preparation of locust bean fruit pulp for shortbread biscuit and flow chat in preparing the formulated biscuits are discussed. The sampling for the sensory evaluation and how to analyses of data are presented in this chapter.

Study Area

The research was conducted in Was Municipality in the Upper West Region of Ghana. Wa Municipal is one of the eleven districts in the Upper West Region of Ghana. Wa district was created in 1988, which was later split in two by a decree of the then president, John Agyekum Kufuor, in July 2004. Wa is the capital of the Upper West Region of Ghana. The Wa Municipality is bounded to the south by the Northern Region of Ghana and to the west by the Black Volta. The distance of Wa from the capital city of Ghana, Accra, is about 560km. For the geographical coordinates Wa Municipality has a latitude of 10°03'38.5"N (10.0606900°) and longitude of 2°30'06.9"W (-2.5019200°). The distance of the Wa Municipality to the equator (0° lat) is 1,114 km (i.e., north of the equator). Wa municipality is 274 km west of the prime meridian with a land area of 239,460.0 km2 and a population of 200,672 people.

The Map of Wa Municipality is shown in Figure 6.

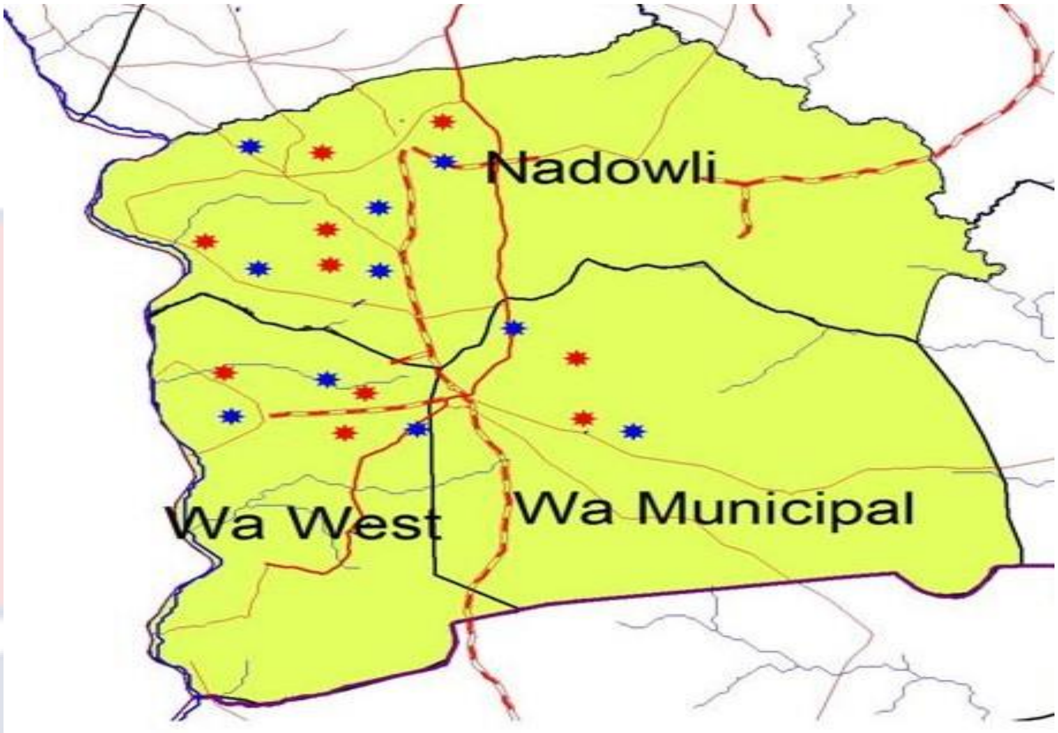

Figure 6: Map showing Wa Municipality

Research Design

The study adopted true experimental research design. The objective of this study was to develop a new product to be known as biscuit by using African locust beans pulp powder in a composite flour. An experimental design is one in which the researcher controls other important elements while manipulating at least one independent variable and observing the impact on the subjects. It's the only way to look at hypotheses about cause-and-effect interactions.

Creswell (2012) suggest an experimental technique for generating new products, which permits a small number of experimental runs to generate a great amount of knowledge about a new product. They went on to state that by examining data from the experimental design, a variety of parameters for the new product can be swiftly and precisely determined. The independent variables were altered, and the test subjects were asked to score the sensory acceptability of the various formulations. Other essential characteristics, such as the nutritional composition of the various formulations, were also determined.

The use of actual experimental research design was to determine which of the biscuits that would be developed would be acceptable to the participants. Experimental design is the traditional method of performing quantitative research, according to Creswell (2012). In developing a new biscuit from African pulp fruit and the use of other raw materials, different ratios of the composite blend of the pulp were processed in the home science canteen of Wa Secondary Technical High School. The different ratio formulations were to help in developing good biscuits. The formulations were in four different parts which could be tested with the help of true experimental research design.

The actual experimental research design was the most appropriate design for the study since the physicochemical characteristics of prepared samples would be analysed on developed biscuits at the University of Cape Coast's School of Agricultural Laboratory. The Department of Home Science personnel and students were the intended audience.

Formulation of blends

The study was conducted using a completely randomized design (CRD) with two (2) treatments: wheat flour (WF) and African locust beans fruit pulp flour (ALBFPF). Table 2 shows the percentages of African Locust bean fruit pulp (ALBFP) flour used to replace wheat flour at 100, 75, 25, and 0%. Following

Hussein, Yaseen, Esmail and Mohammad (2020), approach, these formulae were utilized to make shortbread biscuits.

Table 2: Ratio of wheat flour to African locust beans fruit pulp flour

Treatments	Wheat flour (g)	African locust beans fruit pulp flour(g)
A	100	0
B	75	25
C	50	50
D (Control)	25	75

Source: Field data, Lenia (2021)

Table 2 shows the four treatment groups: A, B, C, and D, as well as the amounts of wheat flour and African locust beans fruit pulp flour in each. Table 3 lists the ingredients that went into making the flour for the formulated biscuits. Salt, castor/icing sugar, butter flavour, and margarine are among the constituents in the designed biscuits.

Table 3: Ratio of other ingredients in short bread biscuits preparation

Treatments	Salt	Castor/Icing sugar(g)	Butter flavour	Margarine (g)
A	Pinch	50	½ tea spoon	50
B	Pinch	50	½ tea spoon	50
C	Pinch	50	½ tea spoon	50
D	Pinch	50	½ tea spoon	50

Source: Field data, Lenia (2021)

Sources of raw materials

In formulating the proposed biscuit, a wide range of raw materials were needed. The local raw materials used for the development of the biscuits include

African locust powder from the dried fruits from the community and wheat flour, sugar, butter and milk powder were purchased from a store in Tuffour in Wa central market. The African locust bean for the biscuit formulation was obtained from Busa, a village in the Upper West Region Wa. The raw materials used in the biscuit formulation are presented in Figures 7.

Figure 7: Ingredients for biscuit formulation. Where A) African locust bean; B) African locust pulp flour; C) Flour; D) Butter; E) Sugar and F) Milk powder. Source: (Lenia, 2021).

Preparation of locust bean fruit pulp flour

The process described by Gernah et al. (2007) was used to make locust bean fruit pulp flour. The mature and dried African locust bean pulp was harvested from the tree in the wild where the community people usually go for their fruits for domestic and other uses. The matured and dried fruit look brownish and when shaken, it makes sound which is used to judge its maturity or otherwise. Two males from the community closed to the African locust bean trees have been engaged to do the harvesting of the fruits.

The harvested fruits were inspected in the bush to ensure their wholeness (that no worms had entered the pods) before packing them into a clean fertilizer sack to be transported. The fruits were further dried for two days under the normal sunshine on clean fertilizer sacks. By physically removing the outer brown cover of the pods, the golden fruit pulp was separated from the seeds embedded inside it.

The yellow pulp was dried for 9 hours at 60°C in a hot air oven (Genlab Widnes, Model T1211) to a moisture content of 10%. To make a fine flour, this dried powder was milled with a laboratory hammer mill (Christy hunt, England) and sieved through a 0.5 mm screen. The flour was wrapped in polythene bags and kept at room temperature in an airtight container.

Preparation of locust bean fruit pulp shortbread biscuit

The biscuits were made using the creaming method, described by Eke et al. (2008) and Anon (2004), with wheat-locust bean fruit pulp flour blend, sugar, margarine, milk powder and salt.

Flow diagram for the preparation of biscuits

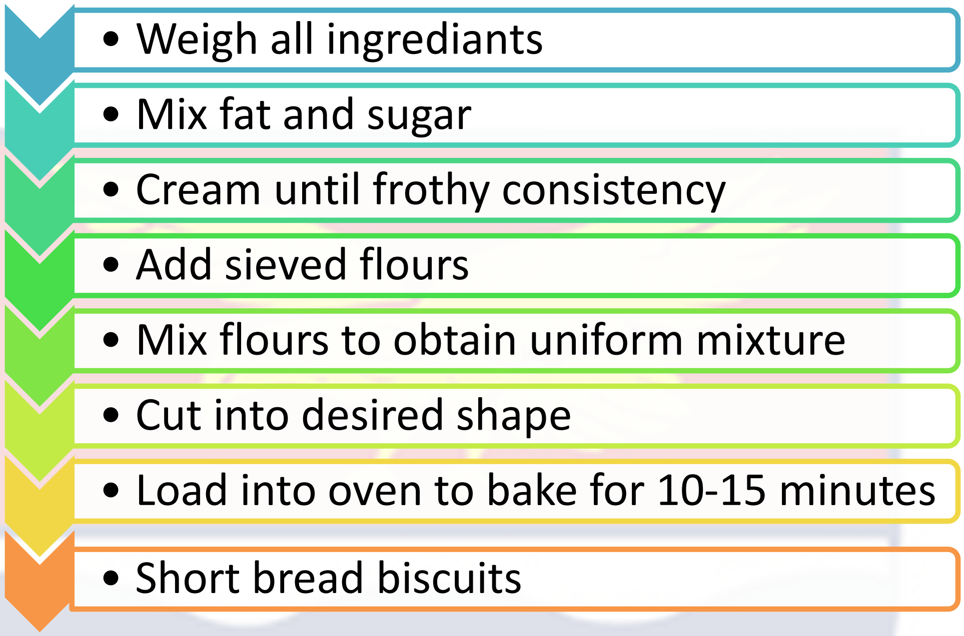

Figure 8: Flow diagram for the preparation of biscuits. Source: (Lenia, 2021)

Population

Population generally refers to the entire pool that statistical sample is taken, which reflects the fundamental characteristics of the population The population of the Wa Municipality according to the 2021 Population and Housing Census was 200,672 (Ghana Population and Housing Census, 2021). The targeted population for this study was the staff and students in the Wa Senior High School in the Department of Home Science.

Sample size and Sampling Approach

A total of 100 staff and students were selected in Wa Senior High School for testing of the new product. The respondents were drawn from the Home Science Department for the study. The number of respondents used was consistent with the standards of the hedonic method of sensory evaluation, which calls for a total of 75 to 150 people to participate in such testing. The respondents for the study were chosen using a purposive sampling technique. This technique of sampling was chosen because it allowed the researcher to focus on people who are familiar with biscuits.

Instruments for Data Collection

The instrument used for the data collection for the sensory evaluation of the new formulation was in two parts. The first part was Section A which was used to collect the biographical information of the respondent. The second, section B was on how the panelist were to access the formulated biscuits.

Data Collection Procedure

For the aim of this study, primary data was gathered. Data on proximate analysis of the various samples produced was sent to the University of Cape Coast's School of Agricultural Laboratory for proximate analysis. A month was spent developing and testing the spread samples. Taste panelists were used to collect data for sensory evaluation. A group of 100 tasters were given the opportunity to taste, smell, and feel each sample, as well as provide feedback on several aspects of the sample, such as appearance, taste, texture, odour, and general acceptability, using a 9-point hedonic scale questionnaire. The evaluation took place over two days in the Wa Senior High School's Home Science Block.

Respondents' sensory evaluation of composite blend biscuits were collected using a structured questionnaire. Using a 9-point hedonic scale. Respondents were given the chance to try the product and express their hedonic opinion on various features of it by choosing and marking one of five options (range from 1 to 9). The structured questionnaire for responses is shown in Appendix A.

Nutritional Analysis

Proximate composition

Moisture content, ash, crude protein, and crude fiber and minerals were determined using AOAC-standard methods (1990). The Soxhlet process was used to separate crude fat from petroleum ether (60-80oC). Carbohydrate content was determined using differences in carbohydrate content (Kirk & Sawyer, 1991).

Moisture Determination

The moisture content was determined according to AOAC (1990).Porclain crucibles were washed, dried and weighed. About 10-12g of the fresh samples were put into clean oven-dried crucibles and weighed. The crucibles containing the sample were spread over the base of the oven to ensure equal distribution of heat. They were then kept in a thermostatically controlled oven at 105°c for 48 hours. At the end of the period the samples were removed, cooled in a desiccator and weighed. Each sample was done using three replicate samples. The moisture content was then calculated as the percentage water loss by the sample.

Ash Determination

The dried samples from the moisture determination were heated gently in oven at 105°c for about an hour and transferred to furnace at a temperature of 550°c overnight. The heating was continued until all the carbon particles were burnt away. The ash in the dish was removed from the furnace cooled in a dessicator and weighed. The ash content was then calculated as a percentage of the original sample.

Oil/ Fat Determination

Reagents

1: Petroleum Spirit

Procedure

About 10- 12g of the milled samples were weighed into a 50 ×10mm soxhlet extraction thimble. This was transferred to a 50ml capacity soxhlet extractor. A clean dry 250ml round bottom flask was weighed. About 150ml Petroleum spirit was added and connected to the soxhlet extractor and extraction carried out for 6 hours using a heating mantle as a source of heating. After the 6 hours, the flask was removed and placed in an oven at 60oC for 2 hours. The round bottom flask was removed, cooled in a desiccator and weighed. The percentage fat/oil was calculated as followed.

Calculation

Crude Fat (%) = $\frac{\text{W (g)} \times 100}{\text{Sample (g)}}$,

Where W is Weight of Oil

Protein Determination

Protein present in the food was calculated from nitrogen concentration of the food using the kjeldahl method. The method can be divided into three steps: digestion, neutralization or distillation and titration.

Digestion

About 0.2g of the sample was weighed into a 100 ml Kjeldahl flask. 4.4mL of the digestion reagent was added and the samples digested at 360oC for two hours. A blank was prepared without sample but treated in the same manner. After the digestion, the digests were transferred quantitatively into 50ml volumetric flasks and made up to the volume.

Distillation

A steam distillation apparatus was set up and flushed with distilled water for about twenty (20) minutes. After flushing out the apparatus, 5ml of boric acid indicator solution was poured into a 100 ml conical flask and placed under the condenser of the distillation apparatus with the tip of the condenser completely immersed in the boric acid solution. An aliquot of the sample digest was transferred to the reaction chamber through the trap funnel. 10mL of alkali mixture was added to commence distillation immediately and about 50mL of the distillate was collected.

Titration

The distillate was titrated with 0.1N HCl solution until the solution changed from green to the initial colour of the indicator (wine red). Digestion blanks were treated the same way and subtracted from the sample titre value. The titre values obtained were used to calculate the nitrogen and hence the protein content. The conversion factor used was 6.25.

$$\%\text{Total Nitrogen } (\%N) = \frac{(\text{Sample titre value} - \text{Blank titre value}) \text{ X } 0.1 \text{ x} 0.01401 \text{ x } 100}{sample\ weight\ X\ 10}$$

% Protein = %N x 6.25

Crude Fibre Determination

Reagents

Sodium hydroxide, 1.25%

1.25%. Dissolve 12.5g NaoH in 700ml distilled water in a 1000ml volumetric flask and dilute to volume.

Sulphuric Acid, 1.25%

Add 12.5g conc. Sulphuric acid to a volumetric flask containing 400ml distilled water and dilute to volume

Procedure

About 1g of the sample was weighed and placed in a boiling flask, 100 ml of the 1.25% sulphuric acid solution was added and boiled for 30 mins. After the boiling, filtration was done in a numbered sintered glass crucible. The residue was transferred back into the boiling flask and 100 ml of the 1.25% NaOH solution was added and boiled for 30 mins. Filtration continued after the boiling and the residue washed with boiling water and methanol. The crucible was dried in an oven at 105 ^{O}C overnight and weighed. The crucible was placed in a furnace at 500 degrees for about 4 hours. The crucible was slowly cooled to room temp in a desiccator and weighed.

Calculation

$$\% \text{ Crude fibre} = \frac{\text{weight loss thro ashing}}{\text{Sample weight}} \times 100$$

AOAC (2008)

Preparation of Sample Solution for the Determination of N, K, Na, Ca, Mg, P,

The preparation of sample solutions suitable for elemental analysis involves an oxidation process which is necessary for the destruction of the organic matter, through acid oxidation before a complete elemental analysis can be carried out.

Sulphuric Acid-Hydrogen Peroxide Digestion

The digestion mixture was made up of 350 mL of hydrogen peroxide, 0.42 g of selenium powder, 14 g Lithium Sulphate and 420 mL sulphuric acid. 0.1000 g to 0.2000 g of the oven-dried ground sample was weighed into a 100 mL Kjeldahl flask and 4.4 mL of the mixed digestion reagent was added and the samples digested at 360^{o}C for two hours. Blank digestions (digestion of the digestion mixture without sample) were carried out in the same way. After the digestion, the digests were transferred quantitatively into 100mL volumetric flasks and made up to volume.

Colorimetric Determination of P using the Ascorbic Acid Method

The procedure required the preparation of colour forming reagent and P required standard solutions. The colour forming reagent was made up of reagents A and B. Reagent A was made up of 12g ammonium molybdate in 20ml distilled water, 0.2908g of potassium antimony tartarate in 100mL distilled water and 1L of 2.5M H_2SO_4. The three solutions were mixed together in a 2L volumetric flask and made up to volume with distilled water.

Reagent B was prepared by dissolving 1.56g of ascorbic acid to every 200mL of reagent A. A stock solution of 100μgP/mL solution was prepared from which 5μgP/mL solution was used to prepare a set of working standards of P with concentrations 0, 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0μgP/mL in 25mL volumetric flasks. 2mL aliquot of the digested samples were pipetted into 25mL volumetric flasks. 2mL aliquot of the blank digest were pipette into each of the working standards to give the samples and the standards the same background solution.

10ml of distilled water was added to the standards as well as the samples after which 4 mL of reagent B was added and their volumes made up to 25mL with distilled water and mixed thoroughly. The flasks were allowed to stand for 15minutes for colour development after which the absorbances of the standards and samples were determined using a spectrophotometer at a wavelength of 882.nm. A calibration curve was plotted using their concentrations and absorbances. The concentrations of the sample solutions were extrapolated from the standard curve.

Calculation

If C = μgP/mL obtained from the graph,

then μgP/g (sample) = $\frac{\text{C x Dilution Factor}}{\text{weight of sample}}$

(IITA, 1985)

Determination of Potassium and Sodium

Potassium and sodium in the digested samples were determined using a flame photometer. In the determination the following working standards of both K and Na were prepared: 0, 2,4,6,8 and 10 μg/mL. The working standards as well as the sample solutions were aspirated individually into the flame photometer and their emissions (readings) recorded. A calibration curve was plotted using the concentrations and emissions of the working standards. The concentrations of the sample solutions were extrapolated from the standard curve using their emissions.

Calculation

μgK/g = $\frac{\text{C x solution volume}}{\text{Sample weight}}$

Stewarte et al. (1974)

Determination of Calcium and Magnesium by EDTA Titration

The method involves chelation of the cations with ethylene diaminetetra-acetic acid (EDTA). The procedure involved the determination of calcium and magnesium together and the determination calcium alone and magnesium found by difference.

Calcium and magnesium together were determined by placing an aliquot of 10mL of the sample solution in a 250mL conical flask and the solution was diluted to 150mL with distilled water 15mL of buffer solution and 1mL each of potassium cynacide, hydroxylamine hydrochloride, potassium ferro-cyanide and triethanolamine (TEA). Five drops of erichrome Black T (EBT) were added and the solution was titrated against 0.005M EDTA. Calcium was determined by pipetting 10mL of the sample solution into 250conical flask and diluted to 150mL with distilled water. 1mL each of potassium cyanide, hydroxyl-amine-hydrochloride potassium ferro-cyanide and TEA five drops of calcon indicator were added and the solution was titrated with 0.005M EDTA.

Calculations

$$\% \text{ Ca} = \frac{0.005 \text{ x } 40.08 \text{ x T}}{\text{Sample wt}}$$

$$\% \text{ Mg} = \frac{0.005 \text{ x } 24.31 \text{ x T}}{\text{Sample wt}}$$

Where T = titre value

Page et al (1992)

Functional Properties of biscuits

The functional properties of the biscuits determined were bulk density, water and oil absorption capacity, solubility, and swelling power.

Bulk density

The approach employed by Oladele and Aina (2007) was adopted for the experiment with slight adjustments. A 50g flour sample was placed in a 100ml measuring cylinder. The cylinder was repeatedly tapped until the volume remained consistent. The last stage was by dividing the weight of flour (g) by the volume of flour (cm3), the substance density (g/cm3) was calculated (cm3).

Water and oil absorption capacities

The ability of the flour samples to absorb water and oil was assessed using a process adapted from Abbey and Ibeh (1988). In a centrifuge tube, one gram of flour was combined with 10 mL distilled water or oil, and the suspension stirred for one hour on a griffin flask shaker before centrifugation for 15 minutes at 1204^{O}C. The volume of water or oil was measured on the sediment-water. The capacity to absorb water and oil per gram of flour was tested in millilitres of water or millilitres of oil.

Swelling power and solubility

The swelling power and solubility of the flour was determined using Oladele and Aina's method (2007). One gram of flour was combined with 10 cc distilled water in a centrifuge tube and cooked for 30 minutes at 80oC 55. This was regularly shaken during the heating process. The tube was taken out of the bath, wiped dry, cooled to room temperature (28°C), and centrifuged at 1204^{o}C for 15 minutes. To determine the solubility, the supernatant was evaporated and the dry residue weighed.

Weighing the swelled sample (paste) obtained by decanting supernatant yielded the swelling power. The swelling power was calculated by dividing the weight of the paste by the weight of the dry sample.

Ethical Consideration

The Panelists that consumed the developed or formulated biscuits did give their personal data as part of the requirement for the study. At the onset of the data collection, measures were put in place to avoid biases and distortion of the data provided. The participants were briefed about the study after they have been selected using the appropriate sampling technique. When they agreed to be part, they were made to sign the consent form in duplicate. One was kept by the principal investigator and the other one-handed to the participant.

The participants were briefed about their rights and responsibilities in line with the study. Any of the participants had the right to withdraw from participating in the study at any stage of the study without prejudices. The participant only needed to pre-inform the investigator or the Vocational and Technical Department at the University of Cape Coast. Participation in the study was purely voluntarily. Hence, any participant withdrawing from the study did not incur any cost. All information provided was treated as confidential. The application was sent to the Department of Institutional Review Board for clearance. The clearance given was to guide how the data collection and ethical issues had to be handled to bridge any ethical issues. A copy of the clearance letter given is shown in Appendix B.

Sensory analysis

Sensory assessment of the sampled biscuits was conducted within 24 hours of baking in the staff common room of the Home Science Department at the Wa Senior High School. Samples of the prepared biscuits with varying codes were placed on plates in a cool, dry, well-lit, ventilated area of the Home Science Department at the Wa Senior High School. Each item was presented on its own plate. Before going on to the next coded sample, each evaluator was given a piece of bread and rinse his/her mouth with water. The items were rated on a nine-point hedonic scale (1– Like extremely, 2– Like moderately, 3–Like slightly 4-Like or dislike, 5–Like or dislike, 6–Dislike slightly, 7-Dislike very much, 8–Dislike moderately, 9–Dislike Extremely) Colour, texture, taste, odour, and overall acceptability were all assessed

Statistical Analysis

The information gathered for the three research objectives was analyzed using statistical software. ANOVA as carried out using SPSS (version 23) Turkey's multiple range test was used to separate the means, and a significance difference of 5% was recognized as significant.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Introduction

This chapter presents the result of the study. The results are in two main parts. The first part gives the biographical information of the panelists. The second part of the result presentation was on the three research objectives for the study. The research objectives include determination of nutritional composition of African locust beans pulp powder, the formulation of composite biscuits and the consumer acceptability of the developed biscuit.

Biographical Information of Panellists

The biographical information of the Panelists is presented in Table 4 and gives the gender and age of the Panelists.

Table 4: Biographical Information of Panelists

Characteristics	Frequency(n)	Percentage (%)
Gender		
Male	33	33.0
Female	67	67.0
Age (years)		
18-22	14	14.0
23-27	30	30.0
28-32	39	39.0
33-37	12	12.0
38-52	5	5.0

Source: Field data, Lenia (2021)

The female panelists were more than their male counterpart by 34, which represents 34%. The age of the panelists ranged from 18 years to 52years. Most of the panelists were between 28 -32 years old while the least were in the age bracket of 38 -52 years of age.

Majority of the panellist were adult since the adult age in Ghana is 18 years. In Ghana also, females out number males this is reflected in the composition of the sensory panel.

Research Objective One

Nutritional composition of composite Biscuits

Results of the nutritional composition of the composite biscuit formulated from the African locust beans pulp power, the results are presented in Tables 5 –8. The nutrients found in the wheat flour, locust pulp and the composite flour are indicated in the table.

Physicochemical properties of wheat, locust pulp and composite blend flour

Physicochemical properties of wheat, locust pulp flour and blend are shown in Table 5.

Dry Matter

The results indicated that dry matter content varied significantly ($p < 0.001$) among wheat, locust pulp and composition flour. Percentage dry matter of samples ranged from 89.21 - 92.59, with locust pulp obtaining the highest dry matter content, significantly different from white flour which recorded the least percentage dry matter. With regards to the composite flour of wheat and locust pulp, a blend of 25 parts of wheat flour and 75 parts of locust pulp flour had the highest dry matter content of 91.57, which was significantly higher than 50/50 (90.93%) and 75/25 (90.00%) which was the least (Table 5).

Moisture content

Moisture content of flour samples had diverse weighty (p < 0.001) (Table 5). The moisture content varied between 7.408 - 10.791 percent for locust pulp flour and wheat flour, respectively. In general, white flour (10.79) had the highest moisture content, which was higher than 75/25 (10.00%), 50/50 (9.07%), 25/75 (8.43%) and locust pulp (7.41%) (Table 5).

Ash content

There were significant differences (p <0.001) in ash content between the five flour samples. The blend of 25/75 had 3.59% ash content which was significantly greater than white flour (0.573%) which had the least ash content (Table 5). Locust pulp flour had 1.913% ash content which was significantly more than 75/25 (1.558%) but lesser than 50/50 blend, which had 2.66 ash content (Table 5).

Protein content

Significant differences (p <0.001) were observed among the flours in terms of the protein content. 50/50 composition had the highest (18.79%) protein content which was higher than 25/75 (8.21%) which had the most negligible protein content (Table 5). On the other hand, Locust pulp had 10.24 protein content whilst white flour recorded 12.06% protein and 75/25 blend had 11.48 protein content.

Fat and oil content

The amount of fat in the research samples differed considerably (p 0.001). Flour samples had fat content ranging from 0.28 to 0.99%. The maximum fat content was found in white flour (0.992%), which was significantly greater than the lowest fat content of 0.277% in locust pulp flour. Furthermore, the 75/25 flour mix had a 0.854, which was greater than the other flour blends (Table 5).

Fibre content

The result of the study indicated significant ($p < 0.001$) variation in fibre content between flour samples (Table 5). Fibre content (6.20%) was recorded by locust pulp flour which was the highest among the samples with white flour (0.43%) recording the most minor fibre content. Among the composition flour, the fibre content of the 50/50 blend was much higher than the fibre content of the 25/75 (3.58%) and 75/25 (3.24%) blends (Table 5).

Carbohydrate content

There was a statistically significant variation in carbohydrate content across the flour samples ($p > 0.001$). White flour (85.95%) had the highest carbohydrate content followed by 25/75 (83.98%), 75/25 (82.87%), locust pulp flour (81.37%) and 50/50 (78.06%) which had the least carbohydrate content as shown in Table 5.

Table 5: Proximate composition of wheat, locust pulp flour and composite flour

	Measurements						
Samples	**Dry matter (%)**	**Moisture (%)**	**Ash (%)**	**Protein (%)**	**Fat/Oil (%)**	**Fibre (%)**	**Carbohydrate (%)**
Wheat flour	89.21 **a**	10.79 **e**	0.57 **a**	10.24 **d**	0.99 **e**	0.428 **a**	85.95 **e**
Locust Pulp	92.59 **e**	7.41 **a**	1.91 **c**	12.06 **b**	0.28 **a**	6.202 **e**	81.37 **b**
75/25	90.00 **b**	10.00 **d**	1.56 **b**	8.21 **c**	0.85 **d**	3.238 **b**	82.87 **c**
50/50	90.93 **c**	9.07 **c**	2.66 **d**	11.48 **e**	0.39 **b**	3.577 **d**	78.06 **a**
25/75	91.57 **d**	8.43 **b**	3.59 **e**	13.79 **a**	0.65 **c**	5.099 **c**	83.98 **d**
ANOVA							
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
l.s.d.	0.2937	0.2937	0.1279	0.2305	0.01568	0.2083	0.3172
Cv	0.2	1.8	3.4	1.1	1.4	3.1	0.2

Where 75/25 = blend of 75 parts of wheat flour, 50/50 = blend of 50 parts of locust pulp flour and 50 parts of wheat flour, and 25 parts of locust pulp flour and 25/75 = blend of 25 parts of wheat flour and 75 parts of locust pulp flour. In row and column, the percentages affected by the same letter are not statistically significantly different at P< 0.05. Means with similar variables are insignificant whiles means with different variables are significant at 5% probability level. Source: (Lenia, 2021).

Mineral composition of wheat, locust pulp and composite blend flour

The mineral composition of wheat, locust pulp flour and bled are shown in Table 6.

Phosphorus Content

Phosphorus content among flour samples was statistically significant ($p < 0.001$) (Table 6). Locust pulp had the highest phosphorus content of 1678 µg/g, significantly higher than the phosphorus content of white flour (1361 µg/g), which was the least. Although flour blend of 25/75 had 1554 µg/g phosphorus content greater than phosphorus content of 50/50 (1542%), this was statistically insignificant but was significantly different from 75/25 (1429 µg/g) (Table 6).

Potassium Content

Significant variation ($p < 0.001$) was observed among the flours in terms of the potassium content. Locust pulp flour had the highest (6509 µg/g) potassium content which was higher than white flour (1058 µg/g) which had the least potassium content (Table 6). 25/75 on the other hand, had 5477 µg/g potassium content whilst 50/50 and 75/25 blend had 4427 and 2875 µg/g potassium content respectively (Table 6).

Sodium content

Sodium content varied significantly ($p < 0.001$) among flour samples as seen in Table 6. Locust pulp flour had the highest sodium content of 974.6 µg/g which was significantly different from the other samples except the 50/50 blend (958.6 µg/g). The composition of 50/50 had a greater sodium content (958.6 µg/g) than 25/75 (933.2 µg/g), but there was no statistical significance difference between among these two samples. Similarly, there was an insignificant difference between sodium content obtained by 25/75 and 75/25 blend samples. White flour recorded the least sodium content of 461.0 µg/g (Table 6).

Calcium content

Calcium content among flour samples ranged between 0.76 – 0.98%. Locust pulp flour had the highest calcium content of 0.98%, which was significantly different ($p < 0.001$) from 75/25 (0.76%), which had the least calcium content (Table 6). Although there was a difference in calcium content obtained by white flour (0.78%) and 75/25 (0.76%), this was not significant. Similarly, calcium content between 25/75 (0.85%) and 50/50 (0.86%) blend was insignificant.

Magnesium content

Statistical significance ($p = 0.043$) was observed in magnesium content among flour samples used for the study (Table 6). Locust pulp flour had the highest magnesium content of 0.054 % which was statistically different from 75/25 which had the least magnesium content of 0.05048%. On the other hand, magnesium content obtained by white flour (0.05%), 25/75 (0.05%) and 50/50 (0.05%) were not statistically different.

Table 6: Mineral composition of wheat, locust flour and composite flour

	Measurements				
Samples	**Phosphorus (μg/g)**	**Potassium (μg/g)**	**Sodium (μg/g)**	**Calcium (%)**	**Magnesium (%)**
Wheat flour	136 **a**	1058 **a**	461.0 **a**	0.78 **a**	0.051 **ab**
Locust Pulp	168 **d**	6509 **e**	974.6 **d**	0.98 **c**	0.054 **b**
75/25	143 **b**	2975 **b**	908.7 **b**	0.76 **a**	0.050 **a**
50/50	154 **c**	4427 **c**	958.6 **cd**	0.86 **b**	0.052 **ab**
25/75	155 **c**	5477 **d**	933.2 **b**c	0.85 **b**	0.052 **ab**
ANOVA					
p-value	<0.001	<0.001	<0.001	<0.001	0.043
l.s.d.	20.4	84.4	26.5	0.017	0.0024
cv (%)	0.7	1.1	1.7	1.1	2.5

Where 75/25 = blend of 75 parts of wheat flour, 50/50 = blend of 50 parts of locust pulp flour and 50 parts of wheat flour, and 25 parts of locust pulp flour and 25/75 = blend of 25 parts of wheat flour and 75 parts of locust pulp flour. In row and column, the percentages affected by the same letter are not statistically significantly different at P< 0.05. Means with similar variables are insignificant whiles means with different variables are significant at 5% probability level. Source: (Lenia, 2021).

Effect of Composition on Physicochemical Properties of Prepared Biscuit

Physicochemical properties of wheat and the composite biscuit are shown in Table 7.

Dry Matter

Dry matter content varied significantly ($p < 0.001$) among prepared biscuits. Wheat flour biscuit had the highest mean dry matter of 95.32% compared to 75/25 (95.32%), 25/75 (93.30%) and 50/50 (93.06%), which recorded the least. Among the composite biscuits, 75/25 composite recorded the highest mean dry matter compared to the others. Thus, dry matter of composite biscuit increased with increasing locust pulp ratio.

Moisture content

Both composite biscuit and wheat flour differed significantly ($p < 0.001$) in moisture content. The moisture content ranged between 4.68 - 6.94% for 75/25 composite biscuit and 25/75 biscuit respectively. On the other hand, wheat flour had moisture content of 5.32 whilst 50/50 composite biscuits had 6.71% respectively. An increasing trend in moisture content was observed in relation to the increased proportion of locust pulp flour.

Ash content

There were significant differences ($p <0.001$) in ash content between the wheat and composite biscuit. In general, the ash content of biscuits prepared from composite flour was relatively higher than biscuits prepared from wheat flour. Biscuit prepared from a blend of 25/75 had 3.32% ash content which was significantly greater than 50/50 (3.17%), 75/25 (2.69%) and wheat flour (2.57%) which had the least ash content.

Protein Content

In terms of protein content, there was a significant difference (p 0.001) between the biscuits. The maximum protein level of 8.09% was found in biscuits made with a 25/75 blend, which was much greater than for 50/50 (7.72%), 75/25 (7.16%), and wheat flour (7.04%). As a result, the protein level of biscuits increased as the ratio of locust pulp flour increased. Although the mean protein content of biscuits made from composite 50/50 was higher than that of 25/75, the difference was not statistically significant.

Fat and Oil Content

Composite 75/25 biscuit had the highest (22.88%) fat content which was significantly different ($p < 0.001$) from 25/75 (19.11), wheat flour (18.19%) and 50/50 (16.32%), which had the least fat content (Table 7). Insignificant variation was observed between mean fat content of wheat flour biscuit (18.19%) and 50/50 composite biscuit (16.32%).

Fibre content

The result of the study indicated significant ($p < 0.001$) variation in fibre content between biscuits prepared from flour samples (Table 7). Fibre content of biscuit samples ranged from 1.24 - 2.28%. 50/50 composite biscuit had a fibre content of 1.72 compared to wheat flour biscuit, which had 1.34 but the variation was insignificant.

Carbohydrate content

There was a statistically significant variation in carbohydrate content between the biscuit samples (p>0.001). The highest carbohydrate content was found in 25/75 composite biscuits (71.63 percent), followed by wheat flour biscuits (69.81%), 50/50 (68.25%), and 75/25 composite biscuits (66.27%).

Table 7: Effect of blending on proximate composition of composite biscuit

	Measurements						
Samples	**Dry matter (%)**	**Moisture (%)**	**Ash (%)**	**Protein (%)**	**Fat/Oil (%)**	**Fibre (%)**	**Carbohydrate (%)**
Wheat flour	95.32 **c**	5.32 **b**	2.57 **a**	7.04 **b**	18.19 **b**	1.34**a**	69.81 **c**
75/25	95.32 **c**	4.68 **a**	2.69 **a**	7.16 **b**	22.08 **d**	1.24 **a**	66.27 **a**
50/50	93.06 **a**	6.71 **c**	3.17 **b**	7.72 **a**	16.32 **a**	1.72 **b**	68.25 **b**
25/75	93.30 **a**	6.94 **c**	3.32 **b**	8.09 **c**	19.11 **c**	2.28 **c**	71.63 **d**
ANOVA							
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
l.s.d.	0.22	0.22	0.13	0.098	0.199	0.096	0.324
Cv	0.1	2	2.3	0.7	0.6	3.1	0.2

Where 75/25 = blend of 75 parts of wheat flour, 50/50 = blend of 50 parts of locust pulp flour and 50 parts of wheat flour, and 25 parts of locust pulp flour and 25/75 = blend of 25 parts of wheat flour and 75 parts of locust pulp flour. In row and column, the percentages affected by the same letter are not statistically significantly different at P< 0.05. Means with similar variables are insignificant whiles means with different variables are significant at 5% probability level. Source: (Lenia, 2021).

Effect of Composition on Mineral Properties of Prepared Biscuit

Phosphorus content

Significant variation ($p < 0.001$) was observed in phosphorus content among biscuits prepared from wheat and composite flour as seen in Table 8. The 25/75 composite biscuit had the highest phosphorus content of 1680 µg/g compared to the 75/25 composite biscuit which recorded the least phosphorus content of 1376 µg/g. Thus, the phosphorus content of composite biscuits increased with decreasing locust pulp flour content. Although phosphorus content varied among the biscuits minor variation existed between the mean phosphorus content of the composite 50/50 (1680 µg/g) and 25/75 (1697 µg/g). On the other hand, biscuit prepared from wheat flour had a phosphorus content of 1528 µg/g, which was statistically different from the other biscuit samples.

Potassium Content

The potassium content of all the biscuits prepared varied significantly ($p < 0.001$) from each other as seen in Table 8. Potassium content varied between 1326 - 3259 µg/g for wheat flour and composite 25/75 biscuit respectively. Composite 75/25 and 50/50 had 1942 and 2776 µg/g potassium content, respectively.

Sodium Content

There was a significant difference between the sodium content of the 25/75 composite biscuit and the other four biscuits which did not show any significant difference in the sodium content. The sodium content of 25/75 composite biscuit was 990.5 µg/g whilst those of the other biscuits ranged between 859.1 µg/g, and 885.8 µg/g as shown in table 8.

Calcium Content

Calcium content varied significantly ($p < 0.001$) among biscuit samples (Table 8). Calcium content ranged from 0.6441 – 0.8141 per cent. Calcium content of biscuit prepared from wheat flour was 0.7034 but was not statistically significant from 50/50 composite which had calcium content of 0.6925. Composite 75/25 had the least calcium content and as statistically lower than the other samples.

Magnesium Content

The wheat flour biscuit had the lowest magnesium content of 0.048% though this was not significantly different from the 75 wheat/25 locust composite biscuit. The others recorded slightly high magnesium content as shown in Table 8.

Table 8: Effect of blending on mineral composition of composite biscuit

	Measurements				
Samples	**Phosphorus (µg/g)**	**Potassium (µg/g)**	**Sodium (µg/g)**	**Calcium (%)**	**Magnesium (%)**
Wheat flour	1528 **b**	1326 **a**	859.1 **a**	0.70 **b**	0.048 **a**
75/25	1376 **a**	1942 **b**	862.7 **a**	0.64 **a**	0.049 **a**
50/50	1680 **c**	2776 **c**	885.8 **a**	0.69 **b**	0.051 **ab**
25/75	1697 **c**	3259 **d**	990.5 **b**	0.81 **c**	0.054 **b**
ANOVA					
p-value	<0.001	<0.001	<0.001	<0.001	0.004
l.s.d.	41.5	98.4	32.24	0.031	0.003
Cv	1.4	2.2	1.9	2.3	3.2

Where 75/25 = blend of 75 parts of wheat flour, 50/50 = blend of 50 parts of locust pulp flour and 50 parts of wheat flour, and 25 parts of locust pulp flour and 25/75 = blend of 25 parts of wheat flour and 75 parts of locust pulp flour. In row and column, the percentages affected by the same letter are not statistically significantly different at P< 0.05. Means with similar variables are insignificant whiles means with different variables are significant at 5% probability level. Source: (Lenia, 2021).

Research Objective Two

Formulation of composite biscuits from wheat and African locust beans pulp powder

Composite biscuits from African locust bean pulp and wheat flour were formulated. The varied biscuits' formulation was done according to the ratio proposed in the Methodology chapter of this study. The formulations were done from the composite flour milled in Wa Municipality. The flow diagram for the preparation of biscuits has been shown in Figure 13 in the methodology section. The formulated biscuits for the various ratios have been presented in Figure 9.

Figure 9: Pictures of various biscuits prepared from both wheat and composite locust and wheat flour. Where, A) 100% wheat flour; B) 50% Wheat + 50% ALBP flour; C) 75% wheat flour + 25% ALBP and D) 25%. Source (Lenai, 2021).

Research Objective Three

Effect of blending on sensory parameters of wheat and composite biscuit

Results of sensory evaluation of the present study is shown in Figure 10A-F.

Appearance

Biscuit prepared from wheat as well as composite biscuits was scored for appearance. The study results revealed that the vast majority (53.4%) of the respondents accepted the appearance of biscuit prepared with 100 percent wheat whilst 42.2% and 38.5% immensely liked the appearance of 50/50 25/75 biscuit samples respectively. At the other extreme, 5.5 percent of the panellist disliked samples prepared from 75/25 wheat and parkia flour, 8.2 percent disliked sample 50/50 and 1.4 percent disliked samples 100 percent wheat and 25/75 respectively. Regarding composite biscuit samples, 13.7% of panellists neither liked nor disliked sample 25/75, 21.9 per cent for sample 75/25 and 2.7% for sample 50/50.

Flavour

A product's flavor contributes to its overall quality; flavor is one of the most important factors for most consumers when purchasing a product. The flavour of prepared biscuit samples increased with growing content of parkia flour. In general, the highest percentage (42.5) of panelist extremely liked the biscuit prepared with 25/75 flour blend followed by 100 per cent wheat (39.3%), 50/50 (37.5) and 75/25 (27.4%) which had the least score for flavour. On the other hand, 23.3% of panelists were uncertain about sample 75/25, 21.9% for 100 percent wheat, 20.5% for 50/50 biscuit sample and 12.3 for 25/75 composite biscuit.

Taste

The results showed 38.8% of panelists liked the 25/75 sample very much, 45.2% liked sample 50/50 slightly, 20.4 percent neither liked nor disliked sample 25/75, 8.2 disliked sample 50/50 and 11 disliked biscuit prepared form 25/75 flour blend. Despite this, majority of panelist were satisfied with the taste of the composite biscuits.

Crispiness

Biscuit prepared from wheat as well as composite biscuits were scored for crispiness. The study results indicated that the majority (44.2%) of the respondents were satisfied with the crispiness of biscuits prepared from 25/75 flour blend whilst 35.6% and 34.2% extremely liked the crispiness of 100 percent wheat biscuit and 50/50 biscuit samples extremely. At the other extreme, 4.1 percent of the panelist disliked the sample prepared from 25/75 wheat and parkia flour, 2.7 percent disliked biscuit samples prepared with 100 percent flour and 1.4 percent disliked samples 75/25 and 50/50 respectively. Concerning blended biscuit samples, 12.3% of panelists neither liked nor disliked sample 25/75, 20.5 percent for sample 75/25 and 16.4% for sample 50/50.

Texture

Product texture influences consumer purchasing decisions, and the texture of a food product can affect the food's overall quality after manufacture. The study's findings revealed that the texture of the biscuits varies significantly. When compared to wheat flour biscuits, samples enhanced with locust wheat flour obtained the highest texture score (47.9). Among composite biscuit sample, 25/75 had the highest mean score of the texture of 46% compared to 50/50 and 75/25 which had texture values of 34.2 and 31.5 respectively for likeness.

Acceptability

Acceptability was higher among biscuits prepared from wheat flour supplemented with locust pulp flour. Overall acceptability score was significantly different among study samples. Vast majority of panelist (46.5%) liked biscuit prepared with 25/75 parts of wheat and parkia flour very much, 43.8% liked biscuits prepared from sample 50/50. Thus, in general, the overall acceptability of samples increased with increasing parkia flour content. 54.7 percent, on the other hand liked the biscuit prepared with 100 percent wheat whilst 13.5% and 16.4% neither liked nor disliked sample 100 percent wheat and 75/25 biscuit.

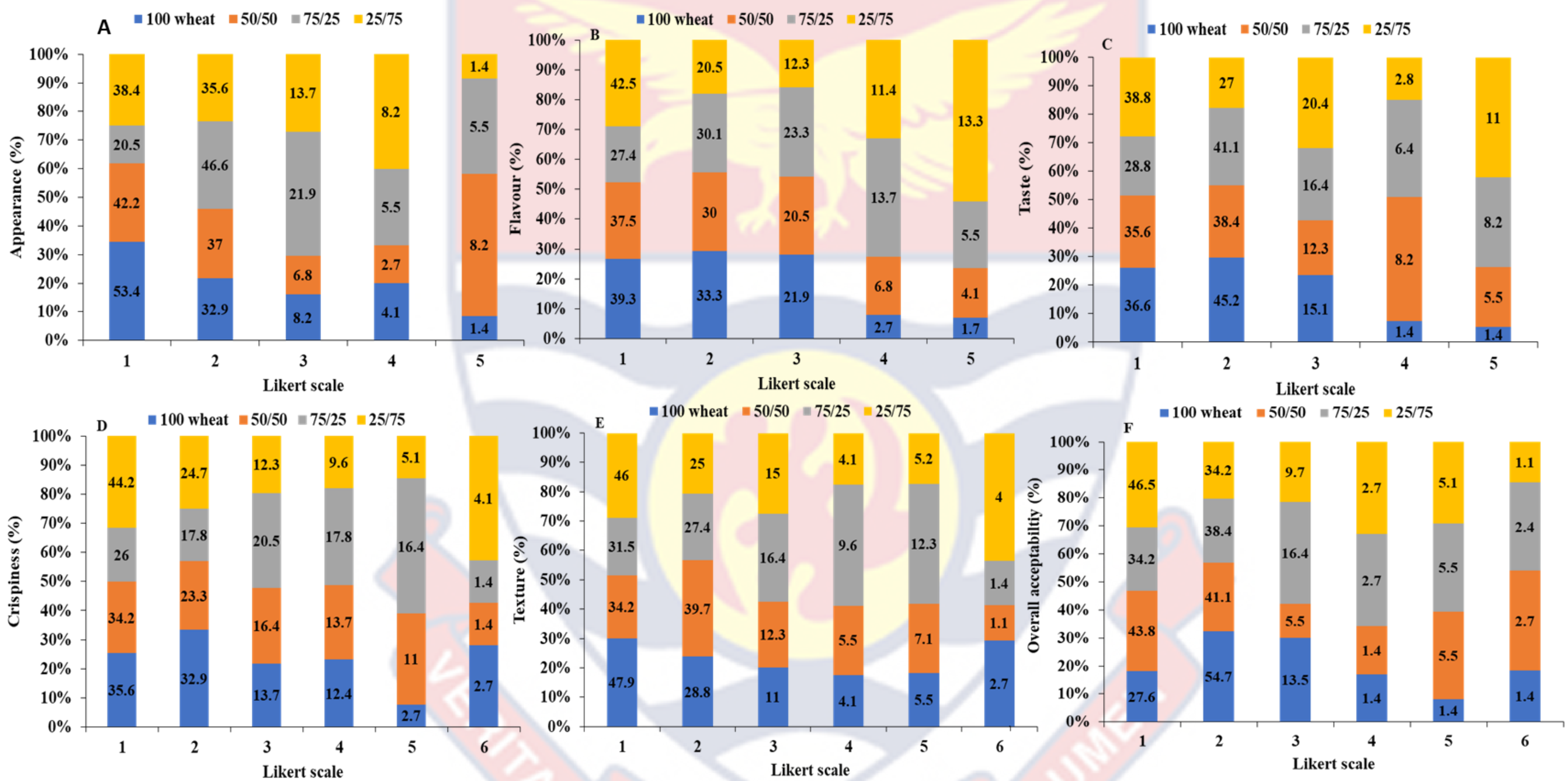

Figure 10: Sensory evaluation of wheat and composite biscuits. Where A) Appearance; B) Flavour; C) Taste; D) Crispiness; E) Texture and F) Overall acceptability of prepared biscuits. Source: (Lenia, 2021).

Discussion

Physiochemical properties of wheat, locust pulp and composite flour

The dry matter content of a product is a better indicator of the product's nutrient content. The proximate analysis of the study revealed that the dry matter content of both locust pulp flour and composite flour was greater compared to wheat flour. The dry matter content of locust pulp found in the present study is similar to that reported by Alabi et al. (2005). The testa (covering tissue) of Parkia have been shown to have high dry matter content (Alabi et al., (2005) compared to the other parts of the plant. This accounts for high dry matter observed since locust flour was prepared using the covering of the plant. Similarly, the results of this study corroborate with Sackey and Kwaw (2013), who reported dry matter for Parkia flour to be 77 - 81 percent. Kwari and Igwebuike (2002) has reported the dry matter content of African locust bean pulp (*Parkia biglobosa*) to range from 90.48 to 91.1 percent whilst (Olujobi, 2012) and Bello et al. (2008) has reported 87 percent dry matter content.

The moistness content of fresh materials plays a key role in establishing the final moisture level of mix juice (Aderinola & Abaire, 2019). Wheat flour has a higher moisture content than composite and locust pulp flours, according to the proximate composition of wheat, locust pulp, and composite flour found in the present study. The increasing moisture level of the composite flour substituted with locust pulp flour could be a reflection of its composition, which has been estimated to be around 11.9 percent (Dahouenon-Ahoussi et al., 2012). It's possible that the high sugar content of locust bean fruit pulp flour contributed to the composite's higher moisture content. (Zakari et al., 2020). The moisture value for Parkia pulp flour obtained in this study is in agreement with the moisture content of milled Parkia flour (7.7 percent) reported by Stadlmayr (2012). The value of moisture obtained was within the limit of 4 % - 12 % reported by Olayemi (2008). The low moisture content of the fruit pulp also indicates better shelf stability and quality of the flour. According to Gernah et al. (2007) flours with low moisture content can be stored in an airtight container for a long period without spoiling.

The ash content of composite flour increased significantly with increasing levels of Parkia pulp flour. The ash content of Parkia flour obtained in the study is lower than the percentage (3.94 - 4.50) ash reported by Olujobi (2012) but within the range for most legumes (1.9 % - 5.0 %) as reported by Gernah et al (2007). The increased ash concentration in the composite flour reveals that Parkia flour has a higher ash content than wheat flour. The level reported by Zakari et al. (2015) during their investigation on qualitative features of African locust bean fruit pulp cakes is similar to the ash content of composite flour obtained in the present study. Ash content is a commonly applied parameter for the detection of impurities adulteration and substitution.

The protein content for the Parkia pulp flour was higher than the protein content of wheat flour. A similar result was obtained by Sankhon et al. (2013) who during their studies recorded high protein content in Parkia flour compared to wheat flour. The protein content of parkia pulp flour and composite flour obtained during the study is similar to the percentage protein (9.33 – 10.88) reported by

Sackey and Kwaw (2013). However, the protein found in the locust pulp flour and composites was higher than the 4.29 % reported by Dahouenon-Ahoussi et al. (2012) and comparable to 6.56 % reported Gernah et al. (2007). The high protein quantity of the composite flour may be attributed to parkia being a good source of protein and being a member of the Leguminosae family. The current findings are consistent with those of Adeloye and Agboola (2020), who found that when parkia was used to augment orange in juice preparation, the protein content of the juice increased from 1.35 percent to 12.37 percent. According to Okaka (2005), cereals like wheat flour are low in protein and lysine but high in Parkia, which is high in lysine with about 22.56 percent crude protein and a good balance of other essential amino acids. Thus, parkia supplemented flour will improve protein content and quality, resulting in a higher nutritional value that will help reduce protein-energy malnutrition.

Generally, the fat content of locust pulp flour (0.27) found in the present study was relatively low during the study. However, when compared to the value obtained by Sankhon et al., (2013) the fat content reported during the investigation was relatively high. This discrepancy could be attributable to differences in parkia's proximate composition in regard to portions employed in flour preparation. Also, the fat content of composite flours decreased with increasing locust flour due to low-fat content of parkia pulp. The value obtained is in conformity with those reported for most legumes. Ihekoronye and Ngoddy (1985) reported that most legumes have less than 3.0 % fat, with lentils having as low as 0.60 percent. This low fat level indicates that the fruit pulp can be stored for long periods of time at the proper temperature and moisture without succumbing to rancidification, which is common in legumes.

Results on the chemical composition of study samples revealed that flour prepared from locust pulp had the highest crude fibre content compared to wheat flour. The percentage crude fibre recorded for the parkia pulp flour was higher than the value reported by Sankhon et al. (2013). The fibre content of the composite flour was similar to those reported by Sankhon et al. (2013). The Parkia flour supplemented had a considerable increase in crude fiber content. The increase in these proximal characteristics may be attributable to their abundance in Parkia flour, this is in line to Sankhon et al (2013).

Carbohydrate content of wheat flour was greater than locust pulp flour and the composite flour. The result agrees with Sankhon et al. (2013), who observed higher carbohydrate content in wheat flour than parkia and composite flour during their study. The carbohydrate content of the parkia flour (81 %) recorded in this study was higher than the value (57.01) reported by Sankhon et al. (2013). Parkia flour and composite flour have a low carbohydrate content and a high fiber content, which promotes colon digestion and reduces constipation, which is typically associated with refined grain flour products (Elleuch et al., 2011; Slavin, 2005).

Mineral composition of prepared wheat, locust pulp and composite flour

Minerals are essential parts of the human diet because they work as cofactors in a variety of physiological and metabolic processes. Parkia has been reported to have a high mineral content, including calcium, magnesium, potassium, phosphorus, and iron (Kamisah, Othman, 2013). The phosphorus content of locust pulp flour and composite flour was higher compared to the phosphorus content of wheat flour. The phosphorus content in parkia pulp flour obtained during the study was higher than the value reported by Emmanuel Iheke et al. (2017). Such variation might be due to the procedure used in the processing of the parkia flour. The increasing trend of phosphorus level observed in composite flour was due to high phosphorus found in parkia flour.

Potassium is required to maintain bodily fluid volume and osmotic balance. The potassium content of locust and composite flour observed was significantly high compared to wheat flour. Bello et al. (2008) reported a potassium content of 3945mg/kg for Parkia fruit pulp. The high potassium content of parkia have been reported by Dahouenon-Ahoussi et al. (2013) and Iheke et al. (2017). However, potassium content obtained in the present study was more than the values reported by Dao et al. (2021) and Bello et al. (2008). High potassium content accounts for the increasing potassium content of the composite flour observed in relation to increasing locust flour content.

Sodium is required for the proper functioning of body fluids as well as the upkeep of electric potential in body tissue (Iheke et al., 2017). Bello et al. (2008) reported sodium content of 1795mg/kg for Parkia fruit pulp which is higher than the value of sodium obtained in the present study by for both locust and composite flour. The calcium content of composite flour increased as the locust flour ratio was raised. Iheke et al. (2017) claim that locust flour is a good source of calcium, during their study on the effect of fermentation on the physicochemical properties and nutritionally valued minerals of locust bean (*Parkiabiglobosa*). The present study results agree with the aforementioned since locust pulp flour had 0.98% calcium, which was significantly higher than the calcium content of wheat flour.

Magnesium is indispensable for the proper functioning of over 300 enzymes in the body, and it is involved in a number of important physiological processes such as glucose homeostasis and the maintenance of good health. Magnesium relaxes the muscles that lining the lungs' airways, making breathing easier for asthma patients. The locust flour contains 0.054 percent magnesium, according to chemical analysis, yet Parkia fruit pulp has a magnesium level of 7000 mg/kg, according to Bello et al. (2008). A direct relationship was observed between magnesium content of composite flour with increasing ratio of locust pulp flour. The ash content shows high levels of minerals contained in the composite sample of biscuits.

Effect of composition on physicochemical properties biscuits

Dry matter content of biscuits prepared from wheat flour had the highest dry matter content compared to biscuit prepared from composite flour. This could be attributed to wheat flour's high initial dry matter percentage. However, the dry matter content of biscuits prepared from composite flour increased with increasing content of locust fruit pulp flour. The results of the present study are in agreement with Sackey and Kwaw (2014) who, during their studies on nutritional and sensory analysis of *Parkia biglobosa* (dawadawa) based cookies reported that, wheat flour cookies had the highest dry matter; however, addition of parkia flour improved the dry matter content of cookies.

Moisture content of the composite biscuits increased with increasing locust pulp flour. Thus, there was a direct relationship between moisture content of biscuit and increasing level of parkia flour. The rise in moisture content can be accredited to the elevated water content of locust pulp flour. Similarly, Zakari and Ndife (2015) reported an increasing trend in moisture content of cakes with an increasing ratio of parkia fruit pulp flour with wheat flour. Also, the moisture content of composite biscuit samples ranged from 1.63 to 3.13 and increases with the increased addition of African locust pulp flour (Olatoye et al., 2019). Low moisture content is desirable as inhibits the growth of spoilage microorganisms and promote shelf stability (Olatoye et al., 2018).

The amount of ash in flour has an impact on its quality. Composite biscuits have a lot of ash, which indicates that they have a lot of minerals in them. By providing a dark color to completed products, ash influences color. The ash level of biscuits increased as the quantity of locust pulp flour increased in the current investigation. Parkia fruit has a high ash content, indicating that it is a good source of minerals (Zakari et al., 2015).

Dietary proteins are necessary for the natural production and maintenance of human tissues, enzymes, hormones, and other compounds that are necessary for optimal functioning (Hayat et al., 2014). With increasing locust pulp flour quantity, the protein level of the resulting biscuit increased. This could be explained by the fact that parkia biglobosa is high in protein and belongs to the

Leguminosae family. The protein concentration of parkia-orange juice was comparable to that found in parkia pulp extracts (Bot et al., 2013), but other researchers found lower levels (Afolayan et al., 2014; Sotolu & Byanyiko, 2010). The result of the present study contradicts the findings of Zakari and Ndife (2015), who reported a decreasing trend in protein with increasing substitution of Parkia flour with wheat flour. Such variation could be accounted by the difference in part of parkia fruit used for the preparation of flour since the physicochemical properties of parkia fruit differs with parts of the plant.

The pulp of locust beans is high in dietary fiber, important vitamins, minerals, and phytochemicals like flavonoids, phenols, and carotenoids (Gernah et al., 2007). Based on the crude fiber content, locust pulp flour could be effective for supplementing cereal diets. This is due to the fact that fruits contain more soluble fiber than grains (Okoye et al., 2008). The percentage fibre of the biscuits increased significantly in relation to an increasing percentage of locust pulp flour. Fibre content increased significantly as the percentage of parkia juice in the blends increased (Adeloye & Agboola, 2020). An increasing trend in percentage fibre of cookies prepared from composite locust pulp flour and wheat flour have been reported by Sackey and Kwaw (2013) the percentage of locust pulp flour increased.

In general, the fat content of composite biscuits was relatively high compared to biscuit prepared from wheat flour. Fat content increased with an increasing proportion of parkia pulp flour. Sackey and Kwaw (2013) observed similar findings in their nutritional and sensory analyses of Parkia biglobosa (dawadawa)-based cookies. Adeloye and Agboola (2020) found a rise in fat content with an increasing percentage of parkia juice in their studies on bioactive characteristics, Orange and African locust bean juice blends' chemical composition and sensory acceptance (Parkia biglobosa).

Effect of composition on mineral content of biscuits

Phosphorus (P), which occurs in a mass ratio of 1 phosphorus to 2 calcium, is an important component of bone mineral (Akubor, 2016). Phosphorus content of the biscuit increased with increasing content of locust pulp flour substitution. This could be because of high initial content of phosphorus in locust pulp flour used in blend. Because a high amount of ash shows a high mineral content, the high phosphorus content of biscuits made from composite flour could be attributed to the high ash content of parkia flour. High phosphorus content of locust pulp flour has been reported by (Akubor, 2016).

A significant increase in potassium content of biscuit was observed with increasing percentage of locust pulp flour. Bello et al. (2008) reported a potassium content of 3945mg/kg; for Parkia fruit pulp. Hence increasing trend in potassium content of composite with increasing locust pulp flour content could be attributed to the high potassium content of the flour (Akubor, 2016). Olatoye et al. (2019) reported a substantial amount of potassium in biscuit prepared from cassava, wheat and parkia flour blend; however, an insignificant variation was observed between the potassium content of composite biscuit and control biscuit. However, the result of the present study showed the opposite trend, which could be due to variation in baking conditions used by the various studies.

With a higher percentage of locust pulp flour in composite biscuits, the calcium content increased. Because the locust pulp flour used in the study had a high calcium content, composite biscuits had a high calcium load. Bello et al. (2008) reported a 11650mg/kg calcium content for Parkia fruit pulp. The calcium content of composite bread is increased when wheat flour is partially replaced with flour from locally grown grain legumes (Oladele & Aina, 2009). Calcium is involved in most phosphate transfer reactions and is thought to be necessary for the structural integrity of nucleic acid intestinal absorption. Man's magnesium shortage, on the other hand, causes severe diarrhoea, headaches, hypertension, cardiomyopathy, arteriosclerosis, and stroke (Appel, 1996).

Composite biscuits contained significantly higher magnesium than biscuits prepared from wheat flour. As the quantity of locust pulp flour increased so did the magnesium content. According to Bello et al. (2008), the magnesium content of Parkia fruit pulp is 7000mg/kg (2008). The mineral content of composite bread increases when wheat flour is partially replaced with flour from locally cultivated grain legumes (Oladele & Aina, 2009).

Sensory attributes

It's crucial to assess the appearance of composite biscuits since people who see the product from afar, even after tasting it, develop an interest in it and want to buy it. One of the most important quality factors that buyers value is color or look. The yellow color of parkia flour, which improves the appearance of baked biscuits, was credited with the highest appearance score attained during the trial. The seeds are trapped in the Parkia fruit's yellow dry powdery fruit pulp.

Therefore, it suggests that parkia flour could be used as an organic colorant in the food industry in both juice and food preparation to reduce the use of various synthetic colourants related to health risks. The current study's findings corroborate with Adeloye and Agboola's (2020) who posited that the yellow colour of the parkia makes it more attractive and appealing to consumers (Adeloye & Agboola, 2020). A similar result was observed by Adeloye and Agboola(2020) studied the bioactive characteristics, chemical composition, and sensory acceptance of orange and African locust bean juice blends. They reported in their sensory score an increase in appearance (colour) with increasing parkia concentration. Similarly, Sackey and Kwaw (2013) reported an increase in the colour of parkia based cookies with increasing parkia concentration.

Panel scoring on taste revealed an increase in taste with an increasing percentage of parkia flour compared to wheat flour composition. Such a trend could be attributed to the high sugar content of parkia, which tends to improve the taste of biscuits, making it preferable to biscuits with higher levels of wheat flour. Thus, the parkia blended biscuit had the highest sensory score. Probably as a result of the allure of parkia's high sugar content. This implies that parkia flour could be improved and used as a natural sweetener in the food industry which will be of paramount importance for patients diagnosed with high blood sugar levels and diabetics. Parkia is strong in highly digestible carbohydrates, such as natural sugars (Gernah et al., 2007), which contribute to its sweet flavor, dietary fiber, vitamins, and minerals.

The overall acceptability of the biscuit samples was high for biscuits prepared with an increased proportion of parkia flour. This might be attributed to the appearance, crispiness, taste and texture of the parkia-wheat blend biscuit. This shows that consumers prefer Parkia supplemented biscuit to wheat prepared biscuits and that would buy the composite biscuits if commercially available. Sackey and Kwaw (2013) also showed that as the preparation of dawadawa flour to wheat flour increases, the panel liking of the product increased. Similarly, Adeloye and Agboola(2020) reported an increase in overall acceptability of Parkia-orange juice with increasing concentration of parkia. These observations could be due to the sweetness of parkia, which improves the taste of the biscuit. The acceptability of composite biscuits with their enrichment with necessary mineral content make them potentially valuable for use in the creation of a variety of confectioneries. It will play a paramount role in solving malnutritional problems especially protein malnutrition in deprived regions.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview of the Study

Consumption of African locust bean fruit is typical in the Northern Region of Ghana. Children and adults go to the wild for such fruits when they are in season. The fruit from the African locust bean is a leguminous plant that can supply the protein and other minerals for humans. The consumption of fortified foods has become the order of the day, given its role in alleviating malnutrition. Biscuits are widely consumed by both adults and children. The use of the nutritious African locust beans pulp to fortify wheat flour to bake biscuits was therefore considered as a suitable strategy for reducing malnutrition in the Northern Region of Ghana and even reduce the price of biscuits making it more affordability. The use of composite flour as in the study would bring many benefits to the people in the Northern Region and other parts of Ghana. The study had three research objectives anchored on the relevant theoretical framework and empirical literature.

The formulations of the biscuits were based on three different ratio combinations. Actual experimental research was used in the study as the flour from African locust bean pulp and wheat were to be varied to see their impact on the composite biscuit. The formulated biscuits were evaluated by sensory panel to determine their acceptability.

Summary of Key Findings

1. Proximate composition of the composite flours showed that dietary protein (12%), fibre (6.2%), dry matter (92.59%) and ash (1.9%) were higher in locust pulp flour compared to the wheat flour except for fat and oil.
2. Minerals such as phosphorus (1678 µg/g), calcium (0.975 µg/g) and sodium (974.6 µg/g) were high in locust pulp flour compared to the wheat flour. Similarly, the composite biscuits had higher nutrient composition compared to the control sample.
3. Mineral content was significantly ($p < 0.001$) different among composite biscuits. Phosphorus, calcium, sodium, and magnesium content increased with increased locust pulp flour, with sample 25 percent wheat and 75 percent locust flour had the highest mineral content.
4. Biscuits were successfully formulated from the African locust pulp flour with three ratios; 100 percent wheat flour, 50 percent wheat flour: 50 percent locust flour, 75 percent wheat flour: 25 percent locust flour and 25 percent wheat flour:75 locust pulp flour.
5. The acceptability of prepared biscuit samples was high for biscuits prepared with an increased proportion of parkia flour.

Conclusions

Consumer demand for high-quality, nutritious food is increasing, despite the lack of key amino acids like lysine, tryptophan, and threonine in wheat flour, which is often used to make cookies and pastries. Supplementing wheat flour with locust pulp flour, on the other hand, could improve the nutritious quality of baked goods like biscuits. In this context, a study was carried out to assess the nutritional value of composite wheat and locust pulp flour and biscuits in order to improve the goods' sensory and nutritional characteristics. Based on the study's findings, the following conclusions were reached.

Wheat and locust pulp flour differed in their nutritional composition and this was reflected in the nutritional composition of composite flour with an increasing proportion of locust pulp flour significantly increasing the level of dietary protein and minerals including phosphorus, calcium, sodium, potassium. Composite flour constituting 75% locust flour and 25% wheat flour had the highest value for most of the nutrients including the micronutrients.

On the 9-point hedonic scale, respondents were able to appropriately identify between the various samples in terms of sensory qualities. Sample consisting of 75% locust pulp flour and 25% wheat flour, on the other hand, received the highest total score for sensory qualities. Composite biscuits received positive feedback from the panel, indicating that the locust pulp flour has novel fortification potential. The sensory acceptability of the juice blends, as well as their mineral compound enrichment, make them potentially useful in the production of functional cookies.

Recommendation

This study has shown that there is an improvement of the nutritional quality biscuit when part of wheat flour is substituted with African locust pulp flour, a cheap and available source of protein. However, the following recommendations are made:

1. Further studies should be conducted on how various processing techniques/unit operators affect the nutritional, mineral content and the shelf life of locust pulp flour since various processing factors (temperature, moisture, humidity etc.) have been reported to affect such products.
2. The contribution of the African Locust flour to the increase or decrease in the vitamin content of the composite biscuit should be studied.

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APPENDICES

APPENDIX A

SENSORY QUESTIONNAIRE PANELISTS

UNIVERSITY OF CAPE COAST

FACULTY OF EDUCATION

DEPARTMENT OF VACATIONAL AND TECHNICAL EDUCATION

The series of questions in this questionnaire forms part of a research conducted in the Department of Vocational and Technical Education, UCC to assess the "*Nuttritional Composition and Consumer Acceptability of African Locust Beans Fruit Pulp Biscuit in Wa Municipality*". This study is entirely voluntary, and all participants will remain anonymous. All information provided will be treated as confidential, and the results will be presented in such a way that no individual will be identified.

Date ………………….   Panelist ID ……………..

A: Biographical Information of Respondent

Please **tick** [√]

Gender: Male [ ]   Female [ ]

Age (years): 15-20 [ ]   21-25 [ ]   26-30 [ ]   31-35 [ ]   36-40 [ ]   41-45 [ ]

B: Sensory appraisal of samples

Please you have been presented with four (4) coded samples. Kindly assess the samples based on your degree of likeness for the following listed attributes using the scale shown below. Please taste where appropriate then rinse your mouth with water provided before going to the next sample.

Sample A

Sample A=100%		Appearance	Flavour	Taste	Crispiness	Texture/ mouth-feel	Overall Acceptability
1	Like extremely						
2	Like very much						
3	Like moderately						
4	Like slightly						
5	Like or dislike						
6	Dislike slightly						
7	Dislike very much						
8	Dislike moderately						
9	Dislike Extremely						

Sample B

Sample B=75/25%		Appearance	Flavour	Taste	Crispiness	Texture/ mouth-feel	Overall Acceptability
1	Like extremely						
2	Like very much						
3	Like moderately						
4	Like slightly						
5	Like or dislike						
6	Dislike slightly						
7	Dislike very much						
8	Dislike moderately						
9	Dislike Extremely						

Sample C

Sample C=50/50%		Appearance	Flavour	Taste	Crispiness	Texture/ mouth-feel	Overall Acceptability
1	Like extremely						
2	Like very much						
3	Like moderately						
4	Like slightly						
5	Like or dislike						
6	Dislike slightly						
7	Dislike very much						
8	Dislike moderately						
9	Dislike Extremely						

Sample D

Sample D=25/75%		Appearance	Flavour	Taste	Crispiness	Texture/ mouth-feel	Overall Acceptability
1	Like extremely						
2	Like very much						
3	Like moderately						
4	Like slightly						
5	Like or dislike						
6	Dislike slightly						
7	Dislike very much						
8	Dislike moderately						
9	Dislike Extremely						

APPENDIX C

CONDUCTING PROXIMATE ANALYSIS IN UCC LABORATORY


APPENDIX D

SENSORY EVALUATION BY PANELIST