UNIVERSITY OF CAPE COAST

DEPARTMENT OF VOCATIONAL AND TECHNICAL EDUCATION

FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION

COLLEGE OF EDUCATIONAL STUDIES

DEVELOPMENT AND CONSUMER ACCEPTABILITY OF LOCUST BEANS AND GROUNDNUT (LOGROUND) SPREAD

MONICA MENSAH ANKOMAH

2024

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BY

MONICA MENSAH ANKOMAH

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

JUNE 2024

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: 5/07/2024

Name: Monica Mensah Ankomah

Supervisors' Declaration

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

Principal Supervisor's Signature: ………………………… Date: 5/07/2024.

Name: Prof. (Mrs) Sarah Darkwa

ABSTRACT

Spread of various ingredients have dominated the Ghanaian market creating jobs for other outside Ghana. The purpose of the study was to develop spread from underutilized legumes and beans in Ghana for bread, etc. The study came out of three research objectives and two hypotheses of the possibility to use groundnut and locust beans indigenous in the Northern Ghana for spread formulation. Relevant literature was reviewed to guide and support findings from the study. The study adopted true experimental research design and the hedonic scale for sensory evaluation. The products developed from groundnuts and locust beans were sensorily evaluated by selected 100 panellists. Appropriate statistical tools were used from the IBM-SPSS version 25 for Windows to aid the data analysis. The results showed that groundnuts and locust beans could be used to develop spread formulation i.e., Groundnut and Locust spread (GALS, 50:50), Groundnut with Locust spread (GWLS, 75:25) and Locust with Groundnut Spread (LWGS, 75:25). The proximate composition i.e., dry matter, moisture, ash, protein, oil/fat, fibre and carbohydrate were determined. The proximate values for each formulation differed and in most cases in the control formulation (groundnut paste). The sensory evaluation showed that the control formulation coded (GS, 100% groundnut) was the most accepted formulation (LWGS<GALS<GWLS<GS). There was a statistically significant difference in the nutritional composition in the three formulations ($p<0.05$) and the second hypothesis showed that, there was statistically significant difference in the consumer acceptability of the three spreads ($p<0.005$). The study revealed that, overall acceptability decreased with increased proportion of locust beans in the spread.

KEYWORDS

Locust beans

Product development

Proximate analysis

Spread

Sensory evaluation

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This work could not have been completed without guidance and extrinsic motivation from varied people in the academia and outside the academia. Without the support of some people, this thesis could not have been completed. First and foremost, I want to express my profound gratitude to the Almighty God for giving me the courage to complete this study.

My sincere gratitude also goes out to Prof. (Mrs.) Sarah Darkwa, my supervisor, for her help and direction and patience to tailor my thesis to best of shape, form and acceptability to the University of Cape Coast as partial fulfilment of my programme. My appreciation also goes out to the following people who helped in making this thesis come to fruition in different ways: Mr. Stephen Adu, Mr. Addoh Dekyi Richmond, and Mr. Cosmos K. Nutakor; your efforts were commendable. I do truly appreciate the panellists who volunteered to have offered themselves during data collection in terms of the sensory evaluation to test the acceptability of the formulations.

DEDICATION

To my husband Ing. Daniel Apraku.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

Background to the Study

People have recently become more conscious of their health, particularly when it comes to what they eat and its impact on their health. This has given rise to a desire for variety in what people consume on a daily basis. As nutritionists, it has also become increasingly important for us to be very innovative with food. Food innovation is defined as the creation and commercialization of completely new or modified food products, services, or processes. Improved foods can be created by reducing the amount of certain ingredients, adding new ones, or swapping out traditional ingredients with others. Manufacturers can offer healthier options to an increasing number of consumers interested in eating a balanced diet by reformulating their products (Rabadán, 2021).

The importance of plant seeds and nuts in human nutrition cannot be overstated. Plant seeds are considered highly nutritious because they contain essential macro and micronutrients that, when consumed in sufficient quantities, provide the body with the nutrients it requires.Nuts and seeds have been part of diets worldwide for millennia. Nuts and seeds are highly nutrient-dense dietary components, rich in macronutrients including monounsaturated fatty acids and polyunsaturated fatty acid, proteins, and fibers . They are also rich in vitamins and minerals, and a range of active metabolites such as phenolic acids, phytosterols, carotenoids, and polyphenolic compounds (Rajiv Balakrishna, 2022).

Parkia biglobosa (African locust bean, monkey cutlass tree, two ball nitta-tree, fern leaf [English]; néré, nerre, arbre à farine, caroubier africain [French]; Farroba [Portuguese]; néré [Bambara]; dosso [Djerma]; runo [Kanouri]; rouaga [More]; netto, nété, nér [Mandika]; dawa-dawa, dawadawa, dadawa, ogiri okpi [Igbo]; narghi [Fulani]; netetou [Gambia]; kinds [Sierra Leone]; dours [Sudan]; mnienze, mkunde [Swahili]), named by Robert Brown after the famous Scottish botanist and surgeon Mungo Park, has long been recognized as an important indigenous multipurpose plant.

Many countries in Sub-Saharan Africa have fruit trees. The African locust bean tree is its scientific name.The tree yields a natural nutritious condiment that is commonly found in the traditional diets of both rural and urban residents in at least seventeen West African countries, including Nigeria (Sadiku & Ayodele, 2010). *Parkia biglobosa* is a deciduous tree with a very broad crown that can grow to a height of 20 meters.The species grows in a variety of environments, including those with annual rainfall ranging from 600 to 1500 mm and a dry season lasting 5-7 months. It can be found in a variety of natural and semi-natural habitats, including savannahs and woodlands, as well as rocky slopes, stony ridges, and sandstone hills. Because of its deep taproot, it can withstand drought (Iretiola Builders, 2014).

Numerous studies on locust beans have concluded that they are an excellent source of essential nutrients. *Parkia biglobosa* is a vital tree in Burkina Faso, providing edible products and income to the vast majority of rural households (Termote et al., 2022). In medicines, Parkia biglobosa is used against bronchitis, pneumonia, diarrhea, violent colic, vomiting, sores and ulcers. The root of *Parkia biglobosa* when combined with leaves can be used in lotions for sore eyes, they treat diseases such as dental carries and conjunctivitis, cough, bronchitis, amoebiasis and pile (Amadou & Sankhon, 2019).

It has been identified as one of the candidates with promising therapeutic potential in the prevention, treatment, and management of a number of metabolic diseases including diabetes mellitus (Mudyiwa & Aladejana, 2020). It equally helps in stablizing blood pressure and the presence of antioxidants in it makes it capable of reducing blood sugar which affirms its potency on checking diabeties. It is also noted for aiding in the development of babies during pregnancy since it is rich in protein, calcium, iron, and other essential nutrients needed for the proper growth and development of the baby (Famojuro et al., 2023).

Fermented locust beans have been and continue to be regarded as an excellent source of nutrients for humans. The tree is highly valued for its fermentable seeds. They are fermented to make a condiment known as "dawadawa, soumbala, iru, afitin, and netetu in different West African countries," which is as pungent as French cheese (Parkouda et al 2009). This condiment, which is used to season sauces and soups, is one of the most important commercial products traded in Western Africa. The seeds are ground with moringa leaves and used in sauces and doughnuts. They can be roasted to produce a coffee substitute called "Sudan coffee"(Musara et al., 2020).

Nuts and seeds are commonly consumed as snacks in roasted form because they are tasty, convenient, and easy to eat. However, with the advent of new technologies, a plethora of nut and seed-based snacks and processed products have entered the market, with the form of butter gaining popularity.

(Gorrepati et al., 2014). The consumption of spread made from nuts and seeds can be attributed to varying factors which can be attributed to the quest of modern-day people for a healthier life.

Groundnut

Groundnut, also known as peanut, earthnut, monkey nut, and goobers, is largely consumed by the western and most populations in Africa. It is a crop with a rich and diverse history that spans continents and centuries (Shokunbi et al., 2012). Its origins can be traced back to the southern Bolivia to northern Argentina region of South America, believed to be the centre of origin for the cultivated species of groundnut, Arachis hypogaea (Rao & Murty, 1994). Originating in South America as early as 1000 B.C., groundnut cultivation flourished among indigenous peoples who recognized its nutritional value and versatility (Bhagwati Seeds(n.d.))

Groundnut is characterized by underground plant parts, including fruits, rhizomatous structures, root systems, and hypocotyls (Stalker et al., 2016). The peanut plant has complex leaves on its stalks that have two pairs of leaflets. The blossoms are around 10 mm long and have a golden yellow colour. Groundnuts form oblong peanut pods with rounded ends when they ripen underground and develop via self-pollination into ovaries. Two to three seeds encased in a thin, pale or brownish shell would be found inside each pod. The calcium and other elements that are present in the soil affect how mature these pods get (Binu, 2024).

For households with limited finances, the crop offers a highly healthy alternative to meat products for meals (Oteng-Frimpong, et al.,2017). One study evaluated the growth, yield, and nutritional profiles of fourteen groundnut varieties grown at three different locations in Ghana (Frimpong et al., 2007). The researchers found that kernel yields ranged from 940 kg/ha to 1463 kg/ha, with significant varietal differences. Additionally, the oil and protein content of the groundnut kernels varied from 42. 0% to 57. % (Frimpong et al., 2007) 9% and 18%. (Boubacar et al., 2021) 5% to 29.%. (Frimpong et al., 2007) 3%, respectively, highlighting the nutritional diversity of groundnut cultivars in Ghana (Boubacar et al., 2021).

The American Peanut Council states that the fat profile of peanuts is around 50% monounsaturated fatty acids (MUFAs), 33% paraformaldehyde (PFAs), and 14% saturated fatty acids. This is a combination of fatty acids that is heart-healthy. With 2% stabilizer added, peanut butter has 156 times less trans-fat than what is required to meet food labels' 0 g trans-fat threshold (Arya et al., 2016).

New research unequivocally demonstrates that different types of fat can have distinct effects on health at different phases of life. Malnourished new-borns and children can receive nutritious calories from the fat in peanuts and peanut butter when they need them (Arya et al., 2016)

Although classified as a legume, groundnuts are regarded as nuts in terms of nutrition and cooking. Like most legumes, they are high in plant-based protein; in fact, groundnuts have the greatest protein content of any nut that is routinely consumed (Ld, 2020).

Statement of the Problem

Despite increased awareness of the importance of locust beans and groundnuts to human health and industrial needs, Ghana has seen a decline in per capita consumer expenditure on peanuts and their products over the last two decades. Furthermore, Ghana, like other Sub Sahara Africa countries, has seen reduced competitiveness and limited demand for locust beans and groundnuts, as well as an inability to shift industry focus to the edible confectionary market. As a result, groundnut product markets have been marginalized both nationally and internationally.

Peanut product quantities in supermarkets have been decreasing in both the dynamic (edible locust beans and groundnut) and less dynamic (oil and cakes) sectors. Aside from that, supermarkets prefer stocking products that can sell at higher prices. This highlights the fact that the welfare of supermarkets is determined by the prices of their goods, which determines the level of their profit.

According to Gorrepati`, Balasubramanim, and Chandra (2015), the rising health concerns about consuming diary spreads are highly associated with the high fat and sugar content, and there is a need to find alternatives in plant-based spreads such as nuts and seeds. The groundnut spread has recently become the most popular plant spread in Ghana. This has resulted in a lack of variety in terms of flavour, colour, texture and taste, necessitating the use of locust beans to help bring variety into plant-based spreads made from nuts and seeds.

Shakerardekani, Karim and Mirdamadiha (2012) stated that before consumption of nuts and seeds it is their storage and handling which influence the quality of the product. There are many reports about presence of mycotoxins, especially aflatoxin in nuts. This is because of the moisture content, air temperature, and air relative humidity which result in aflatoxin production (Cheraghali et al., 2015). In that same study by Cheraghali et al. (2015), there was some evidence that contamination occurs during handling and transportation of these nuts and seeds. If the total mycotoxins (especially aflatoxin B1) level of nuts increases to more than the maximum allowance level, the nuts cannot be used by the consumers. Development of new products (such as nut spread) from nuts and seeds using suitable packaging materials can reduce the contamination of these nuts and seeds and also introduce consumers to a healthier, non-animal breakfast snack food.

Although much of the literature has reported on nut spread production, most studies were related to groundnut spread. It then recommended that further research be undertaken to develop other types of nut spreads with prolonged shelf life. There is the need to innovate with the locust beans and groundnut and come out with varied products to increase its consumption in different ways. Producing a spread from locust beans and groundnut is one way to achieve this and also provide a healthy alternative to margarine and butters.

Purpose of the Study

The purpose of the study was to develop a new spread from locust beans and groundnut and test the acceptability of the “loground “spread. The specific objectives of the study were to:

1. develop locust beans spread with different ratios of groundnuts.
2. conduct proximate analysis on the developed products.
3. sensorily evaluate the acceptability of the developed product in terms of texture, appearance, aroma taste and overall acceptability.

Research Hypotheses

1. Ho: There is no statistically significant difference in the nutritional composition among the three different ratios of locust beans and groundnut spread formulation.
2. Ho: There is no statistically significant difference in the consumer acceptability among the three spreads produced from locust beans and groundnut.

Significance of the Study

The Ghana government sees agricultural development as one of the strategies toward economic diversification. It is one of the most important sectors because it provides food security in the country while having the potential to contribute greatly to the country's economy (SRID-MoFA, 2019).

Nothing had been written about consumer acceptability of locust beans and groundnut spread. Hopefully, the present study will provide a pioneering application of consumer acceptability of locust beans and groundnut spread in Ghana. Reasons for consumers' preferences of locust beans and groundnut spread traits relevant for today agricultural and modern technology adoption? According to the characteristic model developed by Lancaster (2016), consumers derive utility not from goods themselves but from the attributes they provide. This implies that consumers are maximizing their household utility by consuming their preferred variety attributes not by directly consuming the varieties embedding those preferred attributes. Hence, what consumers are looking for at the end of the day is variety attribute, and the demand for varieties can be considered as a derived demand revealed from consumers' preferences for variety attributes (Enneking et al., 2017). Therefore, understanding consumers' variety attribute preferences will be useful to predict the likelihood of survival of varieties embedding those attributes. This enables policy makers to identify varieties for which policy incentives are required. In agricultural research priority setting, understanding farmers' and consumers 'variety attribute preferences serve as an input for developing varietal technologies with more chance to be adopted and be successful (Edilegnaw, 2014).

A better understanding of consumer acceptability of locust beans and groundnut spread is also needed to understand the locust beans and groundnut value chain and facilitate locust beans and groundnut market development in Ghana. Studies have shown that consumers are the beginning of the value chain whereby the flow of information about food preference moves back to retailers, manufacturers, farmers, and scientific laboratories (Kinsey, 2015).

Likewise, Boehlje (2019) emphasized the importance of information in the value chains. He elucidates the fact that customer information is the resource that can be used to understand markets better. Researchers, extension staff, producers and NGO personnel need a way to identify the locust beans and groundnut traits on which they should focus on in order to increase local locust beans and groundnut production. This is because an increase in farm output should go hand in hand with improved marketing, as it is not economical to produce any product if it has no market for sale. In fact, the greatest risk a producer can face is not having a market for the products. Important market information on attributes that influence market acceptability and consumers' Willingness to Pay (WTP) for locust beans and groundnut varieties is needed so as to understand the performance of the improved locust beans and groundnut varieties in Ghanaian markets.

Better market information for locust beans and groundnut producers will assist them in making better decisions to produce appropriate locust beans and groundnut qualities and maximize their returns (Kingsley, 2011). Emerging products often require extensive research and development using innovative technology, food manufacturers want to ensure sufficient demand exists and that their return on investment will be justified.

The results of this study could help policymakers and marketers to make more informed decisions about consumer response to some important attributes and promotion of locust beans and groundnut spread. For policymakers and marketers, estimates of the premiums that consumers are willing to pay for locust beans and groundnut spread attribute can guide promotion investment decisions and efficient fund allocation. For producers, the information contained in this study may help select the most profitable marketing strategies. The need to understand consumers' preferences and willingness to pay (WTP) for locust beans and groundnut spread justifies undertaking this study.

Also the development of spread using locally available ingredients will help in achieving the Sustainable Development Goal (SDG) 2: ZERO HUNGER. It can contribute to improved nutrition by using nutritious, locally grown foods that are culturally relevant and often fresher than imported alternatives.

Delimitation of the Study

Although different species of groundnuts are available, the Obolo species was used in the preparation of the spread. This is because according to the catalogue of crop varieties released and registered in Ghana (2019) edition, the Obolo species have sweet taste, good flavour and is good for confectionary. Panel members for the sensory analysis where people who consume locust beans and groundnuts and do not have any allergies associated with its consumption.

Limitation of the Study

The sensory evaluation for the developed spread was limited to students of Al-faruq college of education and Wenchi Methodist senior high school which could not represent fully the population of the country.

Organization of the Study

The study is organized into five distinct chapters. Chapter one introduces the study and highlights the study's problem statement, objectives, significance, delimitation and limitation. Chapter two reviews relevant literature relating to the study area. The chapter reviews literature on the locust beans, the uses of the locust beans and nutritional composition. The section also looks at the types of spreads and how to sensorily evaluate a product.

Chapter three deals with the methodology adopted by the study to meet stated objectives. It deals with all the relevant processes and research tools adopted to execute the research. Chapter four looks at analysis and presentation of research data. The first part of the chapter presents finding on comparative analysis of proximate composition of study samples whiles the second part presents finding from sensory evaluation of test samples. Chapter five concludes the study by presenting findings and conclusions drawn from the work as well as recommendations resulting from the study.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter explore the potential of creating a bread spread by combining *Parkia biglobosa* (African locust bean) and peanuts. It delves into the nutritional profiles of these ingredients, their health benefits, culinary applications, and the sensory attributes, formulation considerations, and shelf life of spreads incorporating these components.

African locust beans yield valuable non-timber forest products. The fruit pulp is rich in sucrose, while the seeds are abundant in carbohydrates, proteins, and lipids, making them an excellent source of energy (Nyadanu et al., 2017a). The seeds serve multiple purposes as a seasoning, and the husks and pods are valuable livestock feed. The pulpy flesh is used to create a revitalizing beverage packed with macronutrients and vitamins A and C. Moreover, the bark, when combined with lemon, possesses wound-healing properties (Musara et al., 2020). During periods of food scarcity and drought, *Parkia biglobosa* serves as a vital food and nutrition security resource, especially in the Sahel, Sudanese, Savanna, and transitional zones of West Africa (Nyadanu et al., 2017).

History of Dawadawa

Dawadawa has a rich history in West Africa, dating back centuries to a time when towns were often encircled by locust bean trees. Although its origins are ancient, like many traditional practices, its history remains largely undocumented. Notably, Mungo Park, a Scottish surgeon, encountered locust bean trees during his exploration of the Niger Basin between 1795 and 1799 (Adeyeye, 2013).

Botanical Overview

Parkia biglobosa belongs to the *Fabaceae* family. This perennial deciduous tree typically reaches a height of 7 to 20 meters, occasionally reaching up to 30 meters (Iretiola Builders, 2014). It features a tap root and lateral roots extending 10-20 meters from the primary trunk. The trunk is straight, robust, and cylindrical, with a diameter of up to 130 centimetres. The bark is thick, exhibiting longitudinal fissures and scales, with shades ranging from ash-grey to greyish brown. When incised, it reveals fibrous, reddish-brown inner bark emitting an amber-hued resin. The tree has a dense crown extending like an umbrella, supported by substantial branches.

Figure 1: African locust bean tree

Source: Heuzé et al (2019)

The leaves are arranged alternately, bi-pinnately compound, measuring 30-40 centimetres in length. Stipules are absent. The leaf stalk (petiole) ranges from 4 to 12.5 centimetres, enlarging at its base with a rounded gland. The central axis (rachis) terminates with a short, awn-like structure. Each leaf bears up to 17 pairs of pinnae, with a gland between the terminal pair. Each pinna has 13-60 pairs of leaflets that lack a stalk, are oblong, measuring 8-30 millimetres in length and 1.5-8 (occasionally 10) millimetres in width. They feature a protrusion at the base known as a proximal auricle, with rounded or obtuse tips and a smooth appearance, with slight fringing near the apex.

Figure 2: Locust beans leaflets

Source: Heuzé et al (2019)

The inflorescence consists of pendulous flower clusters arranged in a racemose manner. The flower stalk (peduncle) ranges from 10 to 35 centimetres, transitioning to a salmon-pink hue as it matures. Flowers can be bisexual, male, or sterile. They appear sessile but seem to have short stalks due to the fusion of calyx, corolla, and stamens at their bases. Both the calyx and corolla have a tubular structure with five lobes. Bisexual flowers are in the upper part, measuring 10-17 millimetres with protruding stamens and a superior ovary. Male flowers are in the lower part, measuring 6-7 millimetres with non-protruding stamens. Sterile flowers are at the very bottom, also measuring 6-7 millimetres with underdeveloped stamens.

Figure 3: African locust beans flowers

Source: Heuzé et al (2019)

The fruit is a linear-oblong pod, 12-35 centimetres in length and 1.5-2.5 centimetres in width, slightly curved, with a 1–4-centimetre base stalk. The pod is cylindrical, smooth, and hairless, turning brown when ripe. It contains 5-23 seeds, enclosed within a yellowish endocarp. The seeds are globose-ovoid, slightly compressed, measuring 0.5-1.5 centimetres in length, with a distinct pleurogram on their lateral face. The hard, smooth, shiny seed coat is dark brown (Protabase Record, n.d.).

Figure 4: African locust beans pod

Source: Heuzé et al (2019)

Locust beans are derived from the pods of the *Parkia* tree, known as "Iru" in Yoruba, "Dawadawa" in Hausa, and "Ogiri" in Igbo. These names reflect the cultural diversity and significance of this ingredient. The *Parkia* tree is naturally protected in many regions due to the numerous advantages it offers, and strict laws are in place to prevent its indiscriminate cutting. It's commonly found across the savannah terrain (Lelea et al., 2022).

Figure 5: African locust beans pulp

Figure 6: African locust beans seeds

Source: Heuzé et al (2019)

Figure 7: Fermented locust beans

Source: Heuzé et al (2019)

The history of Dawadawa, like many traditional practices, is ancient and largely undocumented. Its roots stretch back several centuries, coinciding with a time when towns were often surrounded by locust bean trees. Notably, Mungo Park, a Scottish surgeon, encountered these trees during his exploration of the Niger Basin between 1795 and 1799 (Adeyeye, 2013).

Locust Bean Production in Africa and Ghana

Distribution of *Parkia biglobosa*: *Parkia biglobosa* is widely distributed in the natural savannah zones of the Sudan and Guinea. Its range extends from Senegal on Africa's western coast to Sudan. It is found in 19 African nations, including Senegal, Gambia, Guinea Bissau, Guinea, Sierra Leone, Mali, Côte d'Ivoire, Burkina Faso, Ghana, Togo, Benin, Niger, Nigeria, Cameroon, Chad, Central African Republic, Zaire, Sudan, and Uganda. Notably, P. biglobosa is particularly abundant in Nigeria (Iretiola Builders, 2014).

The indigenous inhabitants of Africa have long utilized the Parkia biglobosa tree for both culinary and medicinal purposes. This versatile tree offers various medicinal benefits, including its use in the treatment of hypertension and diarrhoea due to its histamine content, which widens blood vessels and promotes blood flow.

This literature review delved into the production of locust beans in Ghana, with a specific focus on the savannah landscape of northern Ghana. Locust beans, also known as African Locust Beans or *Parkia biglobosa*, carry significant cultural importance in Ghana, particularly among the Dagomba women who have traditionally been involved in their processing. These beans serve as more than just a food source; they also find applications in building materials, medicine, and livestock fodder. The production of locust beans plays a vital role in the livelihoods of Dagomba women and contributes to the cultural fabric of Ghana (Lelea et al., 2022).

The African Locust Bean tree, the source of locust beans, is facing a growing scarcity in Tamale and its surroundings in Ghana's Northern Region. This decline has raised concerns about the sustainability and future of locust bean production. Numerous studies have explored the production, utilization, and challenges associated with locust bean production across various African regions, including Nigeria. One study conducted in Arigidi Akoko, Ondo State, Nigeria, examined the processing, utilization, and challenges related to African locust beans. The study revealed that locust bean processing and trade are predominantly led by females due to their preference for processing activities.

A study in northern Ghana focused on the observations of farmers and community leaders regarding the decline of African Locust Bean trees. The findings highlighted the alarming decrease in locust bean trees in the community, with the remaining trees not being replaced by new saplings. The decline was primarily attributed to tree cutting for firewood and the age of the trees.

In addition to these studies, other research conducted surveys and interviews with women's groups and farmers in the study area near Nyankpala to gain local insights into the challenges and opportunities associated with locust bean production.

The production of locust beans in Ghana, particularly in the northern savannah region, is interwoven with cultural significance and ecological challenges. Understanding and addressing these challenges are vital for the sustainability of this important cultural and economic resource.

Figure 8: African Locust Beans

Source: Heuzé et al (2019)

Uses of African Locust Beans

African locust beans, scientifically known as *Parkia biglobosa*, are of significant economic and cultural importance to local and regional economies in several African countries, including Benin Republic, Togo, Nigeria, Ghana, Mali, Niger, and Cameroon. These indigenous trees serve multiple traditional purposes in arid Africa.

African locust beans play a crucial role in ensuring food security during periods of scarcity and drought (Nyadanu et al., 2016). The seeds, commonly referred to as "iru" or "dawadawa," are staples in numerous traditional dishes across West Africa, adding flavour and nutritional value to culinary preparations.

Beyond their culinary applications, African locust beans possess medicinal properties. They have been employed in West Africa to treat various medical issues, including fever, diarrhoea, stomach problems, boils, and burns.

African locust beans are also a source of income for rural populations. They are processed into fermented condiments like netetu, iru, sonru, afitin, soumbala, and dawadawa, contributing to the livelihoods of many communities across the continent.

African locust beans, with their unique flavour and aroma developed through fermentation, are widely used in West African cuisine, particularly in Nigeria and Ghana. They play a significant role in flavouring traditional dishes, and various fermented condiments are produced from these beans, depending on the region. Some of the popular condiments include netetu, iru, sonru, afitin, soumbala, and dawadawa. These condiments are known for their strong and distinctive flavours, which add depth and complexity to a variety of African recipes (Donkor et al., 2023).

The production process of these fermented condiments involves several steps, including boiling, DE hulling, short cooking, and fermentation. These steps are not only crucial for flavour development but also affect the physicochemical, biochemical, and microbiological characteristics of the final products (Irakoze et al., 2021).

However, traditional methods of processing African locust beans often rely on rudimentary equipment and manual labour, leading to challenges such as low production and variable product quality. To address these issues, modernization and the introduction of improved processing technologies are becoming essential, especially as urban populations and demand for these condiments grow (Aket al., 2010).

One of the key factors contributing to the unique aroma and flavour of these fermented condiments is the presence of volatile compounds. More than 160 volatile compounds have been identified in these products, including pyrazines, ketones, aldehydes, and alcohols. Some specific compounds, such as 2,5-Dimethyl pyrazine, tetramethyl pyrazine, trim ethyl pyrazine, 3-methyl butane, benzene acetaldehyde, 2-nonadecanone, 2-decanone, 3,5-Dimethyl phenyl methanol, and 3-methyl-1-butanol, have been recognized as key contributors to the overall aroma profile of these condiments (Costantini et al., 2021).

In summary, African locust beans and their fermented condiments are integral to West African culinary traditions, offering a rich and distinct flavour to a wide range of dishes. Modernization and improved processing methods are needed to meet the growing demand and ensure consistent product quality. The volatile compounds present in these condiments contribute to their unique aroma and flavours, making them an essential element of West African cuisine (Balakrishna et al., 2022; Donkor et al., 2023).

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Medicinal Uses of Parkia biglobosa

Parkia biglobosa, commonly known as African locust bean, has a rich history of traditional medicinal use in Africa. These traditional practices encompass a wide range of potential health benefits associated with this plant species. Traditional uses include the treatment of various ailments such as leprosy, hypertension, toothaches, stomach upsets, and diarrhoea (Quansah et al., 2019; Millogo-Kone et al., 2006).

Pharmacological studies have further shed light on the medicinal properties of *Parkia biglobosa*. These studies have revealed significant antioxidant, hepatoprotective, and antiparasitic activities associated with this plant (Adegbola et al., 2019). The therapeutic potential of *Parkia biglobosa* in the prevention, treatment, and management of metabolic diseases, including diabetes mellitus, has also been explored (Oladele et al., 2021).

These pharmacological properties are attributed to the bioactive compounds found in *Parkia biglobosa*, which include sulfides, antimicrobials such as tannins, flavonoids, saponins, and alkaloids (Quansah et al., 2019; Millogo-Kone et al., 2006). The plant has also shown antimicrobial activity against various pathogens, including *Staphylococcus aureus*, *Escherichia coli,* and *Candida albicans* (Sanjeewa & Mishra, 2018; Tijani et al., 2009).

To harness the full potential of *Parkia biglobosa* for medicinal purposes, further studies are warranted to explore mechanisms of action, clinical efficacy, and the isolation of specific bioactive compounds. Clinical studies in humans are essential to validate its efficacy and ensure safety (Saleh et al., 2021). It is also important to investigate potential drug interactions, side effects, optimal dosage, and formulation for different therapeutic applications (Ogunyinka et al., 2019).

The existing literature underscores the significant medicinal potential of Parkia biglobosa, known as African locust bean. This plant holds promise as a source of natural compounds for drug development and therapeutic interventions, paving the way for further scientific investigation and clinical validation of its medicinal properties (Adegbola et al., 2019).

Other Uses of African Locust Beans

African locust bean, scientifically known as *Parkia biglobosa*, is a remarkably versatile tree species with a range of applications that extend beyond its culinary and medicinal roles.

The bark of the African locust bean tree is a valuable resource for firewood and charcoal production, as demonstrated in a study in Nigeria. Its high calorific value and low moisture content make it an ideal fuel source, serving as an essential energy supply in many communities (Donkor et al., 2023).

The leaves of the African locust bean tree are rich in nutrients and serve as excellent animal feed. They are particularly valuable due to their nitrogen content, contributing to improved livestock productivity (Ijigbade et al., 2021).

The branches of the African locust bean tree are utilized in construction. They are employed in various structural applications, including as poles and rafters. Additionally, these branches find use in crafting traditional musical instruments (Nyadanu et al., 2016).

Studies have revealed the medicinal potential of the roots of the African locust bean tree. They possess antimicrobial and anti-inflammatory properties, making them valuable for treating a range of ailments. This adds to the plant's significance in traditional medicine (Donkor et al., 2023).

The African locust bean tree isn't just utilitarian; it also holds ornamental value and is frequently planted in gardens and along roadsides for its shade-providing qualities. This underscores its aesthetic and environmental contributions. *Parkia biglobosa*, the African locust bean tree, proves to be a multifaceted species, serving purposes that encompass fuel, animal feed, construction materials, potential medicinal benefits, and even offering ornamental and shading attributes. Its applications extend far beyond the culinary and medicinal domains, contributing to the well-being and livelihoods of many communities.

Nutritional Composition of African Locust Beans

African Locust Beans, also known as dawadawa, have been the focus of various recent studies aimed at understanding their nutritional content and potential applications in food. These studies provide essential data for the effective utilization of this underutilized tropical legume in diverse culinary contexts. A study conducted by Elemo et al 2011 explored the nutritional and anti-nutritional components of dehulled and defatted African locust bean seeds.

It revealed that these seeds are rich in protein, with protein content ranging from 20.5% to 30% (Elemo et al., 2011; Adjepong et al., 2018).

The seeds are not just protein-rich; they also contain essential minerals, notably potassium and phosphorus. These minerals are vital for various physiological functions (Elemo et al., 2011). The fatty acid composition of African locust bean seeds was also examined in one study. The results indicated a high unsaturated-saturated fatty acid ratio, with linoleic acid being the dominant fatty acid. This suggests that African locust beans can serve as an important source of essential fatty acids in a balanced diet (Elemo et al., 2011; Ahmed et al., 2023). These studies have identified the presence of appreciable quantities of sulphur-containing amino acids in African locust bean seeds. These amino acids play a crucial role in various physiological processes, making African locust beans suitable for fortification applications in food formulations (Elemo et al., 2011; Tersoo-Abiem et al., 2021).

It's worth noting that African locust bean seeds also contain certain anti-nutritional factors, including tannins, phytic acid, and protease inhibitors. These factors can reduce nutrient bioavailability and hinder the nutritional value of the seeds. Therefore, appropriate processing methods are important to reduce the levels of these anti-nutritional factors and enhance the nutritional quality of African locust bean seeds (Elemo et al., 2011; Abali et al., 2022). African Locust Beans, or dawadawa, are protein-rich seeds with a wealth of essential nutrients. They offer significant potential to address nutritional and dietary needs, particularly in regions where protein and essential nutrients are in demand. However, addressing anti-nutritional factors is crucial to fully unlock their nutritional potential.

Table 1: Nutritional and anti-nutritional composition of the African locust bea (Parkiabiglobosa

Parameter Composition.	
Nutritional properties	
Moisture content (%)	8.41
Crude protein (%)	6.56
Crude fat (%)	1.80
Crude fibre (%)	11.75
Ash (%)	4.18
Carbohydrate (%)	67.30
Sugar content (°Brix)	9.00
Hydrogen ion conc. (pH)	5.22
Total carotenoids (fag/100g)	49,175.00
Ascorbic acid (mg/100g)	191.20
B.Anti-nutritional factors/toxins	
Phyticacid(mg/100g)	60.00
Crude saponins (mg/100g)	17.80
Tannins(mg/100g)	18.00
Total phenols(mg/100g)	204.60
HCN(mg/100g)	17.30

Values are means of duplicate determinations.

Source: Gernah et al. (2007)

Spreads

Food spreads are versatile additions to meals that enhance flavour and texture. They can be defined as condiments or toppings that are spread onto food items such as bread, crackers, or vegetables (Young & Wassell, 20019). Spreads come in various forms, including butter, margarine, nut butters, fruit preserves, and cheese spreads (Balakrishna et al., 2022). The nutritional value of food spreads varies depending on the ingredients used. Butter and margarine are common spreads but are known for their high saturated fat content. Nut butters, such as almond, peanut, and sunflower seed butter, provide a good source of protein and healthy fats (Donkor et al., 2023).

Nut and seed butters, such as almond, peanut, and sunflower seed butter, offer the same nutritional value as their whole counterparts but in a more concentrated form. According to the University of Wisconsin Health (2019), two level tablespoons of nut and seed butter contain roughly 200 calories, whereas one ounce of whole nuts like 28 peanuts or 24 almonds, or 1/4 cup of sunflower seeds, provide similar nutrients (UW Medicine). Food spreads obviously encompass a range of options with varying nutritional profiles. It is important to choose spreads that align with your dietary preferences and requirements, as they can significantly impact the nutritional content of your meals.

Consumption of Spreads

Projections for the global spread market vary among different research agencies. According to Grand View Research, a market research company (2019), the spread market encompasses categories such as butter/cheese, chocolate, fruit spreads, nut spreads, and more. In 2018, the global spreads market was valued at USD 27.5 billion, and it is expected to grow at a Compound Annual Growth Rate (CAGR) of 3.1% from 2019 to 2025. However, another market research agency, LP Information (2020), estimated the market's value at USD 23,040 million in 2019, with a projected increase to USD 24,760 million by 2025 at a CAGR of 1.8%.

According to Statista Market Forecast, the global spreads market is expected to reach USD 62,570 million in 2021, with an estimated annual growth rate of 3.1% from 2021 to 2025. Additionally, in 2021, China is predicted to be the leading consumer of spreads. China's significant consumption, expected to reach USD 18,724 million in 2021, is primarily driven by its large population. It is projected that the revenue per person will be USD 8.30 in 2021, with a per capita consumption of 2.0 kg (Statista Market Forecast, 2020).

The global consumption of spreads is on the rise, with varying estimates from different research agencies. China, with its substantial population, is expected to be a significant consumer of spreads in the coming years, contributing to the overall growth of the market.

Types of Spreads

Dairy Butter

Dairy butter is a water-in-oil emulsion that comprises 80% fat and very little water. It may also contain some solids-not-fat (SNF), and it can be purchased with or without salt. Saturated fats are prevalent in butter. According to Scherr and Ribeiro (2010), butter with or without salt contains 222 mg of cholesterol per 100 grammes and 55.2 grammes of saturated fat. Butter has traditionally been the most popular spread for consumption. However, the high amounts of saturated fat in them have given rise to growing health concerns about their use, which has made room for alternatives in plant-based spreads (Kalyani et al 2015).

Peanut Butter

In essence, peanut butter and peanut paste are combined to create peanut butter, also known as peanut spread. Occasionally, the spread may also contain emulsifiers, salt, sweeteners, and other additives. According to Allamprese, Ratti, and Rossi (2009), the spread is made by roasting, blanching, grinding, and tempering peanuts.

Soybean Spread

According to Agrahar-Murugkar et al. (2013), soybean is the best source of substantial amounts of plant protein. The bean contains the essential amino acids for growth as well as 40g of protein per 100g. The bean naturally contains all of the necessary amino acids that the body cannot produce. Many health advantages of soybeans and soy-based meals have been established, including the ability to prevent cancer, heart disease, and menopausal symptoms (Barrett, 2006). These soya bean's health and nutritional advantages have helped to increase its acceptance and popularity as a food product (Rinaldoni, Campderros, & Padilla, 2012). For those with peanut allergies, soybean spread can be the ideal substitute for peanut spread.

Sunflower Spread

According to Thomas and Gebhardt (2010), sunflower seed spread has more monounsaturated fat, less saturated fat, zinc, magnesium, copper, phosphorus, iron, vitamin E, manganese, and selenium than peanut butter. However, sunflower has a more fibrous outer layer and, if not properly roasted, can retain moisture. Its nutritional attributes are comparable to those of peanut butter. Sunflower spread's nutritional and sensory characteristics can be significantly impacted by roasting conditions (Thomas & Gebhardt, 2010).

Almond Butter or Spread

Compared to sunflower and peanut spreads, almond spread is more fibrous and contains higher quantities of potassium and calcium (Thomas & Gebhardt). In a 2003 study, Spiller et al. compared the lipid-altering effects of raw almonds, roasted salted almonds, and roasted almond butter when consumed as part of a plant-based diet. High-density lipoprotein cholesterol (HDL) did not change much with raw or roasted almonds but did modestly increase with almond butter, according to the findings. It has been demonstrated that having high levels of HDL, or "good cholesterol," lowers the risk of heart disease.

Groundnut

Groundnut, also known as peanut, earthnut, monkey nut, and goobers is an underexploited nut largely consumed by the western and most populations in Africa. It is a crop with a rich and diverse history that spans continents and centuries (Shokunbi et al., 2012) . Its origins can be traced back to the southern Bolivia to northern Argentina region of South America, believed to be the centre of origin for the cultivated species of groundnut, Arachis hypogaea (Rao & Murty, 1994). Originating in South America as early as 1000 B.C., groundnut cultivation flourished among indigenous peoples who recognized its nutritional value and versatility (Bhagwati Seeds(n.d.))

Through the voyages of Spanish, Portuguese, British, and Dutch explorers during the sixteenth and seventeenth centuries, groundnut was disseminated to Africa, Asia, Europe, and the Pacific Islands (Stalker et al., 2016). Its introduction to Africa via Portuguese explorers in the 16th century marked the beginning of its journey as a staple food crop globally. By the 19th century, groundnut cultivation had expanded to Southeast Asia and India, where it thrived in tropical and subtropical climates (Stalker et al., 2016).

Today, groundnut is grown in 108 countries across the globe, covering approximately 22.2 million hectares, with major producers including India, China, and the United States (Konaté et al., 2020). The crop plays a vital economic role, particularly through the production of groundnut oil for exports, essential in local dishes, and contributing to snack production (Georges et al., 2016). Industrially, groundnuts are processed into oil, paste, butter, and soap, with potential for further diversification (Konja & Mabe, 2023). Groundnut's significance extends beyond food; it has applications in soaps, medicines, cosmetics, and even as a fuel source (Georges et al., 2016).

Archaeological evidence supports the extensive cultivation of groundnut in both Mesoamerica and South America, with remnant pericarp (fruit hull) tissue recovered from archaeological sites in Peru dating back approximately 3900–3750 years before the present (Das et al., 2023).

Groundnut's journey from ancient South America to its global distribution showcases its significance as a staple crop with diverse applications. As researchers delve deeper into the history of groundnut, considering its historical context and impact on human societies throughout the ages remains essential for understanding its role in shaping agricultural practices, economies, and cultures worldwide.

Plant Description

Groundnut, also known as peanut, is a legume species that originated in South America and has now spread worldwide (Mallikarjuna et al., 2014). It is characterized by underground plant parts, including fruits, rhizomatous structures, root systems, and hypocotyls (Stalker et al., 2016).

The centre of origin for the cultivated peanut species, A. hypogaea, is believed to be southern Bolivia to northwestern Argentina, although there is still ongoing research to determine the exact origin (Stalker et al., 2016).

Groundnut belongs to the genus Arachis, which includes 81 named species. The morphology of groundnut is distinct, with seeds having thick and fleshy cotyledons (Stalker et al., 2016). The peanut plant has complex leaves on its stalks that have two pairs of leaflets. The blossoms are around 10 mm long and have a golden yellow color. Groundnuts form oblong peanut pods with rounded ends when they ripen underground and develop via self-pollination into ovaries. Two to three seeds encased in a thin, pale or brownish shell would be found inside each pod. The calcium and other elements that are present in the soil affect how mature these pods get (Binu, 2024).

The groundnut plant has prostrated to upright stems that can reach a height of up to 46 cm. It grows slowly until about 40 days after planting, after which it starts flowering. The growth rate accelerates between 40 and 100 days (Das et al., 2023).

Figure 9: Groundnut Plant

Source: Agrocares (2024)

Figure 10: Mature groundnut pods

Source: Agrocares (2024)

Figure 11: Peanut kernels

Source: Agrocares (2024)

Groundnut in Ghana

Groundnut, also known as peanut, is a crucial legume crop cultivated extensively in Ghana, particularly in the northern regions of the country. In Ghana, groundnuts hold the largest position among grain legumes in terms of cultivated area. More than 70% of Ghana's groundnut production comes from the Guinea savannah ecosystem making it the most important groundnut region in the country (Oteng-Frimpong, et al.,2017).

Despite Ghana being the 10th largest global producer of groundnuts, the focus has traditionally been on staple crops like maize, rice, and cassava, or exports like cocoa and oil palm, leading to limited investment in improving groundnut productivity and value chain linkages (Ghana: Groundnut, 2024).

It serves as a significant source of edible oil and vegetable protein, contributing to food security and income generation for smallholder farmers (Balasubramanian et al., 2023) Groundnut production in Ghana has been the subject of extensive research, with studies focusing on the agronomic and nutritional characteristics of various groundnut varieties.

For households with limited finances, the crop offers a highly healthy alternative to meat products for meals (Oteng-Frimpong, et al.,2017). One such study evaluated the growth, yield, and nutritional profiles of fourteen groundnut varieties grown at three different locations in Ghana (Frimpong et al., 2007). The researchers found that kernel yields ranged from 940 kg/ha to 1463 kg/ha, with significant varietal differences. Additionally, the oil and protein content of the groundnut kernels varied from 42% to 57.9% and 18.5% to 29.3%

(Frimpong et al., 2007), respectively, highlighting the nutritional diversity of groundnut cultivars in Ghana (Boubacar et al., 2021).

Interestingly, the researchers noted that grain length and 100-grain mass were not consistently correlated, which they attributed to differences in oil content, suggesting that processing requirements may vary across groundnut varieties. Overall, these studies emphasize the importance of selecting appropriate groundnut varieties based on their agronomic characteristics, yield potential, and nutritional value (Boubacar et al., 2021). These studies highlight the need for continued research and breeding efforts to further improve groundnut productivity, enhance nutritional qualities, and develop varieties that are well-suited to the specific agroecological conditions and farming systems in Ghana.

Furthermore, promoting sustainable farming practices and providing farmers with access to improved seeds, modern technologies, and agronomic training are essential for increasing groundnut production and ensuring the continued success of groundnut cultivation in Ghana (Balasubramanian et al., 2023). The findings from various studies underscore the significance of groundnut cultivation in Ghana and its contribution to food security and income generation for smallholder farmers.

Varieties of Groundnuts

Groundnuts can be divided into four main categories: Valencia, Virginia, Runner, and Spanish. These peanuts all have different flavours and sizes. While they go by different names, the kinds grown in other producing nations resemble the ones listed (*Peanut Types and Production*, n.d.)

Runner

Runner type peanuts, introduced in the 1970s with the Florunner variety, are the most popular in America. They produce high yields, medium-sized, uniform kernels, and are ideal for roasting. However, they are more commonly used for peanut butter, accounting for over half of production in the US. Runner peanuts are grown in Georgia, Florida, Alabama, Mississippi, Texas, and Oklahoma (Baessler, 2022).

Virginia

The average levels of protein, oleic acid, sugar, and total phenolics are higher in Virginia groundnuts than the Spanish groundnuts, and they also exhibit higher levels of antioxidant activity and an increase oleic-linoleic (O/L) ratio. The O/L ratio in Virginia groundnuts has a higher coefficient of variation (CV) than in varieties like the Spanish variety, indicating a greater degree of variability (Kumar Mahatma et al., 2014).

Spanish

Spanish Peanuts are small, round, and ovate peanuts with a red-brown, brittle skin. They are the smallest of four major varieties and are used in peanut candies, nut snacks, peanut butter, and oil extraction. They are prized for their high cooking temperature and healthy fat content. They are a significant source of micronutrients and are used by pastry chefs and candy companies (*Raw Spanish Peanuts*, n.d.). The obolo groundnut falls under this variety.

Valencia

A pod of Valenciana often has three or more little kernels. These are highly sweet peanuts that are typically sold in their shell after being roasted; they work well when used raw as boiled peanuts. Another popular usage for velencias is the production of natural peanut butter. valencias are mostly grown in New Mexico and make up less than 1% of U.S. production due to the higher demand for other types (*Peanut Types and Production*, 2021).

Nutritional composition of groundnuts

Groundnut, also known as the "king of oil seed," belongs to the legume family (Fabaceae) and originates from South America but has now spread globally. Widely cultivated across more than 20 million hectares worldwide, groundnut ranks as the second most extensively planted oil seed crop, after rapeseed, highlighting its significance in global agriculture (Balasubramanian et al., 2023). Groundnuts are consumed in various forms such as boiled groundnuts, groundnut oil, groundnut butter, roasted groundnuts, and groundnut meal added to snack foods, energy bars, and candies. Groundnuts are considered a vital source of nutrients, and nutrition plays a crucial role in the growth and energy gain of living organisms (Settaluri et al., 2012).

Table 2: Groundnuts (Arachis hypogaea), All types, Nutritional value per 100g

Principle	**Nutrient value**	**Percentage of RDA**
Energy	567 Kcal	29
Carbohydrates	16.13 g	12
Protein	25.80 g	46
Total Fat	49.24 g	165
Cholesterol	0 mg	0
Dietary Fiber	8.5 g	22
Vitamins		
Folates	240 µg	60
Niacin	12.066 mg	75
Pantothenic acid	1.767 mg	35
Pyridoxine	0.348 mg	27
Riboflavin	0.135 mg	10
Thiamin	0.640 mg	53
Vitamin A	0 IU	0
Vitamin C	0	0
Vitamin E	8.33 mg	55.5
Electrolytes		
Sodium	18 mg	1
Potassium	705 mg	15
Minerals		
Calcium	92 mg	9
Copper	1.144 mg	127
Iron	4.58 mg	57
Magnesium	168 mg	42
Manganese	1.934 mg	84
Phosphorus	76 mg	54
Selenium	7.2 µg	13
Zinc	3.27 mg	30

Source: USDA National Nutrient data base

Fats

The American Peanut Council states that the fat profile of peanuts is around 50% monounsaturated fatty acids (MUFAs), 33% paraformaldehyde (PFAs), and 14% saturated fatty acids. This is a combination of fatty acids that is heart-healthy. With 2% stabilizer added, peanut butter has 156 times less trans-fat than what is required to meet food labels' 0 g trans-fat threshold (Arya et al., 2016). A moderate-fat diet high in monounsaturated fatty acids (MUFAs) provided by peanuts, peanut butter, and peanut oil is more beneficial for heart health compared to low-fat diets (Pelkman et al., 2004). A study by Matilsky et al. (2009) investigated the effects of a moderate-fat diet high in monounsaturated fatty acids (MUFAs) derived from groundnut, groundnut paste, and groundnut oil on lipid profiles. The findings revealed a significant reduction of 14% in LDL cholesterol levels, while maintaining HDL cholesterol levels and decreasing triacylglycerol levels during weight loss. New research unequivocally demonstrates that different types of fat can have distinct effects on health at different phases of life. Malnourished new-borns and children can receive nutritious calories from the fat in peanuts and peanut butter when they need them (Arya et al., 2016).

Protein

Although classified as a legume, groundnuts are regarded as nuts in terms of nutrition and cooking. Like most legumes, they are high in plant-based protein; in fact, groundnuts have the greatest protein content of any nut that is routinely consumed (n.d., 2020). Most groundnuts farmed in the world are primarily utilized to create edible oil. After the extraction of the groundnut oil, the cake's protein level may can be as high as 50% (Zhao et al., 2012). According to Arya et al. (2016), Peanuts are the main source of the protein known as "arginine," and they contain all 20 amino acids in varying amounts. Unlike animal protein, the plant-based protein found in peanuts also contains extra elements that are beneficial to health, such as fibre and special bioactive components.

Fibre

Dietary fibre is made up of lignin and indigestible carbohydrates that are found naturally in intact plants (Odphp, 2015). Fibber makes up almost one-third of the carbohydrates in groundnuts, this explains why groundnuts have a low glycaemic index (GI) and glycaemic load (GL). Eating groundnuts results in blood sugar and insulin levels that remain balanced, but eating certain refined grains or sugary beverages causes our blood sugar and insulin levels to rise and fall quickly, a condition known as a "spike" that is linked to pre-diabetes and diabetes (*How Much & Benefits the Peanut Institute*, 2023).

Vitamins and Minerals

Peanuts are a rich source of vitamins and minerals, including biotin, copper, niacin, folate, manganese, vitamin E, thiamine, phosphorus, and magnesium. Biotin is essential during pregnancy, while copper is often low in Western diets. Niacin has various functions and is linked to reduced heart disease risk. Manganese is found in drinking water and most foods, while vitamin E is found in fatty foods. Phosphorus is crucial for tissue growth and magnesium is believed to protect against heart disease.

Carbohydrates

The total accessible carbohydrate component in groundnut kernels is made up of oligosaccharides, such as starch, raffinose, and stachyose, and water-soluble carbohydrates, such as disaccharides and monosaccharides. Newly sprouted groundnut kernels have high quantities of carbohydrates, but as the seed ages and starts to store energy, those levels decrease from an average of 46% at five weeks (Savage & Keenan, 1994).

Groundnuts offer vital nutrients to the human body, including proteins, fats, vitamins, minerals, and fibre. They serve as a valuable and cost-effective source of nourishment. Consuming protein-rich foods like groundnuts can help prevent diseases and immune-based disorders by providing energy-rich nutrients and bioactive compounds that support the regulation of the human immune system (Balasubramanian et al., 2023).

Uses of groundnuts

Since the beginning of human history, groundnuts, particularly those grown in developing nations, have been utilized historically. It has a high calorie content and is high in protein and oil. Almost 95% of global manufacturing is produced in developing nations. About 70% of this total comes from Asia, where the two largest producers—China and India—combine to account for more than two thirds of global output. Senegal, Argentina, Sudan, and Nigeria are additional significant producers (Groundnut, n.d.).

Medicinal Uses of Groundnuts

Peanut oil has no cholesterol, little saturated fat, lots of unsaturated fatty acids, and no trans-fat. Among the many health advantages of peanuts are bettering blood lipid profiles and lowering the risk of cardiovascular disease, which protects the heart (Abubakar & Ahmad, 2022).

Peanuts primarily guard against heart disease, cancer, neurological and nervous system disorders, and viral or fungus-related infections. Lowers the risk of stroke by increasing the body's synthesis of nitric oxide through the antioxidant resveratrol (Firdous, 2020).

Peanut-based therapeutic food and milk are used to treat malnutrition, leading to rapid recovery. The plumpy nut is an example of a ready-to-use therapeutic food (RUTF) used in Africa to combat severe malnutrition. The United Nations approves RUTF for emergency malnutrition management and many nutritional programs in developing countries (Abubakar & Ahmad, 2022).

High-protein foods might help you feel satisfied on less calories. In terms of protein content, peanuts rank second only to almonds among nuts. Research indicates that those consuming a moderate quantity of peanuts in their diet won't experience weight gain from them. Actually, peanuts might aid with their weight loss (Health Benefits of Peanuts, 2022). Eating peanuts lowers the risk of gallstone disease, diabetes, cancer, Alzheimer's, and inflammation (Variath & Janila, 2017).

Culinary Uses of Groundnuts

Ground peanuts, a versatile and nutritious ingredient, have been a staple in global cuisines for centuries. From thickening sauces to enhancing the flavour of various dishes, ground peanuts offer a unique combination of taste and health benefits that make them a favourite among chefs and home cooks alike (Team & Team, 2024). Labuckas et al. (2016) describes groundnuts as a nutritious dietary item, they are made up of a wide variety of chemicals with significant biological effects. Groundnuts are consumed as parts of a variety of food products, but they are also highly valued as snacks (fried, roasted, or salted-roasted).

Although groundnut oil has several applications, frying oil is its primary purpose. In addition, it's a common ingredient in a wide range of preparations, including lubricants, fuel, cosmetics, shaving cream, leather dressings, and furniture cream. Additionally, groundnut oil is utilized in the production of fatty acids and vanaspati ghee. It is also utilized as a preservation medium while making chutney, pickles, and other foods. Medicated ointments, plasters, syrups, and medicated emulsions are all made with groundnut oil (Bhattacharjee & Biswas, 2019).

In Ghana, between 39% and 60% of the population consumes groundnut soup, making it the most widely consumed food item made from groundnuts (Ghana's Groundnuts, n.d.). In addition to groundnut seeds, other common ingredients for making this soup include vegetables, as well as beef, goat meat, fish, crayfish, dawadawa (locust beans), and other seasonings (Bassey et al., 2020).

Figure 12: Groundnut soup

Source:https://afroculinaria.com/wp-content/uploads/2018/03/20180315_050512524914739.jpg

Groundnut milk is a culinary preparation made by soaking groundnut kernels in a 1 percent sodium bicarbonate solution for 16 to 18 hours, draining off the water, grinding the kernels in an aqueous medium, steeping the wet mass for 4 to 5 hours, and filtering it through cheesecloth to remove any solids. In India, groundnut milk is commercially available under the brand name Miltone®, which is made by extending groundnut milk with buffalo milk (Alam Ansari et al., 2015) .

According to Lamb (2024), there are many ways to savour the creamy and delectable spread known as groundnut butter, or peanut butter. Spread on toast, blended into smoothies, or served as a fruit and vegetable dip, groundnut butter is a healthy and adaptable component of any diet. Even better, you may combine roasted groundnuts until they become smooth and creamy to produce your own groundnut butter at home. This is to say that, one does not need to go through a lot of hustles to make this healthy butter. Peanut butter provides all three of the key macronutrients in a well-balanced energy supply. Four hundred grams, or 3.5 ounces, of peanut butter include 22 grams of carbohydrates (14% of total calories), 5 of which are fibre.

Protein: Compared to most other plant-based diets, 22.5 grams of protein (14% of calories) is a substantial amount .51 grams of fat make up approximately 72% of the calories (Gunnars, 2023).

Dried and defatted peanut taproots are ground to produce peanut flour. It is frequently used in baking and cooking as a gluten-free substitute for conventional flour. A nutty flavour and protein boost can be added to a variety of recipes using peanut flour (Agric4Profits, 2023). The defatted pressed cake is a cheap by-product of extracting groundnut oil that is commonly overlooked but can be utilized to make peanut flour. There are ideal utilization levels for peanut flour based on its flavour, texture, and functional qualities when it comes to pasta formulation, snack items, and beverages. Adding peanut flour to breads and biscuits enhances their protein content and raises their sensory appeal (Labuckas et al., 2016).

Groundnut, whether salted or unsalted, are most commonly enjoyed. The primary method used to prepare these is to fry and coat the peanut kernel (Arya et al., 2016). In Ghana particularly, groundnuts are consumed as snacks in various ways. This includes the Nkate cake, a popular dessert produced by heating finely chopped groundnuts and melted, caramelized sugar together. Coated groundnuts, popularly referred to as Nkatie Burga, is a regularly consumed snack in Ghana. Other snacks include roasted groundnuts, boiled groundnuts and a West African snack known as "kuli-kuli," which is prepared from crushed groundnuts. It is sometimes referred to as groundnut cake or groundnut chips, and it is a favourite in Ghana, Nigeria, Benin, and the northern region of Cameroon. Kuli-kuli can be spiralling cones or little rolled balls.

Other Uses of Groundnuts

Similar to other legume crops, peanut farming can significantly increase the sustainability of cropping systems by promoting biological nitrogen fixation, which increases soil fertility (Witcombe & Tiemann, 2022).

Peanut crop residues, including leaves, stalks (vines), and remaining pods, serve as valuable resources with varying quality. Factors such as harvest method, storage, and plant material proportions influence their nutritional value.

Like other legume hays, peanut forage is susceptible to leaf shattering, which increases stem content. These residues can be fed fresh, dried, or ensiled, depending on the livestock system. Peanut crops yield substantial amounts of high-quality forage and play a crucial role as fodder wherever they are grown. In the USA, peanut hay is produced as winter feed for cattle, especially during droughts. In West Africa, peanut haulms are extensively fed to ruminants, particularly during the dry season

Product Development

In recent years, the field of product development has gained significant attention and interest within both academia and industry. Various studies have explored different aspects of product development, including the processes involved, design methodologies, and the outcomes that influence user acceptance and market success (Radulescu & Radulescu, 2023).

One important area of research within product development is the concept of new product introduction. This refers to the process by which a company brings a new product to the market. Research and development play a crucial role in the success of new product development. Understanding customer needs and market dynamics is crucial for the success of new-product development. Key success factors include recognizing needs, satisfying market demands, and maintaining strong market knowledge. Incorporating customer insights early in projects enhances success rates (Cooper & Kleinschmidt, 2010).

Product development, often known as new product management, is described in an article by Gurbuz,(2018) as involving a variety of phases, including concept generation, product design, product development, and marketing of a newly developed or updated good or service. The role of a new product development in enhancing a company's performance through the introduction of novel products to the market cannot be overlooked (Gurbuz, 2018).

Gurbuz proposed eight stages of a new product development in his article, which are thought to be necessary for the effective launch of a new product on the market. These phases consist of:

1. **Generation of New Product Ideas**: This initial stage involves generating ideas for new products. Ideas can come from various sources such as the R&D department, customers, competitors, seminars, universities, and investors.
2. **Screening and Evaluation of Ideas**: In this stage, all generated ideas are screened and evaluated to identify the most promising ones. A screening process helps to select the most useful ideas and eliminate less viable ones, reducing costs and time spent on development.
3. **Concept Development and Testing**: After selecting the most promising ideas, product concepts are developed in detail. These concepts are then tested to assess their attractiveness to customers, feasibility of production, and overall effectiveness.
4. **Marketing Strategy**: A marketing strategy is created for the selected product concept. This involves identifying the target market, pricing strategy, distribution channels, and marketing budget for the new product.
5. **Business Strategy**: The business strategy focuses on projecting sales, estimating costs and profits, and assessing the financial attractiveness of

the new product. If the projections align with the business objectives, the product moves to the next stage.

6. **Product Development**: The R&D department creates samples of the new product concept, which are then tested for attractiveness, cost-effectiveness, and safety. The testing process helps in selecting the most suitable product sample.
7. **Test Marketing**: Test marketing is conducted to determine the most effective marketing strategies for the new product before full-scale launch. This stage helps in identifying the best marketing approach to maximize results.
8. **Commercialization**: The final stage involves determining when and how the new product will be introduced to the market. Businesses decide on the scale of introduction, such as local, regional, national, or international markets, based on factors like capital, capacity, and market confidence.

These stages collectively guide the product development process, ensuring that a new product is effectively brought to market.

Human Senses in Food Perception

The human senses play a fundamental role in how individuals perceive and evaluate food products. Understanding how food affects our senses is a critical concern for both the food industry and nutritionists striving to create healthier recipes (Choi, 2013). The sensory assessment is a scientific field that measures, evaluates, and interprets responses to food and material features as they are experienced by the senses of sight, smell, taste, touch, and hearing

(Stone et al, 2004). Each of these senses contributes to the overall sensory experience of food:

Sight

The eyes play a crucial role in assessing a food's basic qualities, such as colour, size, shape, texture, and constituents. Colour, for example, can impact a food's acceptability and desirability. Changes in a food's colour can influence a person's preference and desirability. Colour can create certain expectations in the mind, such as associating creamy colour with richness (Choi, 2013). Size, shape, and texture provide information about a food's quality, which, in turn, influences consumer acceptance and preference.

Smell

The sense of smell is a significant contributor to how we judge the quality of food. Volatile molecules, in the form of gas, carry odours. Odour volatility is temperature-dependent, making hot foods easier to smell than cold ones (Choi, 2013). The olfactory epithelium in the nasal cavity detects volatile chemicals either through the straight nasal passageway or by moving through the back of the throat, up into the nasal cavity, and retro-nasally into the mouth. Human olfactory sensitivity can vary with factors such as hunger, mood, and gender. The ability to recognize a novel scent can vary from person to person, emphasizing the importance of employing a broad panel when evaluating food odours (Choi, 2013).

Taste

Taste is one of the most critical factors influencing a person's decision to choose a particular food. Taste is perceived when substances dissolve in water, oil, or saliva. Taste buds on the tongue's surface, palate's mucosa, and certain regions of the throat are responsible for the sense of taste. Taste perception can vary due to individual genetic variations related to taste preferences (Kim et al., 2003). Factors such as the degree of detectability of bitter, fatty, and sweet flavours and consumer preferences for convenience and health can lead to variations in taste perception (Duffy & Bartoshuk, 2000). Taste categories include sweet, salty, sour, bitter, and the more recently identified umami, which is characterized by glutamate molecules present in foods like meats, mushrooms, soy sauce, fish sauce, and cheese (McWilliams, 2008).

Touch

The sense of touch helps us perceive the texture of food through oral or skin sensations. Texture represents the tactile manifestation of a food product's structure or inner makeup in terms of how it feels. Texture can be measured by the mechanical properties of the hand, finger, tongue, jaw, or lip muscles, or by the tactile nerves in the skin, hands, lips, or tongue surface. Minor changes in particle size, thermal conductivity, and chemical composition can be easily detected across food products due to the higher surface sensitivity of the lips, tongue, face, and hands (Choi, 2013).

The sensory experience of food involves the complex interplay of our five senses, each contributing to the overall perception and evaluation of food products. These sensory aspects impact consumer acceptance, preference, and, ultimately, the success of food products in the market. Sensory evaluation is a critical aspect of the food industry that involves systematic assessments of a product's sensory attributes. These evaluations are carried out under controlled conditions and may involve trained or untrained panels, depending on the specific type of sensory analysis to be performed (Ayeh, 2013). Different levels of training are required for different types of sensory analyses, with factors like the number of panellists, the magnitude of differences to be detected, and the product's importance influencing the training level necessary. Sensory evaluation serves various purposes in the food industry, including:

New Product Development: Evaluating the sensory attributes of new products to ensure they meet consumer preferences and quality standards.

1. Product Matching: Comparing sensory attributes of a product with a reference product to ensure consistency.
2. Product Improvement: Identifying areas for enhancement in terms of sensory qualities.
3. Change in Production Process: Assessing how alterations in the production process affect sensory attributes.
4. Cost Reduction: Finding ways to maintain sensory quality while reducing production costs.
5. Selection of New Raw Material Sources: Evaluating the sensory qualities of raw materials to select suitable suppliers.
6. Quality Control: Ensuring that products consistently meet desired sensory standards.
7. Consumer Acceptance and Opinions: Understanding how consumers perceive and accept products.
8. Product Grading and Rating: Assigning grades or ratings based on sensory characteristics.
9. Consumer Preference: Determining which sensory attributes drive consumer preference.

10. Sensory Panel Selection and Training: Assembling and training sensory panels with the required expertise.
11. Correlation of Sensory Properties: Exploring relationships between various sensory properties.

Sensory tests can be categorized into two main types: "product-oriented" or "analytical" tests, and "consumer-oriented" or "affective" tests (Choi, 2013). Product-oriented tests focus on evaluating specific product attributes, while consumer-oriented tests assess how products are perceived and accepted by consumers, considering their emotions and preferences. These evaluations play a crucial role in ensuring that food products meet quality standards, consumer expectations, and market success.

Types of Sensory Evaluation Tests

Analytical Tests (Product-Oriented Tests)

Descriptive Tests: These tests involve a panel of 10–12 highly qualified and experienced individuals who describe and quantify the precise sensory qualities of food samples. Descriptive test methods aim to create detailed sensory profiles of products. Examples of descriptive tests include Flavour Profile Analysis, Quantitative Descriptive Analysis, Texture Profile Analysis, and Sensory Spectrum (Lawless et al., 2010).

Discriminative Tests: Discriminative tests, also known as difference tests, are conducted to determine whether products exhibit sensory differences. These tests typically involve between 25 and 50 trained panellists. Examples of discriminative tests include Triangle Tests, Paired Comparison Tests, and Duo-Trio Tests (Lawless et al., 2010).

Affective Tests (Consumer-Oriented Tests)

Preference Tests: These tests involve consumers choosing between different samples to indicate their preferences. Common examples include paired preference tests, where consumers choose between two samples, and ranked preference tests, where more than two samples are presented (Lawless et al., 2010).

Acceptance Tests: Acceptance tests assess a product's overall consumer acceptability. The hedonic scale is often used to measure how much consumers like a product. This scale typically consists of an odd number of categories, ranging from "dislike extremely" to "like extremely," with a neutral middle category (neither like nor dislike) (Choi, 2013).

These sensory evaluation tests serve different purposes in the food industry, providing valuable insights into the sensory properties of food products and their reception by consumers. Descriptive tests are conducted by trained panellists to create comprehensive sensory profiles, while discriminative tests aim to detect differences between products. Affective tests, on the other hand, are designed to gauge consumer preferences and overall product acceptability.

Panel Selection in Sensory Evaluation

In sensory evaluation, the selection of the right panel is crucial to obtain accurate and meaningful results. There are typically two types of panels employed: consumer panels and descriptive panels.

1. Descriptive Panels: Descriptive panels are composed of individuals who have received extensive training before conducting the sensory tests. Panellists on a descriptive panel are experienced and knowledgeable about the specific type of food being evaluated. They are trained to describe and differentiate sensory qualities in detail.
2. Consumer Panels: Consumer panels are selected from the general population based on specific demographics relevant to the product being tested. It is advisable to have an equal representation of men and women on consumer panels to account for potential gender-based differences in sensory perception. The age distribution of the panel is also considered, as age may influence sensory preferences and perceptions.
3. Selection Criteria for Panellists (Choi, 2013): Members of the panel should be in excellent health and free from conditions such as diabetes, food allergies, or recurrent colds. Smokers should not be included in the panel. Panellists should not have colour perception deficiencies. They should not have specific dietary preferences before participating in evaluations. To optimize panellist performance during sensory evaluations, the following aspects should also be considered:

Timing of Sensory Evaluation

The timing of sensory evaluations should align with the typical time of day when the products are consumed. Late morning (e.g., 11 am) or early afternoon (e.g., 3 pm) is considered appropriate for testing since, during these times, panellists are neither hungry nor overly satiated (Brown, 2008).

Fasting and Chewing Gum

Panellists should fast for at least an hour before testing to avoid any lingering tastes from previous meals. Additionally, they should refrain from chewing gum just before participating in sensory tests (Brown, 2008). The careful selection and preparation of panellists are critical in ensuring that sensory evaluations yield reliable and accurate results, as the panel's characteristics can significantly influence the outcomes of the tests.

Empirical Literature Review

This empirical literature review focuses on the nutritional composition and potential benefits of a spread made from a combination of African locust beans and groundnuts. African locust bean seeds, when dehulled and defatted, have been found to be rich in protein and essential amino acids, making them a valuable source of nutrition for humans (Ojewumi, 2018; Odunfa & Adesomoju, 1986). These seeds are also high in essential minerals, particularly potassium and phosphorus, which are vital for various physiological processes (Elemo et al., 2011).

The fermentation process of African locust bean seeds enhances the distribution of nutrients within the seed and increases their digestibility, ultimately improving the overall nutritional value of the seed (Ojewumi, 2018;

Elemo et al., 2011). However, it's important to note that African locust bean seeds also contain anti-nutritional factors like trypsin inhibitors and phytic acid, which can reduce the bioavailability of certain nutrients (Ojewumi, 2018; Elemo et al., 2011). Combining African locust beans and groundnuts in a spread provides a blend of unique flavours, aromas, and textures, resulting in a versatile and delicious spread for various dishes.

The fermentation process of African locust beans imparts a rich taste to the spread and enhances its nutritional value, as it contributes protein, potassium, and phosphorus. Groundnuts, on the other hand, are rich in healthy fats, protein, and fibre, complementing the flavour and nutrition profile of the spread. The combination of these two ingredients in a spread results in a more balanced and nutritious product, suitable for those seeking a healthy and satisfying snack or meal addition (Falade & Akinrinde, 2020). The blend of African locust beans and groundnuts offers various health benefits, including providing essential amino acids, promoting satiety, supporting healthy digestion, and contributing to overall nutrient intake.

In summary, the combination of African locust beans and groundnuts in a spread is a promising avenue for creating a unique and nutritious food product. The rich umami taste of fermented African locust beans, along with the nutritional benefits of both ingredients, makes this spread a compelling choice for individuals looking for a flavourful, balanced, and healthful addition to their meals or snacks.

CHAPTER THREE

RESEARCH METHOD

Introduction

This chapter presents the methods used in collecting the data for the study. It covers the research design, study area, study subjects as well as panel members, methods and materials, data collection procedures, how data collected was analysed and interpreted, and limitations of the study.

Research design

As per Akhtar (2016), research design can be considered as the structure of research, it is the "Glue" that holds all of the elements in a research project together, in short it is a plan of the proposed research work. According to Gall, Gall, and Borg (2007), "An experimental design is a structured plan for collecting and analysing data that includes the specific manipulations of variables, the subjects or participants involved, and the controls in place to ensure the validity and reliability of the results." According to Douglas C. Montgomery in his book "Design and Analysis of Experiments" (2020), experimental design is crucial in the development process of new products in order to create a product that performs well and meets the desired specifications. Blake et al. (1994) affirms this that, through analysis of information from experimental design various parameters about the new product can be easily and accurately determined.

Different unique variables (three different formulations of Loground spread) were manipulated by the researcher and the respondents were made to access the sensory acceptability of the different formulations. Other relevant variables such the nutritional composition of the various formulations were not ignored.

Population

The study was experimental research that created a new product (Loground spread) for Ghanaian consumers out of various formulations of locust beans and groundnuts. Sensory testing of the new product took place on the campuses of Wenchi Methodist Senior High School and Al-Faruq College of Education, with students and teachers as the target population. The number of students and teachers targeted by the study was 100 in total.

Sampling Procedures

For the testing of the new product at Wenchi Methodist Senior High School and Al-Faruq College of Education, a total of 100 participants were selected. The number of respondents was appropriate for the hedonic method of sensory evaluation, which requires a total of 75 to 150 respondents for such testing (Lim, 2011). The respondents were chosen using purposive sampling, as this method allowed the researcher to select individuals who consume spreads and are not allergic to the ingredients used in the new product.

Purposive sampling is a type of non-probability sampling method in which the researcher intentionally selects a specific group of individuals or cases to study based on their relevance to the research question or purpose (Creswell, 2018). According to Lewis-Beck, Bryman and Liao (2004), it is deliberately seeking out for participants with particular characteristics to meet the needs of a particular study. Using this sampling technique was appropriate for achieving the objectives of this study.

Panel Members

In the sensory evaluation study, participants who participated in the test were referred to as panel members. These panel members were conveniently selected from the Wenchi Methodist Senior High School and Al Faruq College of Education. A total of 100 untrained panel members were chosen for the test. The use of untrained panel members, who are either users of the product or familiar with similar products, and a population size of between 75 to 150, as recommended by Lawless and Heymann (2010), was necessary for effective results in the affective test.

During the sensory evaluation, characteristics of the food such as taste, texture, flavour, aroma, colour, and overall acceptability were assessed. Prior to the test, participants were gathered for an orientation session where they were informed about the purpose and significance of the experiment, and how it related to the research objectives. They were also advised to abstain from consuming alcohol, smoking, wearing strong perfumes, and eating food that could alter their sense of taste on the day of the test.

On the day of the sensory evaluation, participants were invited to participate in the test. Before tasting, smelling, and touching the products, they were educated on the food attributes that would be evaluated and how to properly complete the questionnaire. Once they evaluated the products, they were asked to complete the questionnaire alongside.

Criteria for selecting Panellists

1. The participants were aged 18years and above.
2. They did not have any allergies to any of the ingredients used in the production of the spreads.
3. They did not have any respiratory infections, such as a cold.
4. They were not on any medication.
5. They were individuals who regularly consumed similar products.

Data Collection Instruments

In order to determine the presence and concentration of various nutrients such as protein, calcium, carbohydrates, crude fibre, fats, magnesium, zinc, potassium, sodium, iron, copper, and ash in different samples of Loground spread, laboratory testing was performed using a range of instruments including Atomic Absorption Spectrometers for determination of minerals, flame photometers, Soxhlet machine for fat determination, Kjeldahl apparatus for determination of protein and an oven for determination of moisture content.. These instruments allowed for the accurate measurement and analysis of the nutrients in the Loground spread samples.

A structured questionnaire that used a 5-point hedonic scale was administered to collect data from participants regarding their sensory evaluation of different proportions of Loground spreads. The hedonic rating scale is a commonly used method for quantifying the affective dimension of consumer perception of foods and allows respondents to rate different attributes of a product on a scale by checking one of five alternatives, (ranging from 1 = like very much, 2= like a little, 3 =neither like or dislike, 4 = dislike a little to 5 = dislike very much). (Tuorila, 2008).

Data collection Procedure

For this study, primary data was collected through proximate analysis of food samples and sensory evaluation by a taste panel. The proximate analysis was conducted at the School of Agricultural Science Laboratory at the University of Cape Coast, and the sensory evaluation was conducted at the Dining hall of the Wenchi Methodist Senior High School and the Assembly Hall of the Al-Faruq College of Education. The production and testing of the spreads took place over a period of three weeks, and the sensory evaluation was conducted over a two-day period. A group of 100 panel members or tasters were asked to taste, smell, and feel each spread and provide their opinions on various attributes of the spreads using a questionnaire that utilized the 5-point hedonic scale.

Sample material and methods

Locust beans seeds and groundnuts were used in the study.

The locust bean seeds were obtained from the Wenchi market and the groundnuts were obtained from the Wenchi Farms Institute, which offers a variety of groundnuts for sale. The Obolo variety was chosen for the research. This was because according to the catalogue entries for Scientific research (2019 edition), the Obolo variety of groundnut has a good taste, good smell and good for confectionary. The raw locust bean seeds were pre cleaned, washed, boiled and pounded in a mortar to enable the researcher dehull the outer cover of the beans. It was again boiled for two hours, fermented, steamed for 25minutes to get rid of the pungent smell which was in line with the recommendation by Amoa-Awuah et al(2014), air dried and milled into a powder for the spread samples.

The groundnuts were sorted to remove foreign materials, soaked in brine solution, air dried, roasted for 45minutes at 180^0C which was in line with recommendation by Birch et al. (2010) cooled, dehulled (separation of chaff) and then milled into a paste for the spread. The two samples were mixed in different proportions to prepare the spreads.

For proximate analysis and sensory testing, four different test samples were prepared. The sample for sensory analysis was served with a half slice of bread purchased from the Eussbett hotel in Sunyani. The spread samples were formulated as follows:

- Groundnut spread (GS): It was prepared out of 100% groundnut with no locust beans added to serve as the control.
- Groundnuts with Locust beans spread (GWLS) [75% groundnut, 25% locust beans].
- Groundnuts and Locust beans spread (GALS) [50% groundnuts, 50% locust beans].
- Locust beans with Groundnuts spread (LWGS) [75% locust beans, 25% groundnuts].

Sample Preparation

A total of four spread samples, each weighing 1kg, were prepared using locust beans and groundnuts in various proportions. 42.5g of honey was added to each. Determination of the proximate composition of the spread sample was carried out at the School of Agricultural Science Laboratory University of Cape Coast.

Figure 13: Preparing to dehull Locust Beans.

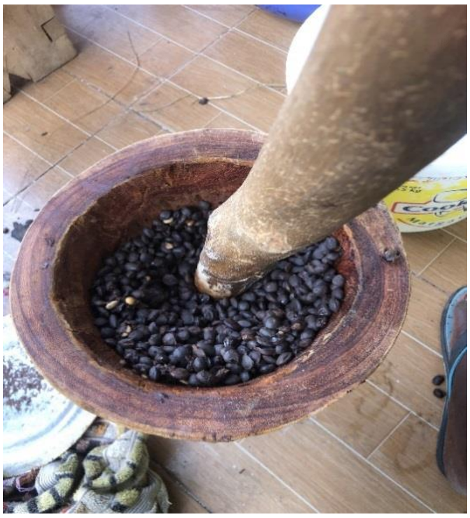

Figure 14: Dehusking locust beans

Figure 15: Dehulled Locust beans

Figure 16: Grounded locust beans

Figure 17: Groundnut paste

Figure 18: Mixing groundnut past and grounded locus beans

Process flow chart

The following flow chart illustrates the steps involved in the production, laboratory analysis, and sensory evaluation of the Loground spread

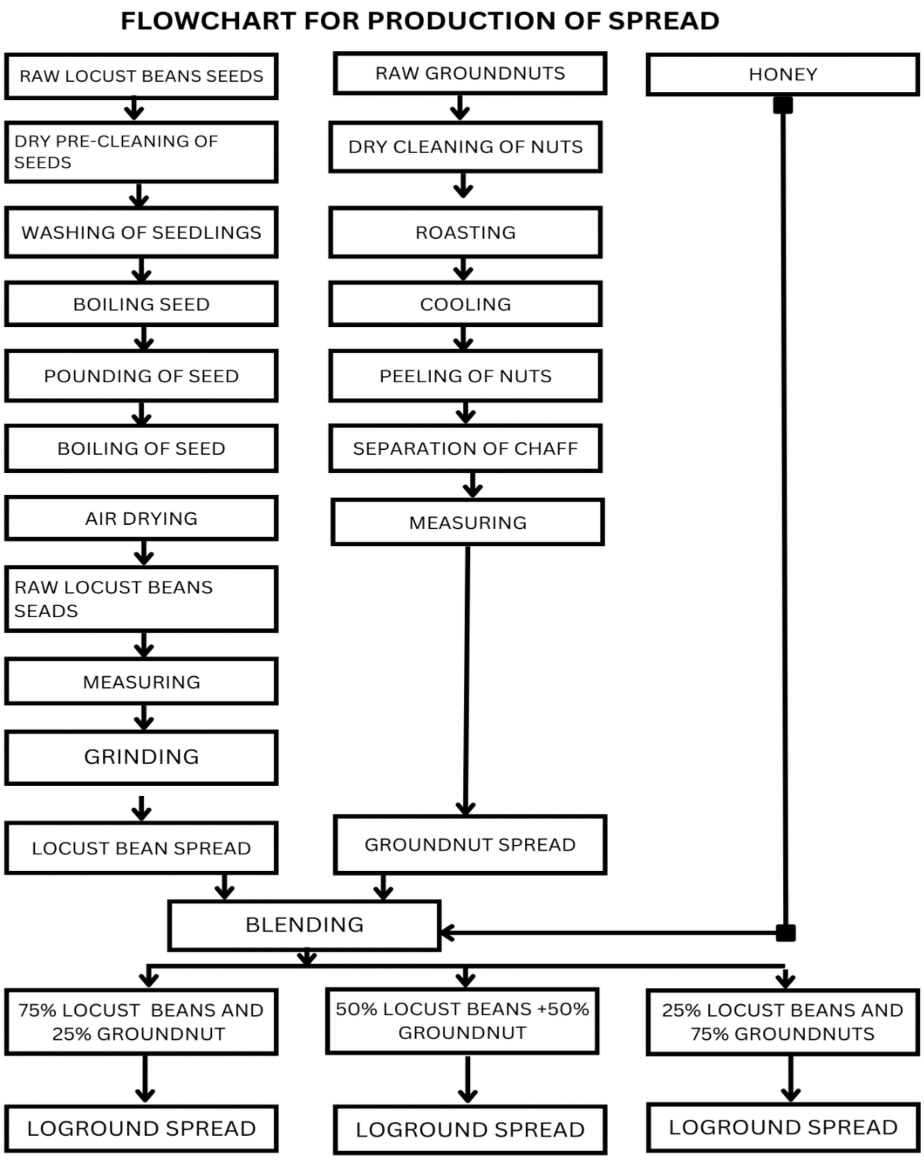

Figure 19: Flow chart of spread production

Source: Author's Construct (2024)

Laboratory Testing

The prepared spreads were analysed to determine the following nutritional and chemical composition (protein, calcium, carbohydrate, fat, crude fibre, magnesium, zinc, potassium, copper, ash. Data on the nutritional composition of the spreads prepared at different proportions with groundnut were recorded and compared to a control (groundnut spread).

Figure 20: Sample testing

Moisture Determination

Porcelain crucibles were washed dried and weighed. About 10-12g of the 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 105^0C for 48 hours. At the end of the period the samples were removed, cooled in a desiccator and weighed. Each sample was done thrice. The moisture content was then calculated as the percentage water loss by the sample.

Ash Determination

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

Oil/ Fat Determination

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 was done 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

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

where W is Weight of Oil

Protein Determination

Kjeldahl method was used in the determination of protein. 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 360°C for two hours. A blank was prepared. (Digestion of the digestion mixture without sample) were carried out in the same way. After the digestion, the digests were transferred quantitatively into 100 ml volumetric flasks and made up to the volume.

Distillation

A steam distillation apparatus was set up. The distillation apparatus was flushed with distilled water for about twenty (20) minutes. After flushing out the apparatus, five (5) millilitres of boric acid indicator solution was poured into a 100 ml conical flask was 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.

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

$$\%\ \text{Protein} = \%N \text{ x } 6.25$$

Crude Fibre Determination

The reagents are Sodium hydroxide, 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, 100ml of the 1.25% sulphuric acid solution was added and boiled for 30mins.After the boiling, filtration was done in a numbered sintered glass crucible. The residue was transferred back into the boiling flask and 100ml of the 1.25% NaOH solution was added and boiled for 30mins.Filtration continued after the boiling and the residue washed with boiling water and methanol. The crucible was dried in an oven at 105 degrees 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)

Total carbohydrate was determined by difference.

Preparation of Sample Solution for the Determination of nitrogen, potassium, sodium, calcium, magnesium, phosphorus, zinc, copper & iron. 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 comprises 350mL of hydrogen peroxide, 0.42g of selenium powder, 14g Lithium Sulphate and 420mL sulphuric acid. The digestion procedure as outlined in Stewarte et al (1974) states that between 0.1000g to 0.2000g of the oven-dried ground sample was weighed into a 100mL Kjeldahl flask and 4.4mL 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.

Colourimetry Determination of Phosporous using the Ascorbic Acid Method

The procedure requires the preparation of colour forming reagent and P standard solutions. The colour forming reagent is made up of reagents A and B. Reagent A is 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 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 pipette 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.

Ten militres (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 absorbance 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 absorbance. 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

$$\mu gNa/g = \frac{C \text{ x solution volume}}{\text{Sample weight}}$$, Stewarte et al (1974)

Determination of Calcium and Magnesium by Edta Titration

The method involves chelation of the cations with ethylene diamine tetra-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 cyanide, 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.

Calculation

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

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

Where T = titre value

Page et al (1992)

Determination of Iron, Copper and Zinc using atomic Absorption Spectrophotometer

Standard solutions of 1, 2 and 5μg/mL solutions of Fe, Cu and Zn were prepared. The standard solutions were aspirated into the atomic absorption spectrophotometer (AAs) and the respective calibration curves were plotted on the AAS. As the sample solutions were aspirated, their respective concentrations were provided.

Calculations

$$\text{Fe } (\mu g/g) = \frac{\text{C x solution volume}}{\text{Sample weight}}$$

$$\text{Cu } (\mu g/g) = \frac{\text{C x solution volume}}{\text{Sample weight}}$$

$$\text{Zn } (\mu g/g) = \frac{\text{C x solution volume}}{\text{Sample weight}}$$

FAO (2008)

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The Chapter presents the results obtained to address the research objectives and the hypotheses. The statistical tools and approaches used for the data analysis differ in view of the varied demands of the research objectives and hypotheses involved. The results were presented in figures and tables depending the mode of the result. The first result in the Chapter was the demographic information of the panellists and the rest were on the research objectives and the hypotheses. The findings have been discussed in conjunction of the appropriate literature.

Demographic Information

The demographic information relating to the panellists is presented in Table 3.

Table 3: Demographic Information of Panellists

Characteristics	Frequency	Percentage
Gender		
Male	44	44
Female	56	56
Age		
16 – 20	50	50
21 – 25	35	35
26 – 30	9	9
31 – 35	4	4
36 – 40	2	2

Source: Ankomah, (2024)

The result in Table 3 covers the gender and age of the panellists that have sensorily evaluated the spread formulations. The females were more than the male by 12 persons. The representation at least reflected the general information on Ghana's district data relating to population and census of Ghanaians which states that females are more than males in Ghana.

In the traditional setting of Ghana, preparing food and its related issues are dominant among women and same seem to be the picture in the hospitality industry of Ghana. The use of the new formulation might be mostly by females as well since it relates to food and beverage. The female does use spreads most often to serve the family and also clients in the hospitality industry. Therefore, the dominance of females in the current study to sensorily evaluate the new formulations for acceptability might not be out of place. The opinion of the females may count a lot and the complementary role of males in telling the taste, aroma among others (hedonic scale of sensory evaluation) of food is in place.

The age factor in accepting food sensorily cannot also be discounted when the need to take the demographic on the age of the panellists. Per the retrieved questionnaires, the ages of the panellists were from 16 years up to 40 years. The range interval was five and those from 16 – 20 years were found to be the most represented in the study. The least number of representations was in the age range of 36 – 40 years with only 2 panellists. This was followed by 35 persons in the age range of 21 – 25 years. Youth are the age groupings that are adventurous and wants to have a taste of every meal. The accepted formulation might be in high demand by the youth which was adequately represented in the demographic information in Table 2.

Research Objective 1

Locust bean spread with different ratios of locust beans

The focus of the objective was to use locust beans as a base and groundnut as a commentary to develop spread for human consumption. The objective was attained by developing three different spreads with varied ratios of locust beans and groundnut. The development of the spread as presented in Figures 22 – 24 indicated the possibility of using the locust beans and groundnut. The formulations and production of the current products was based on the flow chart in Figure 20.

The spreads developed were coded before presenting to the taste panel for the sensory evaluation. The names of the formulations were GALS-Groundnut and Locust spread (50:50), GWLS- Groundnut with Locust spread (75:25) and

LWGS- Locust with Groundnut Spread (75:25) respectively. The formulation of different ratios was to give consumers a variety to choose from. The products were packaged in transparent containers and sealed to avoid contamination.

Figure 21: GALS

Figure 22: GWLS

Figure 23: LWGS

Research Objective 2

Proximate analysis of developed products

In achieving the research objective 2, portions of the formulated spreads were analysed in the Food laboratory. AOAC (2008) protocols were used to determine the proximate composition in the edible fruits. Seven components analysed for were dry matter, moisture, ash, protein, oil/fat, fibre and carbohydrate. These are expressed in percentage and presented as mean and standard deviation as seen in Table 4.

Table 4: Proximate results of the Formulations

Proximate composition	GS (Control)	GALS	GWLS	LWGS
%DM	94.73±0.08	92.53±0.04	93.34±.20	92.51±0.17
%Moisture	5.27±0.08	7.47±0.04	6.66±0.20	7.49±0.17
%Ash	2.33±0.07	1.88±0.13	2.08±0.04	1.77±0.01
%Protein	23.16±0.06	20.38±0.46	17.64±0.47	18.87±0.10
%Oil/Fat	31.38±0.33	27.57±0.08	21.45±0.13	27.22±0.24
%Fibre	8.19±0.06	7.79±0.07	8.24±0.10	7.26±0.13
%CHO	34.95±0.41	42.37±0.49	50.58±0.40	44.87±0.20

*Values are averages of triplicate determinations *Result presented as mean ± standard deviation *All values are significant at 95% confidence level

Source: Ankomah, (2024)

Table 4 presents the proximate composition of the three formulations developed and the control. These values have been expressed as mean and standard deviation for each component present in the spreads. The mean and standard deviation helped to standardized the result for comparison. The % DM present in the GS (control) was a mean of 94.3 and a standard deviation of 0.08 which was higher than that of the three formulations. LWGS formulation had the least mean (92.51) and standard deviation (0.17).

In the case of % moisture for the formulations, the mean and standard deviation were 7.49 and 0.17 respectively showing that LWGS was higher than the other two formulations and repeatedly the control spread (GS) had a lesser value recorded followed by GALS which was a little lower than that of LWGS. The difference between LWGS and GALS was 0.02 for the mean and standard deviation 0.13 which was not statistically significant. Ash content in the control (GS) had a high mean value with the least mean value recorded for LWGS. The ash in GALS and LWGS were less as compared to GS and GWLS which have their mean a little over 2.08.

Crude protein content in the formulations showed that GS had more protein and GWLS had less quantity with a second highest mean value of one of the formulations following that of the control (GS). The mean value reduces from GALS ⩾, LWGS ⩾ GWLS respectively aside that of the control (GS).

GALS had the least lipid content (Oil/Fat) and the highest mean value was reported for GWLS. The control formulation was comparable with (GWLS) but slightly lower. The mean carbohydrate content was very high with the control formulation (GS) having the least mean score of 34.95 and standard deviation of 0.41. The highest mean value was for GWLS followed by LWGS with a mean margin difference of 5.71 and standard deviation of 0.20.

All the nutrients varied in mean quantities with dry matter (%DM) and carbohydrate having high values. The %DM values of 92.53 to 95.73 and the %CHO 34.95 to 50.58. The trend in the mean value showed that aside the % moisture, the %fibre and %CHO were higher.

Research Objective 3

Acceptability of developed products in terms of texture, appearance, aroma taste and overall acceptability.

Data collected was analysed using a One-Way Analysis of Variance (ANOVA). The results are presented in triplicate as well as the post hoc test in Tables 5, 6 and 7 respectively.

Table 5: Descriptive Results of Acceptability of formulations

		N	**Mean**	**Std. Deviation**
Appearance	GS (Control)	100	4.88	.383
	GWLS	100	4.70	.689
	GALS	100	4.40	.974
	LWGS	100	3.75	1.395
	Total	400	4.43	1.029
Aroma	GS	100	4.86	.377
	GWLS	100	4.72	.533
	GALS	100	4.39	.840
	LWGS	100	3.60	1.407
	Total	400	4.39	1.005
Taste	GS	100	4.91	.321
	GWLS	100	4.86	.450
	GALS	100	4.35	1.009
	LWGS	100	3.64	1.460
	Total	400	4.44	1.058

Texture	GS	100	4.82	.458
	GWLS	100	4.69	.692
	GALS	100	4.36	1.010
	LWGS	100	3.56	1.479
	Total	400	4.36	1.099
Over all acceptability	GS	100	4.90	.362
	GWLS	100	4.83	.587
	GALS	100	4.43	.935
	LWGS	100	3.63	1.522
	Total	400	4.45	1.079

Source: Ankomah, (2024)

Table 5 presents results from 100 panellists who evaluated the products/formulations using the senses of appearance, aroma, taste and texture. The mean value of the three formulations and the control in terms of the appearance showed that LWGS had the lowest mean and its corresponding standard deviation. The highest mean was for the GS (control). For the aroma attribute, the control formulation (GS) had the highest mean and the least mean value for LWGS.

The taste attribute of the spread formulation had the highest mean value of 4.91 and standard deviation of 0.31 for GS while the least mean of 3.64 for LWGS. In the case of the texture, the panellists have shown that GS had the highest mean value while LWGS had 3.56 mean. The overall sensory mean value was for GS (control) and the least for LWGS.

The ANOVA result in Table 5 indicate that the appearance of the formulations between groups and within groups had a p-value less than the alpha value of 0.05 ($p<0.05$). The mean value for aroma and taste attributes during the sensory evaluation indicate that the mean square and sum of squares between groups and within groups all had their p-values less than the alpha value of 0.05 ($p<0.05$). This shows that statistically the difference for the attributes for the sensory evaluation were significant.

Table 6: Result of One -Way ANOVA on the Formulations

		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Appearance	Between Groups	73.868	3	24.623	27.994	.000
	Within Groups	348.310	396	.880		
	Total	422.177	399			
Aroma	Between Groups	95.388	3	31.796	40.882	.000
	Within Groups	307.990	396	.778		
	Total	403.378	399			
Taste	Between Groups	104.540	3	34.847	40.346	.000
	Within Groups	342.020	396	.864		
	Total	446.560	399			
Texture	Between Groups	96.048	3	32.016	32.860	.000
	Within Groups	385.830	396	.974		
	Total	481.878	399			
over all acceptability	Between Groups	101.968	3	33.989	37.086	.000
	Within Groups	362.930	396	.916		
	Total	464.898	399			

Source: Ankomah, (2024)

Table 6 presents the post hoc test of the sensory evaluation acceptability. The post hoc test was done as a follow up to the ANOVA analysis which indicated statistically significant difference. The post Hoc was done using Tukey's-b to indicate the mean difference of contribution to the significance level. The Post Hoc showed that the control formulation (GS) had contributed much and was followed by GWLS. The least mean was for LWGS as can be seen in the Post Hoc table for sensory evaluation. The control formulation was the most accepted formulation followed by the others in this manner, LWGS<GALS<GWLS<GS.

Table 7: Post Hoc Test for Sensory Acceptability

		Subset for alpha = 0.05		
Formulation	N	1	2	3
LWGS	100	3.63		
GALS	100		4.43	
GWLS	100			4.83
GS	100			4.90

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 100.000.

Source: Ankomah, (2024)

Table 7 shows how the various means in the formulations were segregated to show clearly what was happening. The Post Hoc analysis was pegged at the alpha value of 0.05.

Research Hypothesis 1

Ho: There is no statistically significant difference in the nutritional composition of the three different ratios (formulations) of locust beans and groundnut spread formulation.

The focus of the hypothesis 1 was to find out if the nutrients found in the formulation was significant enough to help in decision making when it comes to nutrition. One-way ANOVA was run as the appropriate statistical tool to test the formulated hypothesis on the test foods (GALS, GWLS & LWGS). The data was measured in triplicate, entered and analysed. The outcome for the descriptive and the ANOVA results is presented in Table 8 and 9 respectively.

Table 8: Descriptive result of nutritional composition of the Formulations

		N	Mean	Std. Deviation
DM	GALS	3	94.73437	.081296
	GWLS	3	92.52747	.044866
	LWGS	3	93.34273	.200934
	Total	9	93.53486	.972735
Moisture	GALS	3	5.2656	.08130
	GWLS	3	7.4725	.04487
	LWGS	3	6.6573	.20093
	Total	9	6.4651	.97273
%Ash	GALS	3	2.32880	.074161
	GWLS	3	1.88497	.127205
	LWGS	3	2.07830	.042858
	Total	9	2.09736	.207410
%Protein	GALS	3	23.15747	.058882
	GWLS	3	20.38183	.463745
	LWGS	3	17.64483	.465261
	Total	9	20.39471	2.409731
%Fat and Oil	GALS	3	31.37697	.330299
	GWLS	3	27.56987	.075899
	LWGS	3	21.45373	.134188
	Total	9	26.80019	4.339317
%Fibre	GALS	3	8.18953	.060052
	GWLS	3	7.79383	.072330
	LWGS	3	8.23847	.102824
	Total	9	8.07394	.222343
%CHO	GALS	3	34.94723	.409927
	GWLS	3	42.36953	.485186
	LWGS	3	50.58473	.404301
	Total	9	42.63383	6.784590

Source: Ankomah, (2024)

The nutritional composition of the three formulations presented in Table 8 shows the dry matter, moisture, ash, protein, fat and oil, fibre and carbohydrate. The dry matter quantity was more in the GALS and least in GWLS. For moisture content on the other hand, GWLS had the highest quantity and GALS the least. The ash content of the formulations was high in GALS while the least mean value was for GWLS. The protein and fat/oil quantity recorded were higher in GALS in each case than the LWGS which had the least mean values for the two kinds of nutrients found. In the case of fibre and carbohydrate, LWGS had higher mean values in each case. The least mean values were recorded for GWLS and GALS respectively for fibre and carbohydrates.

The ANOVA result is presented in Table 8 and shows the nutrients, the sum of squares and mean square. The p-value of DM was less than the significant value taking into consideration the alpha value (0.05). The moisture, ash, protein, fat/oil, fibre and carbohydrate all have their p-values less than the alpha value of 0.05. Looking at the ANOVA result (Table 9), it can be concluded that the differences in the nutrient composition of the three formulations were statistically significant ($p<0.05$).

Table 9: ANOVA Result on nutritional composition of the Formulations

		Sum of Squares	df	Mean Square	F	Sig.
DM	Between Groups	7.472	2	3.736	228.744	.000
	Within Groups	.098	6	.016		
	Total	7.570	8			
moisture	Between Groups	7.472	2	3.736	228.744	.000
	Within Groups	.098	6	.016		
	Total	7.570	8			
%Ash	Between Groups	.297	2	.149	18.950	.003
	Within Groups	.047	6	.008		
	Total	.344	8			
%Protein	Between Groups	45.584	2	22.792	157.190	.000
	Within Groups	.870	6	.145		
	Total	46.454	8			
%Fat and Oil	Between Groups	150.372	2	75.186	1697.652	.000
	Within Groups	.266	6	.044		
	Total	150.637	8			
%Fibre	Between Groups	.357	2	.178	27.563	.001
	Within Groups	.039	6	.006		
	Total	.395	8			
%CHO	Between Groups	367.111	2	183.556	971.357	.000
	Within Groups	1.134	6	.189		
	Total	368.245	8			

Source: Ankomah, (2024)

Hypothesis 2

3. Ho: There is no statistically significant difference in the consumer acceptability of the three spreads produced from locust beans and groundnut.

To achieve this, a three-way analysis of variance was run. The descriptive and ANOVA results are presented in Tables 10 and 11 respectively.

Table 10: Statistics of consumer acceptability of the Formulations

Formulation	N	Mean	Std. Deviation
GWLS	100	4.90	.362
GALS	100	4.83	.587
LWGS	100	4.43	.935
Total	300	4.72	.700

Source: Ankomah, (2024)

Table 10 shows the three formulations, sample size, mean and standard deviation. The mean values for all the formulations were above 4.0 and the least mean was for LWGS while the highest was for GWLS. The difference in the highest mean value and the least was 0.47 which is very minimal with reference to the mean values in Table 10. The statistics of the consumer acceptability per Table 10 shows that GWLS i.e. the spread with the highest content of groundnut paste and lowest content of the locust bean paste was the formulation most accepted among the three.

Table 11: Test of between-subjects effects on Overall acceptability

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	12.860[a]	2	6.430	14.292	.000
Intercept	6683.520	1	6683.520	14855.601	.000
Formulation	12.860	2	6.430	14.292	.000
Error	133.620	297	.450		
Total	6830.000	300			
Corrected Total	146.480	299			

a. R Squared = .088 (Adjusted R Squared = .082)

Source: Ankomah, (2024).

The three-way interactions among the formulations is presented in Table 11. The alpha value for the comparison was set at 0.05 (α=0.05) to that of the p-value. The result thus showed that there was a statistically significant three-way interaction in the formulations, F (df=2, 100) = 14.292, p = .000. There was thus a statistically significant difference in consumer acceptability of the three spreads ($p<0.00$).

Discussion of Results

The first research objective was to formulate products from locust beans and groundnuts for spread. The results showed that locust beans and nuts could be used for production of spread. The formulations from the basic ingredients (locust beans and groundnut) came with three varieties. The production of the spreads limited direct contact of hands with the seeds or beans. The direct handling of the unprocessed beans and nuts could be contaminated as noted in Cheraghali et al., (2015). Hence, the successful formulation of the locally available ingredients may limit food poisoning. Food poisoning in the tourism industry is one of the major concerns of the Food and Drug Authority in Ghana. The contamination of foods as noted by Cheraghali et al., (2015) easily occurs when the seeds are being transported. The transport system was not purposely designed to transport the fruit of locust beans and groundnut since they are conveyed in public transports.

The self-processing of the raw materials (ingredients) may not have been done under hygienic conditions which could expose the product to contaminations. Food processing techniques and methods could destroy the nutrients or reduce its value. The formulations were developed using the scientific approach described by Radulescu et al (2023). Food science has its dictates of product development and this was strictly adhered to.

Spread as referred to as a condiment, is widely produced and consumed thereby creating employment. Grand View (2019) had earlier indicated the consumption of spread in the year 2018 to be USD 27.5billion. The current formulation when accepted by the market (consumers in general) could have a share in that huge market value. Specifically, the importation of foreign spreads to Ghana could reduce to some level as the years progress and acceptability of the spread increases. The increase in demand implies more production which could directly influence the local economy in terms of sales. The more the demand of sales could have direct impact on job creation along the market chain. There are reports of lack of jobs for several youth in Ghana and the production of spread from local locust beans and groundnut could be leveraged on to create jobs which would reduce unemployment rate at least in the food and beverage industry. Persons visiting eateries could have access to some of the spreads for breakfast or snacks. Job creation is becoming a challenge for graduates in general and the production of the formulation could provide jobs for people from diverse backgrounds. Farmers, drivers, sales persons and accountants could be in the chain of the job creation of spread production.

The second objective was to determine the proximate composition of the products developed. The proximate/nutritional composition of the three formulations and the control showed the presence of seven different nutrients which was tested for. The proximate composition showed varying levels of moisture, dry matter, ash, protein, fats and oil, fibre and carbohydrate for the product. The nutrients found in the proximate analysis are essential to human health and sustenance of good health.

The dry matter in the formulations varied and the variation could explain its influence on the nutritional quality. GS and GWLS had nutrient values close to 100% implying that the quality of nutrients and minerals in the spread formulations might also be very high.

The moisture content in any food helps reduce indigestion and speed up free bowel. Although the amount of moisture present was not so high in the formulations, it was expected because groundnuts and locust beans have low moisture content and had also been roasted reducing the moisture levels further. The groundnuts had been dried and were roasted processing. These would reduce the moisture content and increase the dry matter content and also help in the preservation of the product. The rippened locust bean had also been dried to extend their shelf life, hence would have lost moisture increasing the concentration of the dry matter.

All the formulations had high protein and fat content, ranging from 17.64 to 23.16% protein and 21.45 to 23.16% fat.

The liquid present in groundnut could be more of oil/fat than water. This accession of groundnut having more oil/fat than water when dried can be seen in the % oil/Fat mean quantity shown in Table 2. The mean values of the formulations were far more than that of the % moisture present in all the formulations. The oil/fat present in the formulations were at least three times that of the moisture detected in the proximate analysis.

The result clearly pointed to the fact that following the AOAC (2008) methodology outlined to determine protein and carbohydrate, the result confirmed their presence. Protein needs of individuals vary daily depending on the age of the individuals. The plant protein found in the GS (control) was very high and this could easily be attributed to the ratio of the groundnut used. The GS formulation had 100% groundnut and no amount of locust bean was added in the formulation. Analysis of the groundnut in terms of the quantity that contributes to the high nature of the protein present could be associated with the ratio of groundnuts used or available.

The GALS (50:50; groundnut: locust bean) with less groundnut saw the protein present reduced as well. GWLS (75:25; groundnut: locust bean) confirmed the trend that the less groundnut used, the less the protein in the formulation. The quantum of oil/fat also confirmed that more groundnuts used in the formulations the more the oil/fat present. In the case of protein, the high value of it in all the formulation did confirm what was found earlier in the study of Ojewumi, (2016) and Odunfa et al (1986). The studies reporting locust bean as a rich source of protein however, did not give any value (figure) for the current study to be compared with.

Fibre as one of the main contributors that help in digestion was rather low in the formulations (GS, GALS, GWLS and LWGS). The implication of this could be attributed to the processing method and the nature of the crop. The spread needs to be smooth and this was achieved by grinding the mixture for making the spread to a fine powder, Also, the second factor of having very low fibre quantity could be due to the crops being processed into the spread types.

The result from this study was contrary to that of Falade (2020) who reported that groundnut was rich in fibre.

The nutritional balance of the formulations could be confirmed with that noted by Falade et al (2020) for snacks. Snacks in general are not to be eaten to satisfy hunger. Rather, it is to serve as short gap to address the immediate need for the body and the nutrients in snacks have to be rich in nutrients and minerals. The locust bean and groundnut proximate analysis did confirm the nutrition packed in the formulations.

The function of protein in the human body in general is to support biochemical catalysts, hormones, and enzymes, build blocks and initiators of cellular death. It is therefore presumed that eating large quantities of any of the formulations could provide the body with good protein. The amount to be assimilated by the ileum however, cannot be estimated unless further analysis is done. The consumption of protein for the body to benefit therefore lies on the body needs of individuals per the age of the person involved.

The third research objective was to test the acceptability of the three formulations as against the control formulation of 100% groundnut. The acceptability score the three formulations varied but the 100 panellists score the control formulation higher (4.9) i.e was more preferable as against 3.63 to 4.83 for the formulations. The not too well acceptance of all the three formulations from the study could be attributed to many factors. One of such factors was the quantity of the locust bean used to replace the groundnut. This assertion could be justified by critically observing the descriptive results presented in Table 4. The mean results declined gradually as the percentage quantity of the groundnut also reduced. The ANOVA result also confirmed the fact that there was a significant difference in the mean results.

The most accepted control formulation (GS) had all the mean values being high as compared to the other formulations. The aroma, texture and taste of the control formulations had the mean values higher than any of the other formulations. Groundnut spread has been in the market for a number of years and thus consumers may have developed a taste for it rather than the newly introduced products.

In making a choice in terms of food, a lot comes to play and most of the factors seem to be sensory and economic factors. The panellists were not going to pay for the food for the sensory evaluation so the economic factor may not be under consideration now. However, the sensory factor does stand for consideration where the senses of human are mostly used. The sense of taste per Stone et al, (2004), plays a dominant role with the brain trying to interpret its 'sweetness' or otherwise. The demographic characteristics of the panellists showed they were of age to tell what kind of food they liked or not. The ability of the panellists views to judge which kind of formulations to accept individually before its aggregation could be accorded their sense of judgment. During the sensory evaluation, the panellists were separated from each other and not allowed to communicate so it can be confidently said that the results are representative of the panellists and not influenced by each other. Also, the formulations were coded to hide the identity of the ingredients. Therefore, the acceptability of the control formulation could be only attributed to the groundnut quantity being 100%. All other formulations have their groundnut level reduced and the one with least locust bean of 25% (GWLS) was the next accepted formulation.

The first hypothesis was to test if there was no statistically significant difference in the nutritional composition of the three different formulations of locust beans and groundnut spread. The ANOVA result had established that there was a statistically significant difference in the nutritional composition of the three formulations at ($p<0.05$). The current finding has actually confirmed the second objective of the study indicating the variations in the mean values for nutrients found in the formulations. The consumption of any of the three formulations (GALS, GWLS & LWGS) thus suggest that any of the nutrients found could be of benefit to the consumer. Snacks are not necessary to satisfy severe hunger so getting the needed nutrition from the spread used on bread or others can provide some nutrients.

The second hypothesis was to test for statistically significant difference in the formulation acceptability or not. The result thus indicated that there was statistically significant difference in the consumer acceptability of the three spreads ($p<0.005$).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview of the Study

Food spreads have been with humans and Ghanaians also make use of food spread in several ways. The increased awareness of the importance of locust beans and groundnuts to human health and industrial needs is making the demand higher than before in Ghana. The importation of foreign spread calls for a lot of foreign exchange to be used for the importation of different spreads. The possibility of using locally available fruits like locust beans and nuts like groundnuts have been exploited to develop spreads locally in Ghana.

The focus of the study was to develop spread from groundnut and locust beans which is abundant in the Northern part of Ghana. The spread formulations had three different ratios and a control for comparison during the analysis stage. The three formulations and the control were coded as Groundnut spread (GS; 100%), Groundnut and Locust spread (GALS; 50:50), Groundnut with Locust spread (GWLS; 75:25) and Locust with Groundnut Spread (LWGS; 75:25).

The study was guided by three research objectives and two research hypotheses. The literature relating to the research objectives was reviewed to provide the basis and understanding of the study. The research design was purely experimental where the variables relating to the formulations were experimented upon. The product formulation was done using flow charts detailing out how to approach the product development. The sensory evaluation was done using 100 panellists who responded to the questionnaire. The research objectives and hypotheses were all analysed using the appropriate statistical tools and the results were either presented in figures or tables.

Key Findings

The first objective was to formulate products from groundnuts and locust beans to be used as a spread. The product formulation was achieved and three different products with different ratios were obtained. The first product was groundnut and locust spread (GALS) with 50:50 formulation ratio. The second product with 75:25 being Groundnut with Locust spread (GWLS) and the last formulation was 75:25 for Locust with Groundnut Spread (LWGS).

The proximate composition of the raw materials i.e. groundnuts and African locust beans was the focus of the second research objectives and the result revealed seven nutrients i.e. %DM, %Moisture, %Ash, %Protein, %Oil/Fat, %Fibre and %CHO. The nutrients found had different mean values signifying that each of the nutrients found varied in quantity. The third objective was to sensorily evaluate the formulations. The control formulation coded GS (100% groundnut) was the most overall accepted formulation (LWGS<GALS<GWLS<GS).

The first hypothesis revealed that there was a statistically significant difference in the proximate/nutritional composition in the three formulations ($p<0.05$). The last hypothesis for the study was to test for statistically significant difference in the formulation acceptability or otherwise. The result showed that there was statistically significant difference in the consumer acceptability of the three spreads ($p<0.005$).

Conclusions of the Study

The study was on product formulation of spread from groundnuts and locust beans for domestic use. The study confirmed the possibility of using the groundnut and locust beans for the spread and several nutrients were found after the proximate analysis was conducted on the formulations. The nutrients found after the proximate analysis were essential for human growth and help with the cellular metabolic activities of the body.

The acceptability of the control formulation i.e. the groundnut paste and the 75% groundnut and 25% locust bean formulation (GWLS) suggest that panellists preferred higher groundnut ratio to the use of locust bean as a substitute. The nutrients found in the three formulations were statistically significant and this confirmed the quantities of nutrients to be enough for the body. The customers' preference for the formulated spread was 75% groundnut and 25% locust bean spread out of the three formulations. The results showed that the higher the groundnut content of the spread the higher the acceptance of the spread by the sensory panel. The results therefore suggest that customers might have preference for more groundnut being used for food spread for domestic usage.

Recommendations

The study result for the first research objective showed the possibility of using groundnut and locust beans to formulate spread for consumption. It is therefore recommended that farmers in the local areas in the study area needs to be encouraged to grow more groundnuts. The locust bean tree should also be protected from bush fires by weeding around them. Agricultural extension officers in the area could help nurse some of the seeds of locust beans and distribute free of charge to farmers to plant. This could help make the ingredients for the spread formulation abounds.

The nutrients found in the second objective could be leveraged on by dieticians and health workers to encourage the use of the spread formulated for use. The nutrients could help build good immune system for persons that consume the products. The protein, fat/oil and carbohydrate as some of the nutrients available in the formulations could be of benefits to people of different age groupings. In addressing the third objective, the control formulation i.e. 100% groundnut only spread had the highest score for overall acceptability, hence the most preferred. Hence the possibility of adding other ingredients aside the locust to the groundnut should be explored. The ratio of combination could be made in various permutations for sensory evaluation to assess their acceptability.

Investigation of the first and second hypotheses showed that there were abundant nutrients in the groundnut/locust bean spreads and customers' acceptability of the formulations were statistically significant. It is therefore recommended that the three formulations from the study could be promoted for potential consumers to use. The more the formulations are promoted for consumption, preference could be developed for them as time passes.

Suggested Area for Further Study

The current study developed only three formulations with limited permutations and 100 panellists for the sensory evaluation. The study could be expanded by having different ratio permutation of groundnut and locust beans. Other ingredients could be added for the development varied spreads for domestic use.

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APPENDIX A

Sensory Evaluation Form

Tray Number…………………

Bio Data

Gender: Male [ ] Female [ ]

In front of you is a sample. Taste the sample and tick how much you like or dislike each of thecharacteristics. You can taste the sample more than once. Please wash your mouth with the water provided before and after tasting each sample.

SAMPLE 'GS'

	Appearance	Aroma	Taste	Texture	Overall Acceptability
Like a lot					
Like a little					
Neither like or dislike					
Dislike alittle					
Dislike a lot					

SAMPLE 'GWLS'

	Appearance	Aroma	Taste	Texture	Overall Acceptability
Like a lot					
Like a little					
Neither like or dislike					
Dislike a little					
Dislike a lot					

SAMPLE 'GALS"

	Appearance	Aroma	Taste	Texture	Overall Acceptability
Like a lot					
Like a little					
Neither like or dislike					
Dislike alittle					
Dislike a lot					

SAMPLE 'LWGS'

	Appearance	Aroma	Taste	Texture	Overall Acceptability
Like a lot					
Like a little					
Neither like or dislike					
Dislike alittle					
Dislike a lot					

APPENDIX B

CLEARANCE LETTER

UNIVERSITY OF CAPE COAST

INSTITUTIONAL REVIEW BOARD SECRETARIAT

TEL: 0558093143 / 0508878309
E-MAIL: irb@ucc.edu.gh
OUR REF: IRB/C3/Vol.1/0400
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0011497

4TH SEPTEMBER, 2023

Ms Monica Mensah Ankomah
Department of Vocational and Technical Education
University of Cape Coast

Dear Ms Ankomah

ETHICAL CLEARANCE – ID (UCCIRB/CES/2023/30)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted Provisional Approval for the implementation of your research **Development and Consumer Acceptability of Locust Beans and Groundnut (LOGROUND) Spread.** This approval is valid from **4th September, 2023** to **3rd September, 2024**. You may apply for an extension of ethical approval if the study lasts for more than 12 months.

Please note that any modification to the project must first receive renewal clearance from the UCCIRB before its implementation. You are required to submit a periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours faithfully,

Kofi F. Amuquandoh
Ag. Administrator