UNIVERSITY OF CAPE COAST

DEVELOPMENT OF SESAME SPREAD AND CONSUMER ACCEPTABILITY IN GHANA.

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BY

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DECLARATION

Candidate's Declaration

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

Candidate's Signature ……………………Date …………………………

Name: Hickmatu Sulemana

Supervisor's Declaration

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

Principal Supervisors Signature ………………… Date ……………………

Name: Prof. (Mrs.) Sarah Darkwa

ABSTRACT

This study attempts to innovate and develop a healthy, nutritious spread from sesame seed with different inclusion ratios of peanut. The overall goal of the research was to promote the consumption of sesame seed through its utilization in different food. The purpose of the research was in three folds. The first, to develop four spreads with different inclusion ratios of peanut, to determine the proximate composition spread, and to evaluate sensory properties of the spreads. Analysis of Variance (ANOVA) was used to determine whether there was significant difference between the control and the newly developed spreads. Significance was accepted at $p \leq 0.05$ with multiple comparisons through post hoc testing done with Tukey (HSD).

The findings of the study showed that spread could be developed from the sesame seed with different inclusion ratios of peanut and sesame seed. Sensory evaluation of food attributes of the spread presented PWSS (75% peanut and 25% sesame) and SAPS (50% peanut and 50% sesame) as the most preferred spread samples by consumers.

This study concludes that there was significant difference in nutritional composition as well as consumers' preference for the spreads. This called for a rejection of the study's hypothesis. Acceptability of the spreads to consumers declined as the proportion of the sesame in them increased. Hence, the two most accepted spreads PWSS (75% peanut and 25% sesame) and SAPS (50% peanut and 50% sesame) were seen to have a higher inclusion ratio of peanuts in them. They were also found not to be significantly different from each other and the control. The study recommended the promotion of PWSS and SAPS as substitute for high diary fat based spreads.

KEY WORDS

Product development

Proximate analysis

Sesame seed

Spread; Sensory evaluation

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I also convey my sincere gratitude to my family who provided me their love and support though out this work.

DEDICATION

To my husband and family

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LIST OF ACRONYMS

ACDEP	Association of Church Development Projects
ANOVA	Analysis of Variance
CHD	Coronary Heart Disease
DNA	Deoxyribonucleic Acid
GABA	Gamma Aminobutyric Acid
HDL	High-Density Lipoprotein
LDL	Low-Density Lipoprotein
PS	Peanut Spread
PWSS	Peanut With Sesame Spread
SAPS	Sesame And Peanut Spread
SARI	Savanna Agricultural Research Institute
SNF	Slids-Not-Fat
SNV	Netherlands Development Organization
SS	Sesame Spread
SWPS	Sesame With Peanut Spread
U.C.C	University of Cape Coast
U.S.A	United States of America
USDA	United States Department of Agriculture

CHAPTER ONE

INTRODUCTION

Background to the study

Food innovation refers to the development and commercialization/ commoditization of entirely new or modified food products, services or processes. In today's competitive market food consumers are conscious of the food they take. Food and beverage companies over the world are eagerly searching for ways to produce healthy and nutritious food products that are unique from the competition, enticing, easily accessible, exciting, but also profitable and sustainable (Szakály et al., 2011).

In respect to achieving, introduction of plant seeds and nuts in human diet has been found to play a very important role. Plants seeds are regarded as highly nutritious and contain essential macro and micronutrients, which provide the individual with the needed amount of these nutrients when consumed in adequate quantities. A publication by Harvard Health Publishing outlines that seeds have mostly healthy fat, fibre and are similarly considered as a good source of protein and plant-based omega 3 fatty acids (Harvard Health 2019).

Sesame (*Sesamum indicum L.*), is one of the essential oil seed crops that is grown within the tropics and temperate regions of the world (Biabani & Pakniyat, 2008). Over 4000 years ago, the seed was a highly valued oil seed crop in Babylon and Assyria (Ross, 2005). It is called "sesame" internationally. The name comes from the Greek word "sesamon" ("seed or fruit of the sesame plant") which is believed to be a derivative of the Arabic word "simsim" (Singh et al.,2016). The seed is popularly referred to as "benniseed" in the West African region. In East Africa and India the seed is known as "simsim" and "Til" respectively. Physically, the colour of the sesame seed vary from black, brown, grey and gold depending on the cultivar. It is also very small with an ovate shape similar to that of an egg.

Various researches carried out on sesame conclude that it is an excellent source of vital nutrients. The seed is valued and widely utilized in Asia and Africa due to the high content of edible oil and protein it contains (Makinde & Akinoso, 2013). Kanu (2011); Mohammed and Hamza (2008) also concluded in their studies that the health benefits of sesame seeds are attributable to its nutritional content. Essential nutrients found in the seed include vitamins, minerals, natural oils. It is also high in organic compounds such as calcium, magnesium, copper, iron, manganese, zinc, fiber phosphorus, thiamin, vitamin B6, folate, and tryptophan.

Health benefits of the seed according to these studies include its ability to prevent diabetes. It is also believed to have the potential to reduce blood pressure and limits once chances of being affected by a wide range of cancers (Miyamoto et al., 2016). Similarly, it helps in the building strong bones, protect against radiation and improves heart health. It is also noted to aid in the cure sleep disorders, aid digestion, reduce inflammation and strengthen oral health. Other health benefits attributed to sesame include the enhancement of circulation, detoxification the body, and elimination of depression and chronic stress. (Kanu, 2011; Mohammed & Hamza, 2008).

Sesame has and continues to contribute immensely to human nutrition. The seed is generally grown for its oil, or processed into paste for cooking and also used in food formulation. Because of its rich and nutty flavour it is widely used as the main soup ingredient for cooking in some parts African.

In Ghana, sesame forms part of some traditional delicacies especially among the people in the northern part of the country. The grounded and processed seeds can be used in sweet confections and also for porridge (koko). Locally known as "zinzam" in Dagbani, the Dagombas use it in addition with other ingredients in preparing "tubani", a special meal wrapped in green leaves and eaten with seasoned powdered pepper.

Nuts and seeds are normally roasted and consumed as snack because they are usually handy, good tasting, and easy to eat. However, lately due to the introduction of improved technologies, many varieties of nut and seed based snacks and processed food products are available in the market of which spreads have gained more popularity. In recent times there has been an increased in the consumption of spread made from nuts and seeds due to varying reasons (Manufacturing.Net 2021). This can be the results of the fact that consumers are very conscious of their health.

Statement of the problem

Research by Gorrepati, Balasubramanim and Chandra (2015) revealed that the rising health concerns about consuming dairy spreads owing to their high fat content has stimulated the need to find alternatives in plant based spreads like nuts and seed spread. Extensive studies have been carried out on the nutritional advantages of nuts and seeds. Fraser, Sabaté, Beeson and Strahan (as cited by Ros, 2010) indicated and associated the consumption of nuts with a lower risk of coronary heart disease (CHD). Additionally, a seminal clinical trial by Sabaté et al proves that diets enriched with nuts tend to reduce serum cholesterol levels in humans compared with standard healthy diets (Ros, 2010).

In Ghana lately, sesame seed whose consumption has for a long time been restricted to the northern part of Ghana has become popular on the streets of the southern sector. The popularity of the seed has been its increasing acceptance as a traditional medicine and folklore product in Ghana. A common introduction in recent times has been roasted white sesame seed packaged and sold (either as whole grain or powder) as health promoting condiment. The sale of the products has largely been limited to street vending and sale through public transport ("trotro" and buses).

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., 2010). In that same study by Cheraghali et al. (2010), there was some evidence that contamination occurs during handling and transportation of these nuts and seeds. If the total mycotoxins (especially aflatoxin B_1) 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.

Pathak et al. (2014) bemoans the limited utilization of the sesame seed despite the large benefits it offers. They assert that not much attention has been paid to the production of value added products from the seed to enhance its economic value and called for attention to be paid to value addition in this important oilseed.

Although much of the literature has reported on nut spread production, most studies were related to peanut butter and peanut 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 sesame seed and come out with varied products to increase its consumption in different ways. Producing a spread from sesame is one way to achieve this and also provide a healthy alternative to margarine and butters. A spread from sesame would also appeal to people from all social classes and distribution channels as against the current trend of roasted sesame sold in “trotro” and on streets.

Purpose of the Study

This study aims at producing an innovative and nutrient rich product from roasted sesame seed (sesame spread). The specific objectives of the study are to:

1. develop sesame spreads from sesame seeds with different inclusion ratios with peanut.
2. perform proximate analysis on the sesame spreads
3. sensory evaluate the sesame spreads for consumer acceptability.

Research questions

1. Can sesame spread be developed from sesame seed with different inclusion ratios with peanut?
2. What is the nutritional composition of the sesame spreads?

3. What will be the acceptability of the sesame spreads by consumers?

Research Hypothesis

1. **H_0:** There is no statistically significant difference in the nutritional composition and consumer acceptability of spreads produced from sesame seeds with different inclusion ratio of peanut.

Significance of the study

It is hoped that the findings from this study would result in the development of a new and acceptable product as well as promote the consumption of sesame seeds in the country so that consumers can get the best out of this nutritious seed. Findings from this study will also bring about varieties in the Ghanaian market as far and help break monotony in the manner in which sesame is consumed in most part of the country. This research work will also contribute to the body of knowledge that exists in the area of nutritional quality of food and innovative product development in the food industries. If a spread is successfully developed from the seed, industry players can adopt and fine tune it and further invest in research and development to create other sesame based products for the market. Household can similarly produce such sesame based products to enrich their meals.

Delimitation

Although several cultivars of sesame seeds available, this study will focus on the white sesame seed which is the preferred seed roasted, packaged and sold by vendors in Ghana. The study will primarily explore the possibility of developing a spread from sesame seed focusing on the nutritional composition of the spread. The work will concentrate on nutrients such as protein, calcium, carbohydrate, fats, magnesium, potassium, sodium, iron, copper and ash. Panel members who will be used for sensory evaluation will only be people who eat or are familiar and have eaten the sesame seeds before. However, those who were not fit or had any respiratory infection like cold will be excluded.

Limitation

The targets population for sensory evaluation of the developed spreads is limited to students of the University of Cape Coast which might not fully be representative of 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 sesame plant, the uses of the sesame seed and nutritional composition. The section also looks at the types of spreads and how to sensory 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

The chapter reviews existing literature, which is related and also relevant to the study. It consists of empirical evidence on sesame seeds and its nutritional and health value. Some studies carried out by earlier researchers provide empirical evidence on the importance of the seeds in our diets. The following paragraphs identified some of these studies and reported their findings.

Sesame

Sesame or *Sesamum indicum L* as it is known scientifically is regarded to be among the few ancient oil seed crops consumed as food by humans (Abou-Gharbia et al., 2000). It is a deep-rooted plant that has the ability to survive dry climatic environments. The United States Department of Agriculture (USDA, 2005) reports that the plant has the capacity to grow well on relatively less fertile soils and in climatic conditions that are relatively not suitable for most food crops. This makes it particularly valuable as a nutritional and economic resource in most tropical areas.

The crop is appropriate for smallholder farmers as it has a shorter production cycle of 90 – 140 days affording farmers the opportunity to cultivate other crops on the same parcel of land (USDA, 2005). According to Johnson et al.,(as cited in Makinde & Akinonso, 2013), sesame has been grown in Africa and Asia for a very long time particularly for its enormous edible oil capacity and plant protein content. It ranks ninth among the world's oilseed crops (Adeola et al, 2010). About 70% of global production of sesame comes from Asia with China, India and Myanmar being the highest producers.

In the African continent Uganda, Nigeria, Sudan and Sierra Leone are the major producers. In total, Africa accounts of 26% of global sesame output (Namiki as cited by Makinde & Akinonso, 2013). According to Mukta and Neeta (2017), sesame is known as “gingelly” (india). Its hindu name is “ til” whiles the Chinese refer to it as “huma”. In African sesame is widely referred to as “benne” seed, the Japanese call it “goma” whiles the Portuguese and Spanish refer to it as “gergelim” and “ajonjoli” respectively. In Ghana its is popularly known among the Dagombas as “zinzam”. It is popularly termed as “Queen of Seeds”, due to its high degree of resistance to oxidation and rancidity (Pathak et al. 2014). It is believed that the magical phrase “Open Sesame” found in the story of the Arabian Nights was influenced by a distinct attribute of the sesame pod which is seen to burst open on maturity (Mukta & Neeta, 2017).

History

Anilakumar, Pal, Khanum and Bawa (2010) in their study on sesame reported that one Assyrian legend records that when the Gods met to create the universe they were served with wine produced from sesame. Some people believe that the seed originated from India as old Hindu legends signified the seed as symbolizing immortality. According to believers of this narrative, the seed was introduced from India to Asia, Africa and the Middle East. Oil produced from the sesame crop is regarded as one of the first edible oils known to man whiles the seed itself is one of the oldest condiments to be consumed.

Sesame seeds were introduced in to the United States of America by slaves from Africa during the later part of the 17th century and soon became a popular food ingredient in recipes from the South (Anilakumar, Pal, Khanum & Bawa, 2010). From archeological records, sesame was determined to be widely cultivated in Babylon and Assyria over 4,000 years and was also known to Indians in about 5,000 years ago (Borchani et al., 2010).

Plant description

The sesame plant belongs to the Pedaliaceae family. It is a herbaceous crop that grows well in tropical areas. The crop is an annual crop that is self-pollinating. The matured plant possess an erect stem that is about 0.60 to 1.20m tall with branches. It has ovate leaves that are hairy on both sides. Leaves found at the lower part of the plant are either trilobed or ternate while those located at the upper parts tend to be pointed, undivided and irregularly serrated. Other varieties tend to have flatter and smooth leaves whiles the leaves of non-shattering varieties tend to be cupped in nature with leaf like outgrowths on their lower side. Whiles some varieties can develop branches others are relatively branchless.

The sesame plant has hanging flowers that are tubular in nature with two lips that are bell-shaped. The flower comes in different colours depending on the cultivar and can range from white, pale purple to rose colour. The flower can be between 1.9cm to 2.5cm long with either branches of not. Each flower sits on a tiny glandular pedicel that is connected to the stem. A single flower develops at every leaf axil starting from the bottom. Flowers generally starts blooming between two to three months from that day of planting and this continue up until the time the uppermost flowers are opened. Sesame fruits are oblong and mucronate capsules that are about 3cm long filled with several tiny, ovate and white, red, yellow brown or black seeds depending on the cultivar. A single crop can produce between 15 to 20 fruits holding between 70 to 100 seeds. The seeds are ready for harvesting between 80 to 180 days from planting. Harvesting is done by cutting the plant at the stem and hanging then upside down to extract the ripe seeds on to mats.

Sesame comes in varied colours but is mostly creamy-white or beige when husked. In terms of taste, the seed can vary depending on the cultiva but improper post-harvest activities and improper storage are noted to negatively impact on the taste. (Anilakumar et al., 2010).

Figure 1: Sesame plant

Source: Wikipedia

Sesame production in Ghana

Since 2013, The Netherlands Development Organization (SNV), a Dutch non-governmental organization operating in Ghana has concentrated on empowering small holder farmers, women farmers particularly, to adopt the cultivation of sesame in a bid to diversify cash cropping in Ghana (SNV, 2019). In Ghana it is mostly cultivated in the three northern regions mostly for household consumption. This can be attributed to the fact that sesame plant is a drought-tolerant plant and so can thrive in that part of the country, considering the climate in the three northern regions of the country. A report by Savanna Agricultural Research Institute (SARI,2010), indicates that, in Ghana yields of some local varieties range from 300-500 kg/ha but can go up to 3,000 kg/ha on fertile soils and under good cultural practices and general crop management. However, it is observed that the break-even yield is around 2,000 kg/ha.

The yield components of the crop include pod length, number of pods per plant, number of seeds per pod and seed weight. Sesame seeds do not need any fertilizers when planted on a fertile soil. However, in Ghana due to the nutrient deficient soils such as the soils in the northern Savanna zone, the application of fertilizers becomes very necessary in order to increase yields of the crop (SARI, 2010). It has however been identified that Nitrogen (N) and Phosphorus (P) application to the crop significantly improve soil fertility and consequently raise yields substantially.

In Ghana, improved varieties are uncommon and local varieties planted are not on any large scale. As a result of this, the Association of Church Development Projects (ACDEP) has since 2009 begun collaboration with (SARI) in the areas of fertilizer (fertilizer levels) and plant population studies (Method of planting) on the crop to improve sesame yields. The production of the crop is therefore left in the hands of subsistent farmers who plant the crop in haphazard manner with no fertilizer application and no weed control measure adopted (SARI, 2010).

Mr. Issahaku Zakaria, the manager of the SNV sesame seed project states that, the introduction of sesame production in Ghana is to fulfill two goals: the improvement of food security in deprived communities and the empowerment of women by equipping them with the requisite knowledge and skills to increase productivity, processing and effectively market sesame seeds (SNV, 2019). Commercial production of sesame in Ghana has a promising future as farmers who plant the crop alongside the traditional crops confess the massive profit they get from sesame as compared to other crops especially in drought seasons.

Varieties of sesame

Sesame seeds come in different colours depending on the variety. The colours range from creamy-white to charcoal black, but some cultivars can be yellowish, red or brownish (Naturland, 2002). Arinathan et al. (2007) revealed that the paler varieties of the seeds are regarded to be of sup-erior quality and are preferred in the Middle East and the Western world whiles people from the Far East prefer the black cultivars. A study in Nigeria discovered that the commonest varieties of sesame seeds found in Nigeria are the white, yellow and black varieties (Fariku & Bitrus 2007). Several varieties and ecotypes of the seed however exist and have adapted to different ecological conditions around the world (Nzikou, Matos, Bouanga-Kalou, Ndangui, Pambou-Tobi, Kimbonguila and Desobry 2009).

Table 1: Composition of the Four Main Varieties of Sesame Seeds

Variety	Origin	Purity	Admixture	Moisture	Oil content
Red	West Bangladesh	99%	1%	8% Maximum	40-42% Minimum
Brown	Bangladesh	99%	1%	7-8% Maximum	45-50% Minimum
Black	Assam (India)	99%	1%	8% Maximum	48% Minimum
White	Assam, Tripura (India)	99%	1%	8% Maximum	48% Minimum

Source: Orchid Exim (India) Pvt. Limited (2012)

Figure 2: White sesame seeds

Source: Orchid Exim (India) Pvt. Limited (2012))

Uses

White sesame seeds are known for their nutty flavour and is mostly used as a condiment for baking purposes. It is mostly found sprinkled over buns and cakes.

Figure 3: Black sesame seeds

Source: Orchid Exim (India) Pvt. Limited (2012)

Uses

Black sesame seed is rich in flavour and is mostly used as a seasoning in salads, to marinate meat and vegetables and also for medicinal purposes.

Figure 4: Brown sesame seeds

Source: Orchid Exim (India) Pvt. Limited (2012)

Uses

This variety is known for its high content of oil. As such these seeds are used for extraction of oil.

Figure 5: Red sesame seeds

Source: Orchid Exim (India) Pvt. Limited (2012)

Uses

Red sesame seeds are rich in aroma so they are mainly used in dishes to enhance the flavour.

Nutritional composition of sesame

The USDA National Nutrient Database also provides an in-depth analysis of nutrient profile of 100 g dried whole sesame.

Table 2: Nutrient profile of per 100 g value of whole dried sesame seed.

Principle	Nutritional Value	Percentage of RDA
Energy	575 Kcal	29%
Carbohydrate	23.45g	18%
Protein	17.7 g	32%
Total Fat	49.67g	166%
Cholesterol	0 mg	0%
Dietary Fibre	11.8g	31%
Vitamins		
Folates	97 µg	25%
Niacin	4.51 mg	28%
Pantothenic acid	0.050mg	1%
Pyridoxine	0.790 mg	61%
Riboflavin	0.247mg	19%
Thiamin	0.79 mg	66%
Vitamin A	9 IU	<1%
Vitamin C	0	0%
Vitamin E	0.25mg	<2%
Electrolytes		
Sodium	1 mg	1%
Potassium	468 mg	10%
Minerals		
Calcium	975mg	98%
Copper	4.082 mg	453%
Iron	14.55mg	182%
Magnesium	351mg	88%
Phosphorous	629mg	90%
Selenium	34.4µg	62.5%
Zinc	7.75mg	70%
Phytonutrients		
Carotene-ß	5 µg	
Crypto-xanthin-ß	0µg	
Lutein-zeaxanthin	0µg	

Source: USDA National Nutrition Database (2019)

Sesame has been associated with a variety of health benefits due to the high amount of nutrients found in it. Many researchers have reported extensively on the nutrients found in the seed. A handful of sesame a day has been proven to provide an individual with the right amounts of protein, minerals as well as vitamins, phenolic and anti-oxidants (Tunde-Akintunde & Akintunde 2004), Nutrition And You (2019) reported that sesame seeds contain between 50% to 52% oil, 17% to 19% protein and 16% to 18% carbohydrates.

Large amounts of oxalic acid, calcium as well as crude fibre and minerals are also determined to be present in the hull of the seed. Akinoso et al (2010) also added that proper dehulling of the seed reduces its oxalic acid content from about 3% to less than 0.25% of the weight of the seed. This also reduces the bitter taste of the seed when consumed. Antioxidants are also noted to be present in sesame which has the tendency of limiting the development of rancidity in sesame oil (Akinoso et al., 2010). Below are the medical / health benefits of sesame as highlighted by Nutrition and You (2019).

i. 100g of sesame seeds has about 573 calories. These calories basically comes from its fats.

ii. Sesame is also rich with oleic acid which is classified as a mono-unsaturated fatty acid. This assist in lowering LDL (bad) cholesterol and promotes HDL (good) cholesterol within the human blood.

iii. The seed is a rich source of dietary protein as well as amino acids both of which are vital for bodily growth particularly among children. About 18g of protein is contained in 100g of sesame seeds representing 32% of the daily recommended values for protein.

iv. Sesame contains high levels of essential vitamins and minerals and also serves as an importance source for B-complex vitamins like niacin, thiamine (vitamin B1), pyridoxine (vitamin B6), folic acid and riboflavin.

v. 100g of the seed carry 97µg of folic acid, which is approximately 25% of the daily recommended intake. Folic acid being vital for DNA synthesis helps prevent neural tube defects when given to expectant mothers during pregnancy.

vi. Niacin is also another important B vitamin that is abundant in sesame seeds. The recommended daily intake is 4.5mg or 25% of niacin which can be obtained from just a 100g of sesame seed. The presence of niacin in the body contributes to the reduction of LDL cholesterol concentrations in the blood and helps boosts GABA activity in the brain, which is responsible of reducing anxiety and neurosis.

vii. Several important minerals are similarly contained in sesame seeds. These minerals include zinc, iron and calcium as well as manganese, selenium, copper and magnesium. Such minerals play important roles in activities such as bone mineralization, production of red blood cells and in the synthesis of enzymes. They also promote the production of hormones and regulate cardiac activities and activities in the skeletal muscles.

viii. Sesamol (3, 4-methylene-dioxyphenol), sesaminol, furyl-methanthiol, guaiacol (2-methoiyphenol), vinyl guacol and decadinenalas as well as phenyl ethanthiol and furaneol are all essential health promoting compounds that are found in sesame seeds. Phenolic anti-oxidants such as sesamol and sesaminol helps in shearing off free radicals that can be harmful to the human (Nutrition And You, 2019).

Uses of sesame

For culinary purposes

Sesame is utilized as an important ingredient in human food as well as animal feed. It is primarily grown for its oil. The major market for the seed is the U.S.A where the food industry incorporates the seed into several baked foods and confections. Sesame oil is also considered to be the finest when compare with oils used for cooking. The oil is also seen to be highly stable when compared to others and this stability is largely attributable to the presences of antioxidants in it. The primary oil used for cooking the Eastern part of Nigeria comes from sesame. The crop is largely grown in that part of the country purposely for its rich oil (Tunde-Akintunde and Akintunde, 2007). Oil produced from sesame is odourless, good tasting and is straw-like in colour.

Sesame oil is among the few plant-based oils that needs no refining before it can be used for cooking. It requires less winterization as it is a natural salad oil (Tunde-Akintunde & Akintunde, 2007). The smoke point for light sesame oil is higher than that of dark sesame oil. This makes the former the most preferred oil for deep frying. The latter can however be effectively used for stir frying meat and vegetables as well as making omelets. (Tunde-Akintunde & Akintunde). Sesame oil is widely used in a lot of East Asian and Mexican cuisines. Soap production, canning of sardines and beef, magarine production, shortening and confectionary production are the other areas where sesame oil is widely used (NAERLS, 2010).

The seed has a delicate nutty flavor and can be eaten whole as a nutritious foodstuff. Its unique flavor is enhanced when it is gently roasted at low temperature for a short period of time (Naturland, 2002). Sweet confections are commonly produced from ground sesame seeds. In the middle East and Asia honey or syrup is often added to sesame seeds to produce candy while in Japan paste and starch produced from sesame are used in making “goma-dofu”.

Sprinkling the seeds on desserts and salads and its incorporation in ice cream-based preparations are additional uses of the sesame seed (Tunde-Akintunde & Akintunde, 2007). Various cultures have varied cultural uses of sesame. Whiles the industrial usage and processing of the seed has not yet been attained in Nigeria, it is nonetheless used locally in varied forms in Nigerian states where cultivation of the crop is common.

Products such as “Kantun Ridi” and “Kunun Ridi” are made from sesame. The locals after extracting the oil from the seed produce a cake (‘kulikuli) from the paste which is used with the sesame leaves to prepare a local soup known as “Miyar Taushe” (Tunde-Akintunde & Akintunde, 2007). The Japanese make “gomashio” from sesame seeds. This is largely made from roasted black or tan sesame varieties. The Greeks use sesame in the production of cakes whiles the Togolese use it as a main soup ingredient. The French and

Sicilians eat the seed on bread called "ficelle sésame"and sesame thread. Ground sesame known as “wangila” is a delicacy in Northern Angola and Congo and is often prepared with lobsters or smoked fish.

In Manipur (North Eastern State of India), black sesame is used in the preparation of a favorite side dish called 'Thoiding' and in 'Singju' (a kind of salad). Also in Tamil Nadu, India, a ground powder, Milagai Podi, made of sesame and dry chili is used to enhance flavor and consumed along with other traditional foods (Tunde-Akintunde & Akintunde, 2007). In Togo, the young leaves are eaten as vegetable (Ogunsola and Fasola 2014).

The dehulled seed can also be processed into a paste known as tahini and used for cooking and confectionery. Tahini is extensively used as a food ingredient in the Middle East and Mediterranean regions. Sesame is similarly used extensively either in its hulled or dehulled form in the bakery sector of Europe and North America as a garnish for products such as bread, cakes rolls, crackers, and pastry other products (Nzikou et al., 2009). The process of dehulling the seed remains the major challenge for users who prefer the seed in this form as this has traditionally been done manually by rubbing the skin off previously soaked seeds with the hand. Mechanical devices have however been developed lately to ease the process of dehaulling

For medicinal purposes

Sesame is regarded in sections of Asia and Africa as folk medicine with every part of the crop being utilized for medicinal purposes (Shittu, Ahmed, Bankole, Adesanya, Bankole. and Ashiru, 2006). Parle & Bansal (2006) noted that the oil from the seed beside being used for cooking, was also used as a tonic, diuretic, nutrient and aphrodisiac. It was also used in the treatment of other medical condition as inflammations, asthma, lung diseases, dry cough, ulcers, urinary diseases, vertigo and migraine (Parle, & Bansal, 2006). In that very year, Jadeja et al 2006 reported that the extracts from the seed was also used for treating haemorrhoids. They also noted abdominal pain as another condition that crushed sesame seeds was adopted in treating (Jadeja, et al (2006); (Tayade & Patil, 2006), (Ogunsola & Fasola 2014) (2014) highlighted the presence of phenols and lignan glycosides in the seeds and the antihypertensive effect of sesamin (a lignan from sesame oil).

i. *Treatment for respiratory diseases*

Patil et al. (2008) noted the extensive use of the seed in Jalgaon district of Maharashtra as local medicines for the treatment of respiratory disorders. Locals add the seed to Trachyspermum ammi Linnand (a pungent seedlike fruit in India usually used as seasoning and for its medicinal properties) and use this for the treatment of asthma, lung diseases, dry cough and common cold. Similarly, Ogunsola & Fasola (2014) reports how the immature leaves of the plant is used as medicine in the treating respiratory diseases and the soothing effect of the seed oil is used for treating chest complaints.

ii. *Treatment for prostatic diseases*

In their study of phytotherapy in Yaounde (the capital of Cameroon), Noumi & Bouopda (2014) recommended sesame use for treating and preventing prostatic ailments. In this treatment, a spoonful of sesame oil is taken two times a day for a period of 2 to 3 months.

iii. *A wound healer*

Shittu et al. (2006) cited in their research that, civilizations as far as several thousands of years to date have used sesame seed oil as healing oil. Ahmad

(2008) concurred with this assertion when he reported that the fruit from the plant when fried in mustard oil is effective in healing wounds. In another report published by Saikia (2010) noted that natives of the Bodo tribe in Assam rely on parts of the plant such as roots, leafs, and fruit paste to heal wounds.

iv. *Treatment for gynaecological problems*

As highlighted by Yadav and Siwach (2006) sesame is also applied in the treatment of gynaecological problems in certain communities and the people of Haryana is a typical example. They blend partially ground seeds in “gud” and “ghee” and take it with milk during mensuration as relieve to amenorrhea.

v. *Treatment for urinary troubles*

In their study in Pakistan, Hayat et al.(2008) claimed that bed wetting among children can be cured by administering to them few grams of sesame slightly roasted in “ghee”. Native of north-east Gujarat are also reported to use sesame to cure urinary problems (Punjani, 2010). Punjani also content that the acrid taste of sesame has a soothing and diuretic effect, and this is useful in urinary concretions, strangury and burning sensation.

vi. *Aids for digestive problems*

Intestinal disorders such as dysentery and diarrhea have also been considered ailments that sesame effectively treats. Inflammation of membranes in the mouth are treated with warm water leaves infusion used as gargles (Shittu et al., 2006). (Ogunsola & Fasola (2014), in their study agreed with the use of sesame oil as a purgative.

vii. A relief for earaches and eye pains

The use of oil extracted from sesame for treating ear aches and secretions was proposed by Kala (2005). The oil is often heated with "lahsun" (Allium sativaum Linn.) and drops of this is put in the ears prior to going to bed. Shittu et al. (2006), recounts how native from South Western Nigeria treat catarrh and eye pains with decoction of the leaves.

viii. A benefit for skin and hairs

Many researchers have confirmed the effectiveness of frequent application of sesame oil on scalp in the prevention of hair lost and promoting hair longevity (Mitaliya, 2003; Sakarkar, 2004). Jadeja, Odedra and Odedra, (2006) further states that sesame seed is a major source of hair oils extracts used for skin protection and rejuvenation. Skin eruptions and bruises are treated with decoction of sesame leaves in parts of South-Western Nigeria (Arinathan et al, 2007). Some Asian immigrants in some American state as Georgia, Atlanta, were also noted by Jiang and Quave (2013) to use black sesame for improving skin complexion and for use as blood tonic.

ix. Potency against ailments

Raut (2007) asserted the use of sesame oil as a local antidote for Bhallatak toxicity. Sesame has also been noted to be used as an aid to improving certain deficiencies. Newmaster et al. (2011) reports that sesame oil is added to toasted leaves of *Halophila ovalis*, *Hook.f.* and *Halophila gaudichaudii* and consumed over a period of three days to aid in the treatment of iron deficiency. Another study by Shittu et al. (2006) reports the antiviral and antifungal properties of sesame and confirms how decoction of its leaves and roots are potent for fighting against ailments such as chicken pox and measles (anti-viral) and similarly used as hair shampoo for treating Taenia capitis (antifungal).

For other purposes.

Sesame is also used for so many purposes in different spheres of life. Industrial use of sesame in the personal care sector is extensively documented. Its oil is used in industrial formulation of perfumery and cosmetics. In the pharmaceuticals sector, sesame is widely used for the preparation of several drugs. Likewise, paints, insecticides, and varnishes are other products that utilizes sesame (Chakraborthy et al., 2008). Tunde-Akintunde et al. (2007) adds to this when they indicated the use of sesame oil as solvent in injected drugs or intravenous drip solutions and a cosmetics carrier oil. They also content that oil is used to coat grains meant for storage in a bid to ward off weevil attacks.

Inferior grades of the oil is also reported by Tunde-Akintunde et al. (2007), to be used in the manufacture of local soap, lubricants, and illuminants. The oil is similarly the base ingredient for the production of paints and inks. Other products such as vermicides, bactericided, antiseptics, disinfectants insect repellants, and anti-tubercular agent employs the antioxidant lignans in sesame seed (sesamolin and sesamin) as their primary ingredient and this has proven to be helpful to both man and animal health (Ashakumary et al., 1999). Mixed with methanol and sodium hydroxide, sesame oil can serve as a substitute for diesel fuel (Saydut et al., 2008).

Spreads

A spread is a food that is generally spread onto foods such as bread, crackers and sandwiches. Spreads are generally preparations that mix vegetable fat with other dry powdered ingredients such as dried milk products, nuts and seeds, dextro-maltose, pre-cooked soy flour, sugars, and a vitamin and mineral mix (Briend, 2002). Spreads are added to improve the flavor, texture, taste which may be considered bland without it. Spreads are prepared in a paste, syrup or liquid form.

According to the University of Wisconsin Health (2019), butters and spreads produced from nuts and such as almond, peanut and sunflower seed have the same nutritional content as their whole counterparts but in a more condensed form. For instance, 1 ounce or 28 peanuts, 24 almonds, and 1/4 cup sunflower seeds has about 170 calories whereas 2 level tablespoons of nut and seed butter has about 200 calorie (UW Health) .

Consumption of spreads

Projections for the market for spreads vary from researcher to researcher. According to a the market research firm, Grand View Research (2019) the spreads segment is defined to include butter/cheese, chocolate spreads, fruit spreads and nuts spreads. The global market for spreads in 2018 was valued at USD 27.5 billion and expected to grow by a compound annual growth rate of 3.1% from 2019 to 2025. Another market research firm (LP Information, 2020), puts the market for spreads at USD 23,040 million in 2019 and projected this to rise by a compound annual growth rate of 1.8% to a value of 24,760 million in 2025.

Statista Market Forecast, (2020) similarly forecast the global market value for spreads in 2021 at USD 62,570 million and projects a annual growth rate of 3.1% from 2021 to 2025. The firm points to china as the country expected to consume the largest amount of spread in 2021.

China's consumption is estimated at USD 18,724 million and this is driven by its population figures. Per capita consumption in 2021 was estimated at 2.0kg whiles per person revenue was put at USD 8.30 in the same year (Statista Market Forecast, 2020).

Types of spreads

Dairy butter

Dairy butter is essentially a water-in-oil emulsion, that contains 80% fat with little water, may contain an amount of solids-not-fat (SNF) and come with or without salt. Butters are rich in saturated fat. Butter with or without salt contains 55±2g/100g of saturated fat and 222±2 mg/100g cholesterol (Scherr and Ribeiro, 2010). For the past years, butter has been the most preferred spread for consumption. However, the rising health concerns regarding their intake due to the high amounts of saturated fat in them have paved way for alternatives in plant based spreads (Kalyani, Balasubramanian and Pitam, 2015).

Plant based spreads

Peanut spread

Peanut spread also known as peanut butter is basically a creamy substance made up of paste from peanut and a stabilizer. The spread can sometimes come with added sweeteners, salt, emulsifiers and other ingredients. The spread is produced by roasting, blanching, grinding and tempering peanuts (Alamprese, Ratti and Rossi, 2009).

Soy bean spread

Agrahar-Murugkar et al. (2013) state that soybean is the ultimate source for high levels of plant protein. The bean contains 40g/100g of protein and the needed amino acids required for growth. Essential amino acids that the body cannot synthesis are inherent in the bean. Soy beans and foods made from soy beans have been Acknowledged to have a number of health benefits such as the ability to prevent cardiovascular diseases, cancers as well as menopausal treatments (Barrett, 2006). These health and nutritional benefits of soya beans has contributed to promoting its popularity and acceptance as a food products (Rinaldoni, Campderros & Padilla, 2012). Spread produced from soy bean can be a perfect alternative to peanut spread for people with peanut allergies. However, soya bean spread is currently a new product that is currently not wide spread in the markets.

The production of soya bean spread as pointed out by Kellogg when he cited Kalyani, et al. (2015) involves skin removal of the beans, bean roasting, grinding of beans, mixing the ground beans with an edible vegetable oil in to paste.

Sunflower spread

Sunflower seed spread contains more monounsaturated fat, zinc, magnesium, copper, phosphorus, iron, vitamin E, manganese, Selenium and less saturated fat than peanut butter (Thomas and Gebhardt, 2010). Sunflower however has a more fibrous outer layer and can retain moisture if not roasted properly. Its nutritive qualities are similar to those of peanut spread and roasting conditions can have considerable impact on nutritional and sensory qualities of sunflower spread (Thomas & Gebhardt).

Almond spread/butter

Almond spread is more fibrous and contain higher levels of potassium and calcium, when compared to sunflower and peanut spreads (Thomas & Gebhardt).

A research by Spiller et al. (2003) did a comparative analysis on the lipid-altering effect of roasted salted almonds and roasted almond butter with that of raw almonds, as part of a plant based diet. According to the result, High-density lipoprotein-cholesterol (HDL) did not significantly change with raw or roasted almonds but slightly increased with almond butter. High levels of HDL cholesterol also known as the good cholesterol have been proven to reduces the risk for heart disease.

Product Development

In an article by Rouse (2019), product development, also referred to as new product management involves a number of steps from concept generation, product design, product development and marketing of a newly created or modified product or service. The object of developing a new product is to create, sustain and increase a company's share of the market through the satisfaction of consumer needs (Rouse).

In his article, Rouse suggested eight stages of a new product development which is believed to allow for the successful introduction of a new product in the market. These stages include;

1. Idea generation; this involves the continuous and systematic pursuit for new product opportunities. This can range from modifying an

existing product to replacing an existing product. The main goal is to constantly generate ideas for new products or services or to improve existing products or services.

2. Idea screening; At this stage new ideas are screened for their feasibility, and attractiveness. Less attractive, infeasible and unwanted ideas are dropped at this stage. Unsuitable ideas should be determined through objective consideration, including early testing and feedback with consumers.
3. Concept development and testing; this stage is crucial as it deals with the customer's opinion. This is the stage where a prototype of the idea, or product concept is tested on actual potential customers of the product. The opinions and reaction of the testers' is gathered and analyzed with the needed adjustments made to the concept in responses to feedback from the testing.
4. Market strategy/business analysis; This involves the identification of ideal strategies on the best way to effectively and efficiently promote and sell products or services. It involves the use of the four P's of marketing namely product, price, promotion and place.
5. Feasibility analysis/study; feasibility involves gathering of critical information for a successful product. It entails testing a prototype of the product by a group of people, then evaluating the experience in a test panel. This result represents the target market's level of interest and desired product features, as well as indicate if the developed product will be profitable, attainable and viable for the producers and at the same time satisfying consumers demand.

6. Product technical design/Product development; at this stage, results of the feasibility analyses is integrated into the product to be developed. This stage also involves turning the prototype or concept into a workable market offering; ruling out the technicalities of the product; and alerting and organizing the sectors responsible for product lunch, such as development and research, marketing, finance and operations or production.
7. Test marketing, or market testing; this is different from concept or prototype testing. It involves whole proposed marketing plan, not individual segments. The main aim of this stage is to authenticate the entire concept from marketing angle and message to packaging, advertising and distribution. Test marketing is usually done by making product available to a random sample of target market. Through the testing of the entire package before launch, the company can critically review the reception of the product before the product is finally introduced to the market.
8. Market entry/commercialization; this is the final stage. This is the stage where by the product is introduced to the target market. All the data collected throughout the previous seven stages are used to produce market and distribute the final product to and through the appropriate channels. The product is now available to everyone and the life of the product is shaped by the reception of the target market, the competition and subsequent enhancements to the product.

Sensory Evaluation

Determining how food products affect consumers' senses is one of the most vital goal of the food industry. It also serves as a major concern for nutritionists and dieticians who develop a healthier recipe. Obtaining the benefits of a healthy food can be achieved only if our senses accept it (Choi, 2013). Consumers' reaction as perceived by the five senses is hence considered essential. Sensory evaluation is a scientific discipline used to evoke measure, analyse and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch and hearing (Stone and Sidel, 2004). The qualities of a food acknowledged by these senses are called sensory characteristics of the food. These include the taste, odour, appearance, mouth feel and sound of the food.

The human senses

Sight

The eyes see the initial quality of food such as the colour, size, shape, texture and constituency. Choi (2013) indicates that colour is used to evaluate a food's desirability and acceptability and also can indicate ripeness, strength of dilution and degree to which food has been heated. Therefore, a change in the original colour of a food (cooked or uncooked), can alter a person's choice and desirability. Colour mostly generates certain anticipations in the mind e.g. the creamy colour of vanilla ice cream evokes an expectation of richness. However, it can also be deceptive since the quality of a food can be masked by changes in colour (Choi, 2013). Sizes, shapes, and texture likewise provides information on food quality and thus affects its acceptability and preference.

Smell

Our sense of smell factors much in our evaluation of food quality. Volatility of odours is related to temperature and because of this, only volatile molecules in the form of gas carry odour. This makes it easier to smell hot foods than cold foods (Choi, 2013). According to Brown (2008), molecules that are volatile are detected by the olfactory epithelium in the nasal cavity, through one or two pathways;

1. directly through the nose or
2. after entering the mouth and flowing retro-nasally or forward the back of the throat and up into the nasal cavity.

Choi (2013) describes the gradual decrease in the ability to distinguish between odours over time as adaptation, and this helps to prevent sensory overload. Human subjects have fluctuating sensitivities to odours conditional to hunger, satiety, mood, concentration, presence or absence of respiratory infections and gender. Since different people smell a particular odorant differently, it is essential to use a large panel as possible when identifying a new odour from a food product to get valid results.

Taste

Taste is the most significant factor in a person's selection of a particular food. A substance should be dissolves in the water, oil, saliva to make it possible for it to be tasted (Choi, 2013). Taste buds found on the surface of the tongue, by the mucosa of the palate and in areas of the throat is responsible for a person's ability to taste. Variation in taste by individuals is associated with genetic component of the individual (Kim, Jorgenson, Coon, Leppert, Risch, and Drayna, 2003). Aside genetic component, variation in the taste perception also depends on how noticeable sweet, fatty and bitter component are in the food or beverages (Duffy & Bartoshuk, 2000). Duffy, Peterson, Dinehark and Bartoshuk (2003) also added that variation depends on the value a consumer place on factors such as health and convenience. Taste can be categorised as follows;

1. sweet: sweet taste include sugar, glycols, alcohols and alternative sweeteners (Godshall, 1997).
2. salty: salty taste comes from ionized salts like ions in sodium chloride (NACL) and other salts found naturally in some foods (Choi, 2013).
3. sour: sour taste comes from the natural acids found in foods, fruits, vinegar and certain vegetables (Choi, 2013).
4. bitter: bitterness is imparted by compounds such as caffeine in tea and coffee, theobromine in cocoa and phenolic compounds in grapefruits (Brown, 2008).
5. umami: this a most lately defined component of taste. It is a Japanese word meaning “delicious”. It is induced by glutamate compounds which are commonly found in meats, mushrooms, soy sauce, fish sauce and cheese (McWilliams, 2008).

Touch

The sense of touch conveys an impression of a food’s texture to us through oral sensations or skin (Choi, 2013). Texture is the sensory manifestation of the structure or inner makeup of products in terms of their feel which are measured as mechanical properties in the muscles of the hand, fingers, tongue, jaw or lips; or by the tactile nerves in the surface of the skin, hand, lips or tongue (Meilgaard, Civille and Carr, 2007). Choi (2013) explains that the greater surface sensitivity of the lips, tongue, face and hands makes easy discovery of small differences in particle size, thermal and chemical properties possible among food products.

Sensory evaluation is normally carried out by designed experiments under proper environmental conditions. Trained and untrained panels are used in sensory evaluation and the degree of training panels depends on the type of sensory analysis to do, thus panels with different degree of training are required for different types of sensory analysis (Ayeh, 2013). The level of training required depends on factors, such as degree of differences to be detected, number of panellists required for the tests and time and value of the analysis to the product type. Sensory evaluation is conducted in the food industries for various reasons such of which includes:

1. New product development
2. Product matching
3. Improvement of product
4. Change in production process
5. Reduce cost of production
6. Select new source of raw material supply
7. Quality control
8. Consumer acceptance and opinions
9. Product grading and rating
10. Consumer preference
11. Sensory panel selection and training
12. Correlation of sensory properties

Sensory evaluation tests can be group into two major types. These are the Product-Oriented or Analytical tests and the Consumer-Oriented or Affective tests (Choi, 2013).

Analytical tests (or Product-Oriented Tests)

These are used to discriminate between products (Discriminative tests) or to describe sensory characteristics of the product (Descriptive tests).

Descriptive test

The descriptive test methods are used to provide more-comprehensive profiles of a product by asking panelists to provide information on the specific sensory characteristics of food samples and to quantify the sensory differences. Here the use of 10-12 highly trained and/or experienced panelists are required (Choi, 2013). Examples of descriptive test are, Flavour Profile Analysis, Quantitative Descriptive Analysis, Texture Profile Analysis and Sensory Spectrum. (Lawless et al., 2010)

Discriminative test

According to Stone & Sidel (2004), discriminative test also known as difference test are used to determine if products are different from each other. It is aimed at evaluating specific attribute of products e.g. sweetness. A number of 25-50 trained panelists are used. Examples of discriminative tests are; triangle test, paired comparison test, and duo-trio test (Lawless et al., 2010).

Affective tests (consumer-oriented tests)

Affective tests are used to either evaluate consumer preference or acceptance of the product. Large numbers of untrained panelists are required for these tests (Choi, 2013).

Preference tests

These tests are used to allow consumers make a choice between samples. It answers the question "which of the sample do you prefer?" Examples of preference test are the paired preference test; where two samples are presented for consumers to indicate the one they prefer most and the ranking preference test; where more than two samples are presented (Lawless, et al., 2010).

Acceptance tests

Acceptance tests are used to determine the acceptability of a product by a comsumer. A degree of liking a product is rated by the use of the hedonic scale. The scale is a category-type scale with an odd number (five to nine) categories ranging from "dislike extremely" to "like extremely." A neutral midpoint (neither like nor dislike) is included (Choi, 2013).

Panel selection

Usually two types of panels are used in sensory evaluation. These are the descriptive and consumer panels (Choi, 2013). The author further explains that descriptive panels are usually used to identify differences between food samples. A descriptive panelist is experienced in the type of food being tested and goes through extensive training before test. A consumer panel on the other hand is selected from the public according to the demographics necessary to test a product (Choi). When selecting a panel, it is best to use an equal number of men and women. The age distribution of the panelists must also be considered since it can affect the results (Brown, 2008). She also adds that people to be recruited must be committed to the time and should also know what is expected of them during the test. Choi recommends certain criteria to follow in selecting panel members. These are;

1. panel members should be in good health and free from illness such as chronic colds, food allergies or diabetes.
2. they should not be smokers
3. they should not be colour blind
4. they should not have preferences for food to be tested.

Other factors to consider so as to enhance panelists performance during a sensory evaluation includes;

1. sensory evaluation of certain products should be organized at the time of the day these products are typically consumed (Meilgaard et al., 2007).
2. Late mornings or late afternoons (such as 11 am or 3 pm) are considered the appropriate times for testing because at these times people are not hungry or full (Brown, 2008).
3. panelists should not eat any food for at least an hour before testing and should not chew gum immediately before testing (Brown, 2008).

Empirical Literature

According to Bekele (2017), there exist several studies on sesame and tahini (sesame paste used for cooking), but limited studies exist on developing a breakfast spread from sesame. In her study on optimal roasting parameters and proportion of ingredients that can produce a spread from sesame that will be similar to peanut butter, the researcher concluded that lecithin and sugar levels as well as overall acceptability (appearance, flavor, texture and color) spread is affected by different roasting temperature and roasting duration. The researcher also found flavor to improve and texture stabilized with the addition of hydrogenated vegetable oil at 5.0% and 1.2% of salt. Average chemical composition of sesame fat spread was determine as follows; protein 27.0%, moisture 0.26%, total carbohydrates 16.31%, crude fat 53.51%, ash 3.15%, crude fiber 13.23% and phytic acid 4.64%, oxalic acid 0.73mg/g. The study also concludes that optimal parameters were 180°C temperature, 20 min of roasting, 7.3% sugar and 1.2% lecithin.

In another study by Dubost, Shewfelt, and Eitenmiller (2003), the researchers developed three spreads from different formulations of peanut and soy and used commercial peanut butter and commercial soy nut butter as control. The study results showed that the commercial peanut butter and peanut soy spread with the least soy content were the most acceptable taste to panelist. The soy nut butter and peanut soys with the least amount of peanut received lower scores.

Shakerardekani et al. (2013) view textural, color, and flavour properties of nut spreads to play an important major role in consumer appeal, buying decisions and eventual consumption. They emphasize that milling (particle size reduction) is an activity in the production of nut spreads as this affects the textural, rheological characteristic and overall quality of the nut spread. The researchers highlighted the important role particle size plays in influencing spread stability. Çiftçi et al. (2008) agreed with this assertion when their study determined that a median particle size below 5 µm improves the colloidal stability of sesame paste.

CHAPTER THREE

RESEARCH METHODS

In this chapter looks at the method that was used in conducting the research is discussed. It includes the research design, study area, study subjects and panel members, methods and materials, data collection procedure, how data collected was analyzed and interpreted, ethical consideration and limitations of the study.

Research design

According to Amedahe (as cited in Anhwere, 2009) an experimental study is where the researcher manipulates at least one independent variable, controls other relevant variables and observes or sees what will happen to the subjects as a result. It is the only type that can really test hypotheses about cause and effect relationship. Blake et al. (1994) recommends experimental design for developing new product because it helps obtain an amazing amount of information about a new product by using a limited number of experimental runs. They add that through analysis of information from experimental design various parameters about the new product can be easily and accurately determined.

The researcher manipulated the independent variables (three different formulations of sesame spread) and assessed the sensory acceptability of the different formulations by the test respondents. Other relevant variable such as the nutritional composition of the different formulations was also determined.

Population

The study was an experimental research which developed new product (sesame spread) out of different formulations of sesame seed and peanuts for the Ghanaian consumer. Sensory testing of the new product would be carried out on the campus of the University of Cape Coast with the student of the Vocational and Technical Education students and the residents of A.T.L Hall of the U.C.C campus as target population.

Sampling procedures

A total of 80 students were selected for testing of the new product on the campus of the University of Cape Coast. Respondents were drawn from the Vocational and Technical Studies Department and the A.T.L Hall residents of U.C.C for the study. The number of respondents used was in line with requirements of the hedonic method of sensory evaluation which requires a total number of 75 to 150 respondents for such testing (Lim, 2011). A purposive sampling technique was used to select the respondents for the study. This sampling method was used because it afforded the researcher to target respondents who consume spreads and are not allergic to the ingredients used in formulating the new product.

Lewis-Beck, Bryman and Liao (2004), explain purposive sampling (also known as judgment, selective or subjective sampling) as a non-probability sampling technique in which researcher relies on his or her own judgment when choosing members of population to participate in the study. According to them, 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

Respondents in a sensory evaluation are referred to as Panel members. Panel members were conveniently sampled from the Vocational and Technical Studies Department and the A.T.L Hall residents of the University of Cape Coast for the study. Eighty (80) untrained panel members were selected for the sensory evaluation test. This is because in affective test, a population size of between 75 to 150 is required for effective results (Lawless and Heymann, 2010). Such test also requires the use of untrained panellist who are either users of the product or familiar with similar products.

Food attributes such as taste, texture, flavor/aroma, colour and overall acceptability were examined. Participants were brought together a day prior to the day of the test for an orientation. They were made known of the importance of undertaking such an experiment and its importance to the researcher as well. They were also instructed to stay away from alcohol and smoking, using high scented perfumes and eating food that will interfere with their sense of taste on the day of the experiment.

On the day of the experiment, respondents were invited in batches of twenty for the testing. They were first educated on the food attributes to be assessed and how to complete the questionnaire prior to the testing. They were then allowed to taste, smell and feel the products before completing a questionnaire.

Criteria for selecting panellist

Panellist for the sensory testing was done in line with the following criteria;

1. Participants were between 18- 60 years

2. They were not allergic to any of the ingredients used in producing the spreads.
3. They did not have any respiratory infections like a cold
4. They were not on any medication of any kind and would be available throughout the duration of the study.
5. They were people who consumed similar products.

Data Collection Instruments

Laboratory testing of the following nutrients; protein, calcium, carbohydrate, Crude fiber, fats, magnesium, zinc, potassium, sodium, iron, copper and ash were carried out on the different samples of sesame spread. The following instruments were used in the laboratory to test for the nutrients; spectrometers, titrators, flame photometer, an oven and other laboratory equipment.

A structured questionnaire was also used to collect data from respondents in relation to the sensory evaluation of the different sesame spreads. The questionnaire was designed using the 5-point hedonic scale. The hedonic rating scales are commonly used to quantify affective dimension of the consumer perception of foods (Tuorila, 2008). The scale allows for respondents to sample a product and give their hedonic opinion on different attributes of the product by choosing and marking one of five alternatives, (ranging from 1 = like very much to 5 = dislike very much).

Data collection procedure

Primary data was collected for purposes of this study. Data on proximate analysis of the different food samples produced was undertaken at the School of Agricultural Science Laboratory at the University of Cape Coast.

The production and testing of the spreads lasted a period of one month. Data for sensory evaluation of the spreads were collected by use of taste panelist. A group of 80 tasters were being allowed to taste, smell and feel each spread and give their opinion on various attributes of the spreads by use of a questionnaire adopting the 5-point hedonic scale. The evaluation was done over a two-day period at the Food Laboratory of the Vocational and Technical Department of the University of Cape Coast.

Sample material and methods

White sesame seeds and ground nuts was used to undertake the study. The seeds were bought from a farm in Tamale in the Northern region of Ghana and transported to the researcher in two clean airtight containers. The raw sesame seeds were pre- cleane dry, washed , soaked and peeled. A brine solution was prepared to aid in the separation of the peeled sesame seeds. It was then be desulted, dried, roasted, cooled measured and grounded for the preparation of the spread samples. Same preparation methods were used for the raw peanuts except for the peel separation method in which the researcher adopted the winnowing method, then grinded and prepared the spread samples. Five different test samples were produced and used for proximate analysis and sensory testing. The sample for the sensory analysis was served with half slide of bread bought from the super market in Cape Coast. The spread samples were prepared in following proportion;

Sesame spread (ss): This sample was prepared out of 100% sesame seed with no peanut being added.

Sesame with Peanut spread (swps)[75%: 25]: This sample was prepared out of 75% sesame seed and 25% peanut.

Sesame and Peanut spread (saps) [50%: 50]: This sample was prepared out of 50% sesame seed and 50% peanut.

Peanut with sesame spread (pwss): This sample was made out of 75% ground nut and 25% sesame added.

Peanut spread (ps): This sample was made out of 100% ground nut with no sesame added. It is the most common seed spread in Ghana and was used as the control for the study.

Sample Preparation

A total of five spread samples of 1kg each was produced using 900g sesame seed and peanuts in different proportions. Salt, honey and hydrogenated soya oil was added at a rate of 1.25 percent, 6.75 percent and 2.0 percent by total weight respectively. 100g of each prepared sample was sent to the School of Agricultural Science Laboratory at the University of Cape Coast for proximate analysis while the remaining 900g each of the spread samples was used for sensory analysis.

Process flow chart

The flow chart below highlights the step by step processes followed in the production, laboratory analysis and sensory evaluation of the sesame spread.

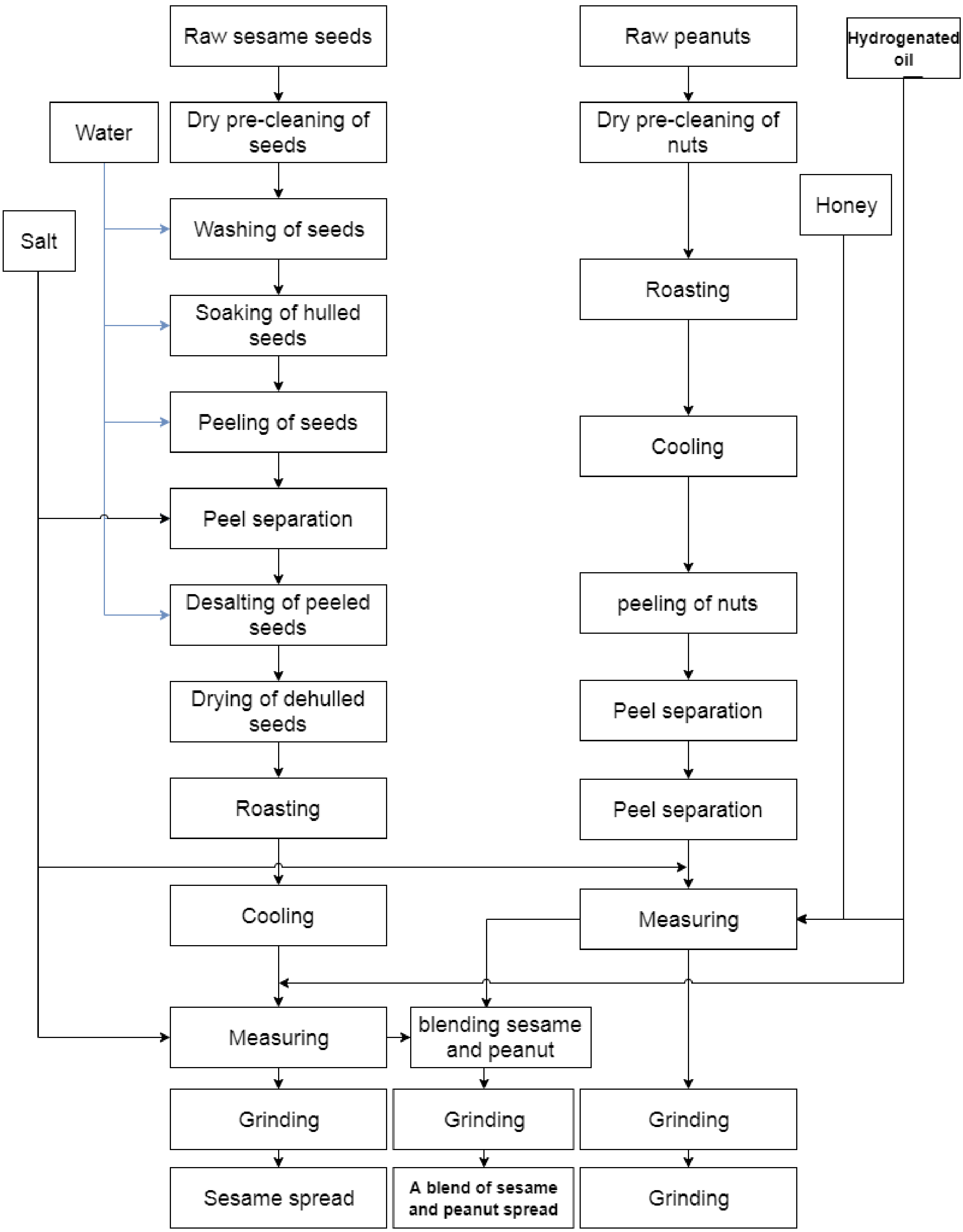

Figure 6: Flow Chart for production of Spread

Source: Researcher's production

Table 3: Ingredients for preparation of spread

	Spread Samples									
	Ss		*Swps*		*Saps*		*pwss*		*Ps*	
Ingredient	Weight (g)	% by Weight	Weight (g)	% by Weight	Weight (g)	% by Weight	Weight (g)	% by Weight	Weight (g)	% by Weight
Sesame	900	90	675	67.5	450	45	225	22.5	0	0
Peanut	0	0	225	22.5	450	45	675	67.5	900	90
Stabilizer (Soya Oil)	20	2	20	2	20	2	20	2	20	2
Honey	67.5	6.75	67.5	6.75	67.5	6.75	67.5	5.67	67.5	6.75
Salt	12.5	1.25	12.5	1.25	12.5	1.25	12.5	1.25	12.5	1.25
Total	1,000	100	1,000	100	1,000	100	1000	100	1,000	100

Source: Researcher's production

The researcher started with 3.0kg of sesame seeds and 2.0kg of peanuts purchased for the production of the study samples. The seeds were initially sorted by removing unwanted materials such as stone and other debris. Before both seed samples were roasted, the sesame seeds were washed and then soaked in fresh water for six hours prior to dehulling. The seeds after sufficiently being soaked were peeled by rubbing them against each other in the palm. Separation of the peels from the kernels was achieved by use of brine solution after which the dehulled seeds were desalted in potable water and then dried at room temperature.

Seed roasting

The dehulled sesame seed samples were roasted in an oven at 130 ^{O}C for 1 hour, El-Adawy et al.(2000), whiles the peanuts were roasted at 180^{o}C for 45 minutes in line with recommendation by Birch et al. (2010).

Cooling

After roasting each sample, it was immediately equilibrated to room temperature to prevent further heating.

Grinding

The roasted sesame seed and each the peanuts were grounded with a grinder for 3 to 5 minutes with salt added at a rate of 1.25 percent.

Liquefactions

The grinded sesame seeds and peanuts were liquefied by adding honey and hydrogenated soya oil at 2 percent and 6.75 percent respectively. This will be stirred until spread is well mixed and even.

Laboratory testing

The prepared sesame spread samples and the control were analyzed for the following nutritional and chemical composition (protein, calcium, carbohydrate, fats, crude fiber, magnesium, potassium, zinc, sodium, iron, copper and ash). Data on the nutritional composition of the sesame spread samples prepared at different composition with peanuts were recorded and compared to a control (the peanut spread).

Chemicals and reagents

The following chemicals and reagents were used for the proximate analysis at the laboratory Petroleum spirit, Sodium hydroxide solution, potassium sulphate (K_2SO_4), copper sulphate ($CuSO_4$), sulphric acid and hydrogen peroxide.

Testing procedure for nutrients

Testing for the various nutrients were carried out using the following methods;

***Determination of moisture**:* Moisture was determined by oven drying method. A sample was accurately weighed in clean, dried crucible (W_1). The crucible was kept in an oven at 100-105^oC for 6-12 until a constant weight was obtained. Then the crucible was placed in a desiccator for 30 minutes to cool. After cooling, it was weighed again (W_2). The percentage of moisture was calculated using the formula below:

% Mosture=(W_1 - W_2 *100)/(Weight of Sample)

Where;

W_1 = Initial weight of crucible + Sample

W_2 = Final weight of crucible + Sample

Determination of fat: About 10 – 12g of the spread was weighed into a 50x10ml soxhlet extraction thimble. A cleaned dry 250ml round bottom flask was also weighed. About 150ml petroleum spirit was added and connected the soxhlet extractor and extraction was done for 4 hours using a heating mantle as a source heating. After the four hours the flask was removed and placed in an oven at 60^0C for 2 hours. The round bottom flask was removed and cooled in a desiccators and weighed. The percentage fat oil was calculated as followed.

Crude fat (%) = (weight of oil*100) / (Sample weight)

Determination of Ash: A clean empty crucible was placed in a muffle furnace at 600^oC for an hour, cooled in a desiccator then the weight of empty crucible was noted (W_1). 1g of each spread sample was taken into the crucible (W_2). The samples were ignited over a burner with the help of blowpipe, until it was charred. Then the crucibles were placed in muffle furnace at 550^oC for 2-4 h. The appearances of gray white ash indicate complete oxidation of all organic matter in the samples. After ashing, furnace was switched off, the crucible was cooled and weighed (W_3). Percent ash of the samples was calculated by following formula:

% Ash = (W_3 -W_1 *100)/(Weight of Sample)

***Determination of Protein*:** Protein in the spread samples were determined using the Kjeldahl method. 0.5-1.0g of the dried samples of the spread were taken into a digestion flask. 10-15ml of concentrated H_2SO_4 and 8g of digestion mixture added. The contents were mixed thoroughly then placed on heater to start digestion till the mixture become clear (blue green in color). The digest was cooled and transferred to a 100 ml volumetric flask and volume was made up to the mark by the addition of distilled water. Distillation of the digest was performed in Markam Still Distillation Apparatus (Khalil and Manan, 1990). Ten milliliters of digest were introduced in the distillation tube then 10ml of 0.5N NaOH was gradually added through the same way. The distillation continued for at least 10 minutes and NH_3 produced was collected as NH_4OH in a conical flask containing 20ml of 4% boric acid solution with few drops of modified methyl red indicator. During the distillation a yellowish color appeared due to NH_4OH. The distillate was then titrated against standard 0.1 N HCl solution till the appearance of pink color. A blank was also run through all steps as above. Percentage of **crude protein** content of the sample was then calculated using the following formula:

% Crude Protein = 6.25* x %N (*. Correction factor)

% N = ((S-B)*N*0.014*D*100)/(Weight of Sample*V)

Where:

S = Sample titration reading

B = Blank titration reading

N = Normality of HCl

D = Dilution of sample after digestion

Determination of crude fiber: A sample of each spread was weighed at 0.153g (W_0) and transferred to porous crucible. The crucibles were then placed into a Dosi-fiber unit and kept the valve in “OFF” position. 150 ml of preheated H_2SO_4 solution was added and some drops of foam-suppresser to each column. The cooling circuit was opened and the heating elements turned on (power at 90%). The power was reduced to 30% when it started boiling, it was then left for 30 minutes. The valves were opened for drainage of acid and rinsed with distilled water thrice to completely ensure the removal of acid from the samples.

The same procedure was used for alkali digestion by using KOH instead of H_2SO_4. The sample was then dried in an oven at 150°C for 1h then allowed to cool in a desiccator and weighed as (W_1). The sample crucibles were kept in muffle furnace at 55°C for 3-4 hrs. It was then cooled in a desiccator and weighed again (W_2). Crude fiber was then calculated by using this formula:

% Crude fiber = $(W_1 - W_2 * 100)/W_0$

Determination of carbohydrates: 500ml of each of the spread samples were weighed in to a 50ml conical flask, 30ml of distilled water was added and a glass bubble placed in neck to simmer gently on a hot plate for 2 hours. This was toped up to 30ml periodically and allowed to cool slightly, then filtered through No. 44 Whatman paper in to 50ml volumetric flask and diluted to volume when cool. The extract was prepared shortly before colour development. A blank was also prepared taking it through the same procedure.

Colour development of the solution was done by pipetting 2ml of each standard in to a set of boiling tubes and 2ml of extracts and water blank also pipetted into a boiling tube. Standards and samples were also treated the same way. 10ml of anthrone solution was added rapidly to mix and the tubes immersed in running tap water. The tubes were placed in a beaker of boiling water in a dark fume cupboard and boiled for 10 minutes. The tubes were then placed in cold water and allowed to cool, preferably in the dark. The optical density was measured at 625mm with red filter using water as reference. A clibration graph was prepared from the standard and used to obtain mg glucose in the sample aliquot. The blank determination was treated same ways and subtractions were done where necessary.

%Soluble Carbohydrate(%) = (C(mg)*extract volume (ml))/(10*aliquot (ml)*sample weight (g))

Where C = carbohydrate concentration from the calibration graph

Determination of zinc, and iron, calcium and magnesium, sodium and copper: These were determined using the flame atomic absorption spectrometry method. A spectrometry machine is more efficient and uses less reagents. Therefore, the mineral content is measured more accurately.

Analysis of data from laboratory testing

Data recorded from the laboratory analysis on the nutritional content of the different spread samples were statistically analyzed and the error reported in standard deviation from the mean. Analysis of Variance (ANOVA) was used to test hypothesis and the significant differences calculated using XLSTAT. Significance was accepted at $p \leq 0.05$ level with multiple comparison done with Tukey (HDS).

Data analysis from sensory evaluation

Testing of the acceptability of the four newly developed sesame spread were done at the food laboratory of the university of Cape coast. Food attributes such as taste, texture, flavor/aroma, colour and overall acceptability. Respondents were invited in batches of twenty for the testing. They were educated on the food attributes to be assessed and how to complete the questionnaire prior to the testing. They were then allowed to sample the products and complete the questionnaire developed based on a five point hedonic scale as presented below;

1	2	3	4	5
Like very much	Like moderately	Neither like nor dislike	Dislike moderately	Dislike very much

Figure 7: Five point hedonic scale

Source: Dimple and Rohanie (2014)

Data collected from the sensory evaluation was statistically analyzed and the level of acceptability of the various spreads attributes were determined using simple mean. Product selection was achieved using overall acceptability of products to panelist and setting a mean score of 1 to 2 as acceptance and 3 to 5 as rejection.

Ethical Clearance

Ethical clearance was obtained from the Institutional Review Board of the University of Cape Coast for the purpose of granting the researcher the permission to carry out the research which may have health implication for the consumption of the sesame spread. Consent form for participation was either signed or thumb printed by the panelist. The consent form was written in English for easy understanding.

Summary of Methodology

This chapter presented the method that was used in conducting the research. It focused on the research design, study subjects and panel members, methods and materials, data collection procedure, how data collected was analyzed and interpreted. Ethical consideration was also spelt out in this chapter.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents and discusses the results from study analysis. Five spread samples (SS, SWPS, SAPS, PWSS and PS) were developed using different proportion of sesame seed and peanut as follows;

Sesame spread (ss): This sample was prepared out of 100% sesame seed with no peanut being added.

Sesame with peanut spread (swps) [75: 25]: This sample was prepared out of 75% sesame seed and 25% peanut.

Sesame and peanut spread (saps) [50: 50]: This sample was prepared out of 50% sesame seed and 50% peanut.

Peanut with sesame spread (pwss) [75:25]: This sample was prepared out of 75% peanut and 25% sesame seed.

Peanut spread (ps): This sample was made out of 100% peanut with no sesame added.

The sample PS was used as a control for the study. The chapter presents and discusses the nutritional and sensory properties of the samples in line with the research objectives.

Proximate Composition of Spreads

Major Nutrients of Spreads

The composition of six major nutrients as determined in the various spreads is presented in table 5. Table 6 also presents the regression statistics from the statistical analysis of the spread samples using ANOVA.

Table 4: Major Nutrient Contents of Spreads Produced from Different Proportions of sesame seed and Peanut

	Dry Matter (%)	Moisture (%)	Protein (%)	Fat/Oil (%)	Calcium (%)	Carbohydrate (%)
PWSS	96.39 a ±0.12	3.61 d ±0.12	19.44 b ±0.19	21.96 d ±0.05	1.24 a ±0.13	50.95 a ±0.14
SAPS	92.18 d ±0.18	7.82 a ±0.18	18.92 c ±0.08	23.48 c ±0.11	1.12 a ±0.05	50.02 b ±0.25
SS	93.84 c ±0.27	6.16 b ±0.27	17.21 e ±0.12	44.69 a ±0.17	1.20 a ±0.08	31.07 e ±0.20
SWPS	95.01 b ±0.03	4.99 c ±0.03	18.33 d ±0.16	33.38 b ±0.26	1.18 a ±0.006	40.34 d ±0.29
PS	93.43 c ±0.14	6.57 b ±0.14	24.61 a ±0.23	21.14 e ±0.19	1.07 a ±0.07	46.90 c ±0.12
Pr > F(Model)	<0.0001	<0.0001	<0.0001	<0.0001	0.105	<0.0001
Significant	Yes	Yes	Yes	Yes	No	Yes

Values are means ± SD of triplicate determinations. Means with different superscripts within the same column are significantly different (P< 0.05). swsp= Sesame with peanut spread; ss = Sesame spread; saps = sesame and peanut spread; pwss= peanut with sesame spread; ps=peanut spread. Pr >F = p-value of the test statistic

Source: Researcher's production

Table 5: Regression of variable for Major Nutrient

	Dry Matter	Moisture	Protein	Fat/Oil	Calcuim	Carbohydrate
Observations	15	15	15	15	15	15
Sum of weights	15	15	15	15	15	15
DF	10	10	10	10	10	10
R^2	0.991	0.991	0.997	1.000	0.505	0.999
Adjusted R^2	0.988	0.988	0.996	1.000	0.307	0.999
MSE	0.028	0.028	0.027	0.029	0.006	0.043
RMSE	0.166	0.166	0.164	0.171	0.075	0.207
MAPE	0.111	1.786	0.555	0.400	4.125	0.341
DW	2.651	2.651	2.824	2.486	3.022	2.934
Cp	5.000	5.000	5.000	5.000	5.000	5.000
AIC	-49.980	-49.980	-50.360	-49.068	-73.602	-43.349
SBC	-46.440	-46.440	-46.820	-45.528	-70.062	-39.808
PC	0.018	0.018	0.005	0.000	0.990	0.001

Source: Researcher's production

Dry Matter

Coefficient of determination (R^2) in the regression statistics (table 6) for dry matter is given as 0.991. It is a measure of the fraction of variability of the response values which is explained by the predictor variables (Ngo, 2012), the remaining variation accounting as chance. This gives a measure of how close the data for dry matter are to the fitted regression line. In this regard, R^2 value of 0.991 indicates that the model explains 99.1% of the variability in the response data for dry matter with only 0.9% accounting for chance**.**

Dry matter content in the spreads ranges from 92.18% to 96.39%. PWSS had the highest content of 96.39±0.12% whiles SAPS had the lowest content of 92.18±0.18%. The control (PS) had 93.43±0.14% whiles SS and SWPS had 93.84±0.27% and 95.01±0.03%. From the ANOVA test it was determined that there was significant difference ($p<0.05$) in the spreads as the p-value of <0.0001 was less than 0.05. The null hypothesis is therefore rejected for dry matter. A post hoc test using Tukey (HSD) revealed that only the control samples (PS) and SS were not significantly different ($p>0.05$). All the other samples were statistically significant different from each other. Table 7 shows four groupings of samples emanating from multiple comparisons in post hoc testing.

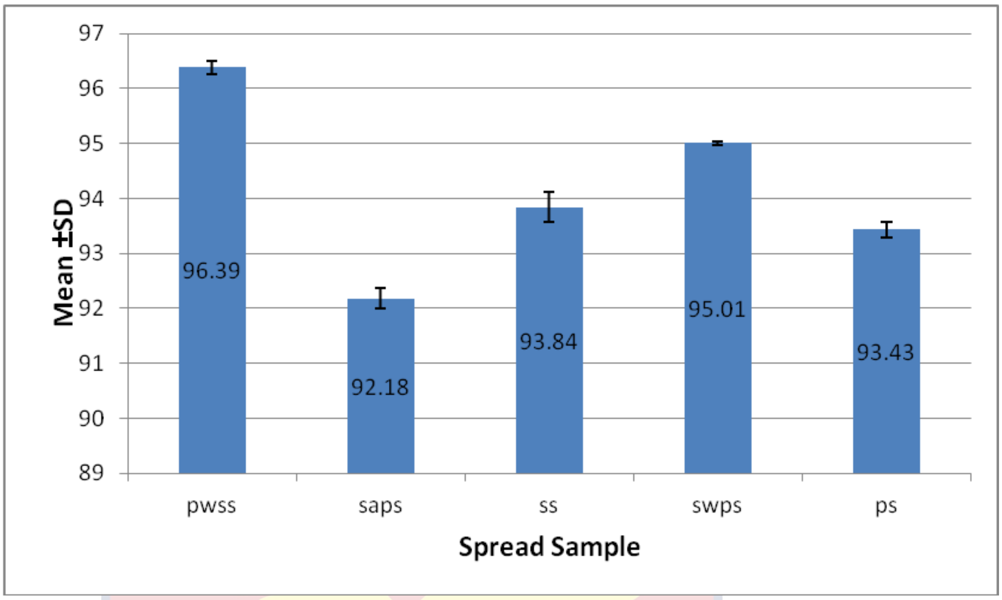

Figure 8: Mean ±SD for Dry Matter of Test Samples

Source: Researcher's production

Table 6: Dry Matter: Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups			
PWSS	96.386	0.096	A			
SWPS	95.015	0.096		B		
0.SS	93.838	0.096			C	
PS	93.430	0.096			C	
SAPS	92.177	0.096				D

Source: Researcher's production

Moisture

The model explains 99.1% of the variability in the response data for moisture as found in the regression statistics (table 6) where the Coefficient of determination (R^2) for moisture is 0.991. Only 0.9% accounting for chance. Moisture in the spreads ranged from 3.61±0.12%. to 7.82±0.18%. SAPS had the highest moisture content of 7.82±0.18% with PWSS having the least moisture content of 3.61±0.0.12%. Samples SS, SWPS and PS recorded moisture contents of 3.61±0.0.12%, 4.99±0.0.03% and 6.57±0.0.14% respectively (table 6 and figure 9).

A p-value of <0.0001 was obtained from ANOVA testing of the samples at a confidence level of 95%. The null hypothesis is rejected for moisture as the ANOVA test of the samples were determined to be significantly different (P<0.05) in at least two of the test samples. Post hoc testing revealed that only the control (PS) and SS were found not to be significantly different (P>0.05) from each other. The remaining samples were significantly different (p<0.05) from each other. A summary of pairwise comparison of the samples is presented in table 7.

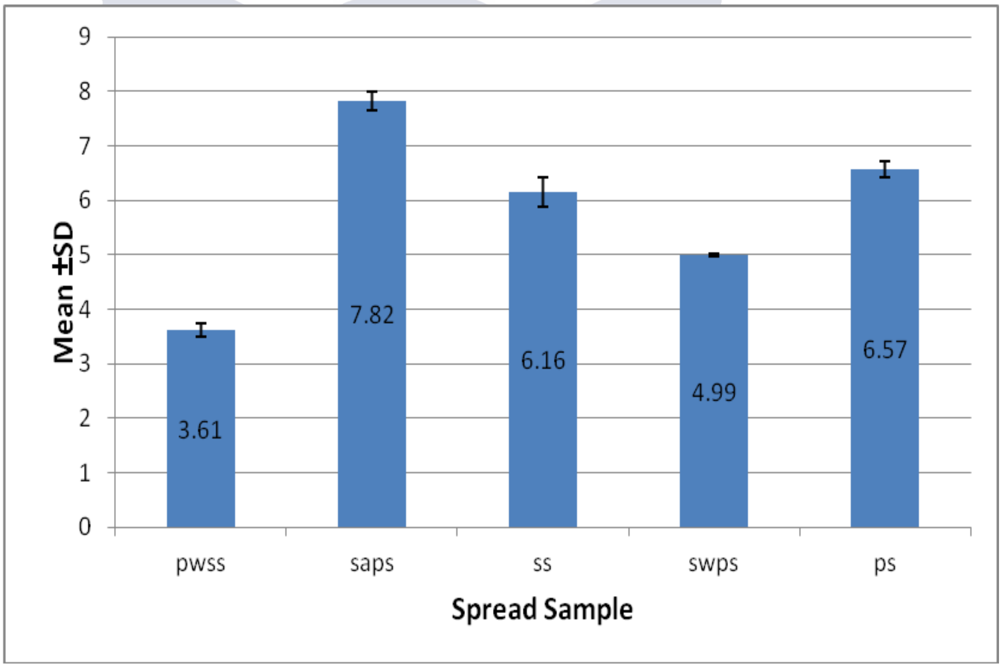

Figure 9: Mean ±SD for Moisture of Test Samples

Source: Researcher’s production

Table 7: Moisture: Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups			
SAPS	7.823	0.096	A			
PS	6.570	0.096		B		
SS	6.162	0.096		B		
SWPS	4.985	0.096			C	
PWSS	3.614	0.096				D

Source: Researcher's production

Protein

In terms of protein 99.7% of the variability of the response data is explained by the model with only 0.3% accounting for chance. This is indicated by coefficient of determination (R^2) of 0.997 in table 6. Protein was found to be highest in the PS (24.61±0.23%) whiles in the lowest in SS (17.21±0.12%) (table 5 and figure 10). PWSS, SAPS and SWPS followed the control sample (PS) with protein content of 19.44±0.19%, 18.82±0.08% and 18.33±0.16%.

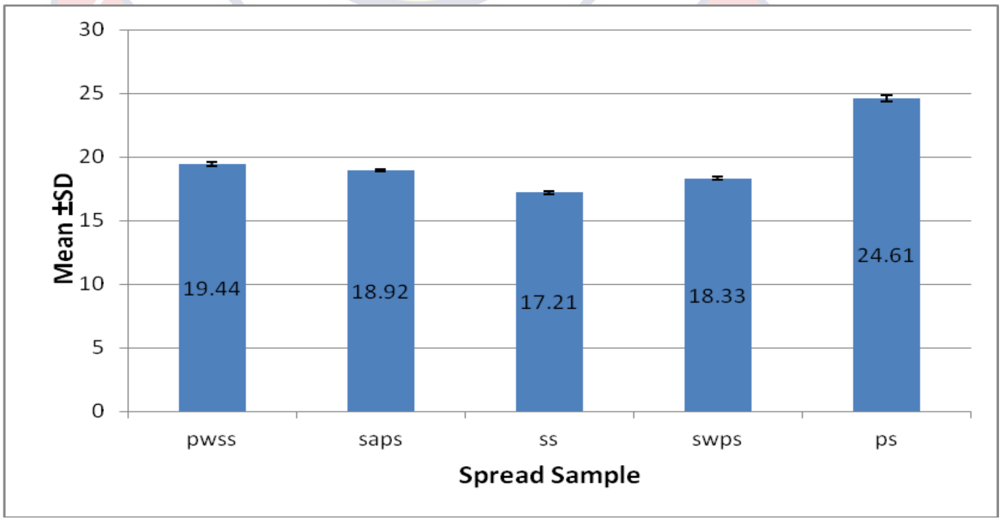

Figure 10: Mean ±SD for Protein of Test Samples

Source: Researcher's production

Table 8: Protein: Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups				
PS	24.608	0.095	A				
PWSS	19.439	0.095		B			
SAPS	18.917	0.095			C		
SWPS	18.333	0.095				D	
SS	17.208	0.095					E

Source: Researcher’s production

The protein content in the spreads was observed to increase as the proportion of peanut in them increased. A p-value of <0.0001 was obtained from ANOVA testing of sample indicating a statistically significant difference ($p<0.05$) in at least two the sample (table 5). Further post hoc testing with Tukey (HSD) showed that all the samples were significantly different ($p<0.05$) from each other (table 5 and table 9).

Fat/Oil

In analyzing fat/oil, 100% of the variability of the response data for fat/oil was explained by the model leaving nothing to chance**.** This is given by the coefficient of determination (R^2) value of 1.000 in table 6. As presented in table 5 and figure 11, the fat/oil content was found to be highest in SS (44.69±0.17 %) and lowest in PS (21.14±0.19%). That of PWSS, SAPS and SWPS ranged from 21.96±0.5%, 23.48 ±0.11% and 33.38±0.26%. Fat/oil was observed to increase with increasing proportion of sesame in the spread samples.

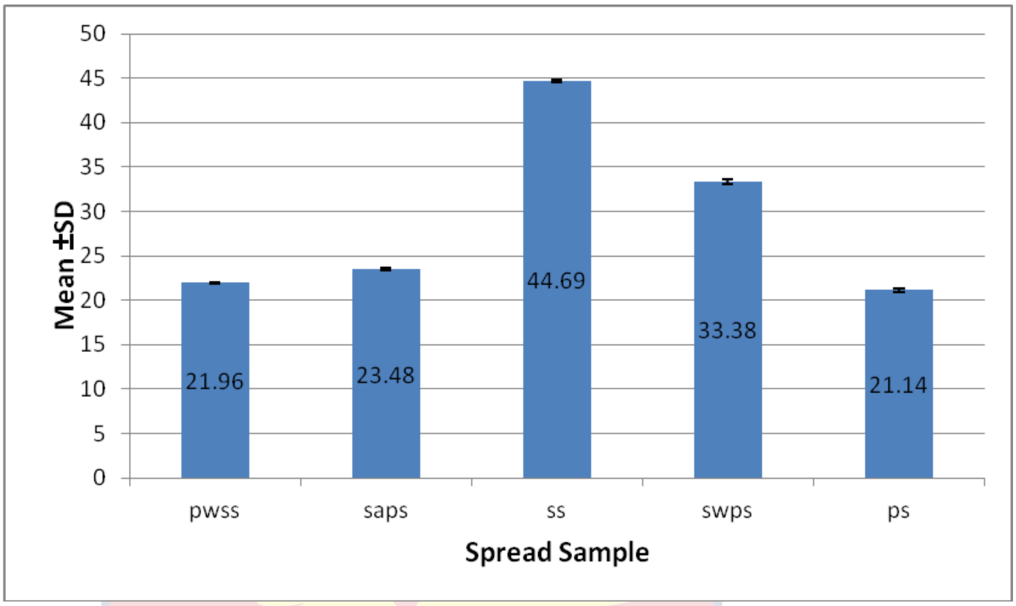

Figure 11: Mean ±SD for Fat/Oil of Test Samples

Source: Researcher's production

A p-value of <0.0001 was obtained in ANOVA testing of the samples indicating a statistically significant difference in at least two of the samples. The hypothesis is therefore rejected for fat/oil. Further post hoc testing also revealed that no two samples ware similar as test concluded that all samples were significantly different (p<0.05) from each other (table 4 and table 9).

Table 9: Fat/Oil: Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups				
SS	44.691	0.099	A				
SWPS	33.381	0.099		B			
SAPS	23.475	0.099			C		
PWSS	21.960	0.099				D	
PS	21.137	0.099					E

Source: Researcher's production

Calcium

From the analysis, only calcium recorded a lowest coefficient of determination (R^2) value of 0.505 (table 6) meaning that the model explained only 50.5% of the variability in the response data with 49.5% accounting for chance. The calcium content in the spreads ranged from 1.07% to 1.24%. The highest content of calcium was found in PWSS (1.24±0.13%), with PS having the lowest calcium content of 1.07 ±0.07%. A calcium content of 1.12±0.05%, 1.18±0.006% and 1.20±0.08% was detected in SAPS, SWPS and SS respectively. A p-value of 0.105 was obtained from ANOVA testing of the samples indicating that there no significantly difference between samples (table 5 and figure 12). The test therefore confirmed the study's hypothesis for calcium. Hence all samples are put into one group (Table 4 and table 10).

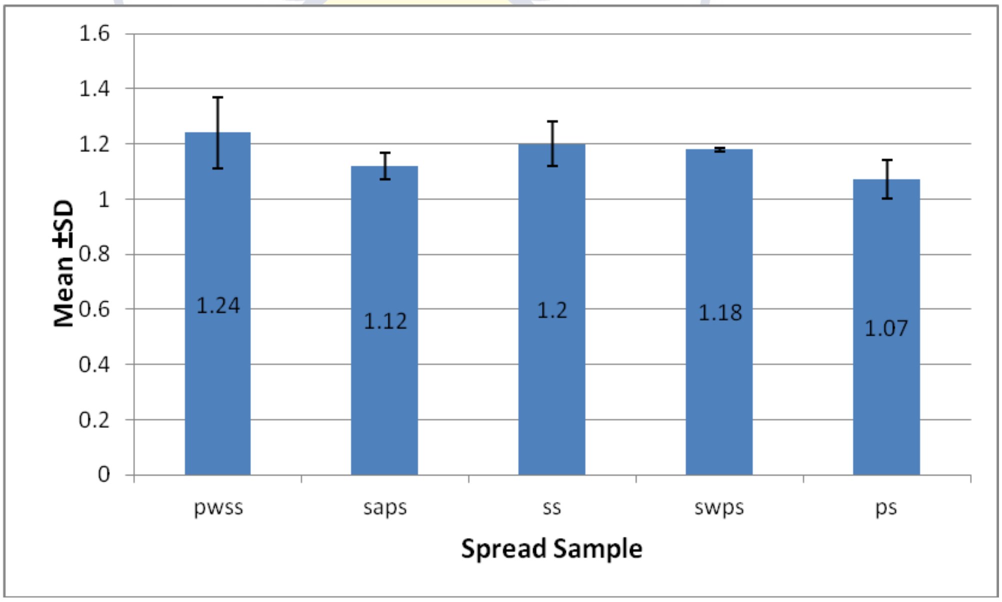

Figure 12: Mean ±SD for Calcium of Test Samples

Source: Researcher's production

Table 40: Calcium -Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups
PWSS	1.243	0.044	A
SS	1.195	0.044	A
SWPS	1.178	0.044	A
SAPS	1.115	0.044	A
PS	1.066	0.044	A

Source: Researcher's production

Carbohydrates

The model explains 99.9% of the variability of response data for carbohydrates leaving only 0.1% to chance. This is depicted by the coefficient of determination (R^2) value of 0.999 in table 6. Analysis for carbohydrates in the spreads showed a higher carbohydrate content of 50.95±0.14% in PWSS with SS recording the lowest content of 31.07±0.20%. SAPS came second with 50.02±0.25% followed by PS (46.90 ±0.12%) and SWPS (40.34±0.29%) as shown in table 5 and figure 13. The study hypothesis was again rejected on carbohydrates as the ANOVA testing returned a p-value <0.0001(table 3) which was less than 0.05 confidence level for the test. Post hoc testing with Tukey (HSD) showed that each of the spreads sample was significantly different ($p<0.05$) from the rest and were put into five distinct groups as seen in table 4 and table 11.

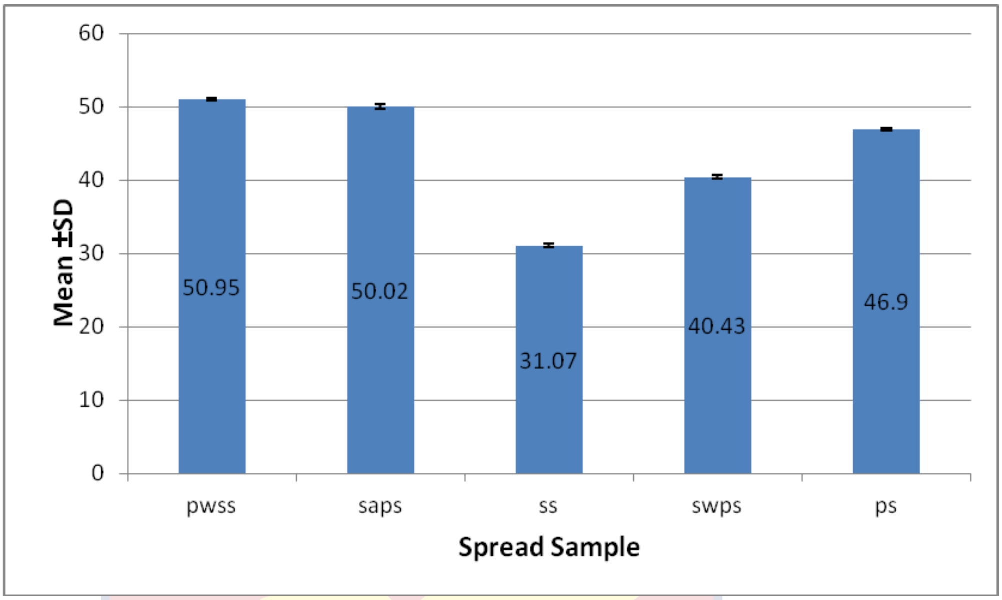

Figure 13: Mean ±SD for Carbohydrates of Test Samples

Source: Researcher's production

Table 11: Carbohydrates: Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups				
PWSS	50.946	0.119	A				
SAPS	50.016	0.119		B			
PS	46.903	0.119			C		
SWPS	40.342	0.119				D	
SS	31.069	0.119					E

Source: Researcher's production

Minor Nutrients of Spreads

The proximate compositions of nine minor nutrients were determined in each of the five spread samples. Results from testing and analysis are presented in table 12. Similarly, table 14 presents the regression statistics from the statistical analysis of the spread samples.

Table 52: Minor Nutrient Contents of Spreads Produced from Different Proportions of Sesame seed and Peanut

	Potassium (K)	Sodium (Na)	Phosphorus (P)	Iron (Fe)	Copper (Cu)	Zinc (Zn)	Magnesuim (Mg)	Ash	Fibre
	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	%	%	%
PS	5537.79 a	3215.25 a	6972.16 b	1034.49 b	56.80 c	116.37 a	0.10 c	2.87 c	4.48 a
	±117.08	±115.09	±57.90	±82.40	±2.77	±9.31	±0.003	±0.02	±0.17
SWPS	4533.58 c	2737.58 b	6690.95 c	785.36 c	289.40 a	108.53 a	0.22 a	4.19 a	3.76 b
	±105.30	±46.27	±12.08	±30.40	±6.67	±4.41	±0.0009	±0.06	±0.14
SAPS	4978.72 b	2660.58 b	5665.76 d	726.91 cd	210.14 b	63.67 c	0.23 a	4.14 a	3.45 b
	±48.60	±68.98	±154.75	±19.31	±12.43	±2.69	±0.01	±0.15	±0.13
SS	4170.61 d	2312.16 c	7677.18 a	624.72 d	227.52 b	84.18 b	0.18 b	4.33 a	2.70 c
	±70.14	±171.76	±125.14	±33.13	±17.18	±2.71	±0.01	±0.03	±0.15
PWSS	5330.34 a	1558.63 d	5402.00 e	1175.60 a	46.83 c	89.57 b	0.17 b	3.26 b	4.40 a
	±164.70	±51.44	±33.9	±59.83	±2.85	±6.30	±0.01	±0.22	±0.16
Pr > F(Model)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Significant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Values are means ± SD of triplicate determinations. Means with different superscripts within the same column are significantly different (P< 0.05). swsp= Sesame with peanut spread; ss = Sesame spread; saps = sesame and peanut spread; pwss= peanut with sesame spread; ps=peanut spread. Pr >F = p-value of the test statistics

Source: Researcher's production

Table 13: Regression of variable for Minor Nutriens

	Potassium (K)	Sodium (Na)	Phosphorus (P)	Iron (F)	Copper (Cu)	Zinc (Zn)	Magnesium (Mg)	Ash	Fibre
Observations	15	15	15	15	15	15	15	15	15
Sum of weights	15	15	15	15	15	15	15	15	15
DF	10	10	10	10	10	10	10	10	10
R^2	0.970	0.978	0.992	0.961	0.993	0.942	0.977	0.972	0.966
Adjusted R^2	0.958	0.969	0.988	0.945	0.990	0.919	0.968	0.960	0.952
MSE	11840.523	10458.902	8850.655	2552.549	101.989	32.080	0.000	0.015	0.023
RMSE	108.814	102.269	94.078	50.523	10.099	5.664	0.008	0.121	0.150
MAPE	1.551	2.830	0.905	3.561	4.065	3.912	3.109	1.908	2.873
DW	2.596	2.496	2.687	2.101	2.094	2.294	2.996	2.241	2.501
Cp	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
AIC	144.607	142.746	140.242	121.591	73.291	55.941	-139.621	-59.327	-52.903
SBC	148.148	146.286	143.782	125.131	76.831	59.482	-136.081	-55.787	-49.363
PC	0.061	0.045	0.017	0.079	0.014	0.116	0.046	0.056	0.068

Source: Researcher's production

Potassium

The ANOVA model explains 97% of the variability of the response data for Potassium as given by the coefficient of determination (R^2) value of 0.970 in table 14. The control (PS) contains the highest potassium content of 5,537.79±117.08ug/g whiles SS had the lowest of 4,170.61±70.14ag/g (table 13 and figure 14). PWSS had 5,33.34 ±164.70ug/g whiles SAPS and SWPS contained 4,978.72±48.60 and 4,533.58ug/g respectively. Potassium content was observed to increase as the proportion of peanut increased in the spreads. A p-value of <0.0001 was recorded in ANOVA testing of samples indicating a significant difference in at least two of the samples. The study hypothesis was therefore rejected. Post hoc testing with Tukey (HSD) showed that only the control (PS) and PWSS were not significantly different from each other (table 13 and table 15). Every other sample was significantly different from the rest.

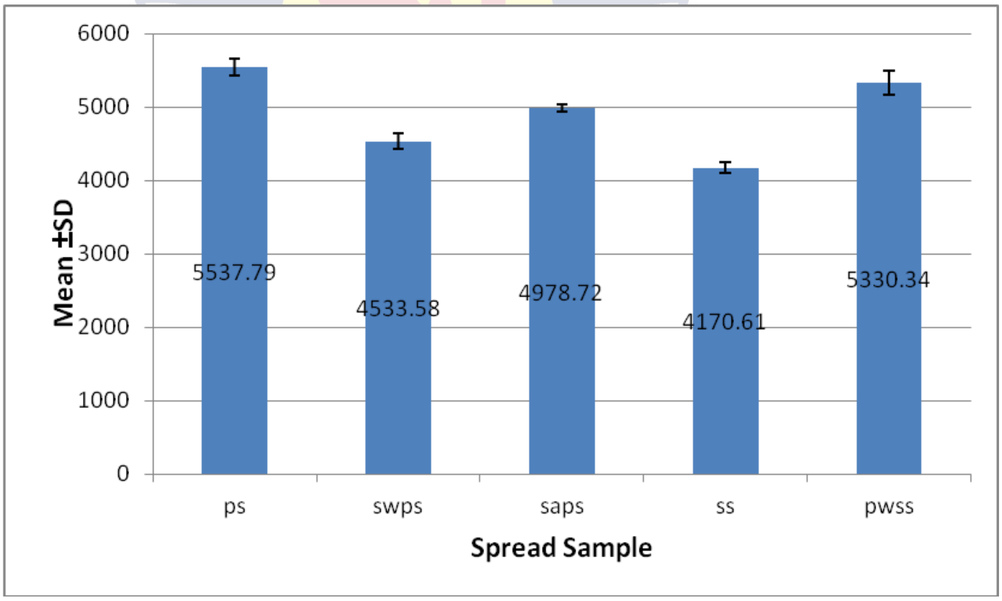

Figure 14: Mean ±SD for Potassium of Test Samples

Source: Researcher's production

Table 64: Potassium: Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups			
PS	5537.785	62.824	A			
PWSS	5330.338	62.824	A			
SAPS	4978.716	62.824		B		
SWPS	4533.581	62.824			C	
SS	4170.609	62.824				D

Source: Researcher's production

Sodium

The ANOVA model explains 97.8% of the variability of the response data for Sodium as given by coefficient of determination (R^2) value of 0.978 in table 14. A p-value of <0.0001 was returned from testing the samples indicating a significant difference in at least two of the samples. Test hypothesis was therefore rejected for sodium.

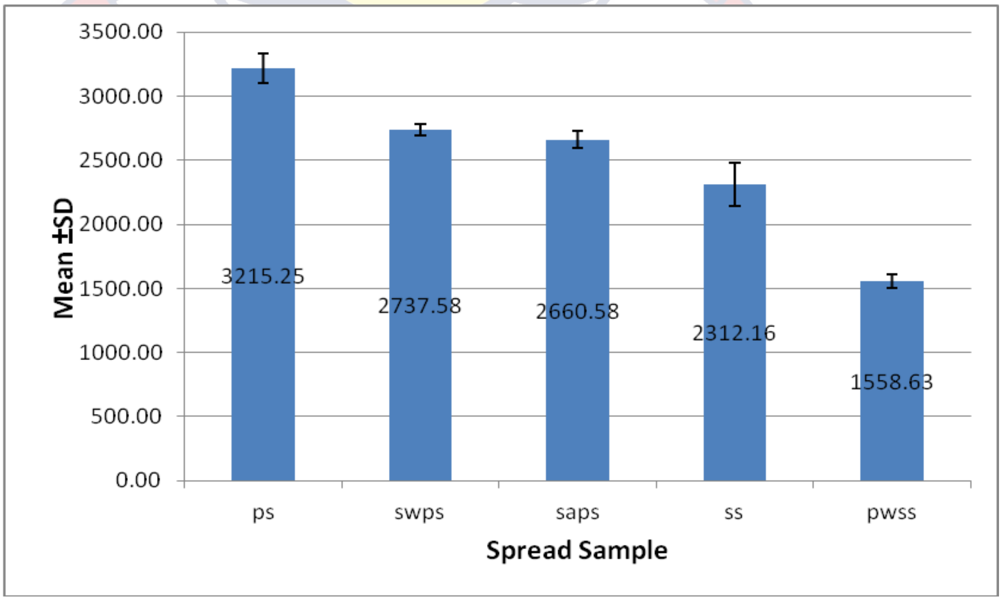

Figure 15: Mean ±SD for Sodium of Test Samples

Source: Researcher's production

The control (PS) had the highest sodium content of 3,215.25±115.09ug/g and was significantly different from all other samples. The lowest sodium content was in PWSS which had 1,558.63±51.44ug/g with SWPS, SAPS and SS each having a content of 2,737.58±46.27ug/g, 2,660.58±68.98ug/g and 2,312.16±171.76ug/g. There was no significant difference between SWAPS and SAPS. There were however significant differences between all other spread samples. Pairwise comparison of samples arising from Tukey (HSD) testing is presented in table 15.

Table 75: Sodium: Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups			
PS	3215.254	59.045	A			
SWPS	2737.581	59.045		B		
SAPS	2660.576	59.045		B		
SS	2312.158	59.045			C	
PWSS	1558.633	59.045				D

Source: Researcher's production

Phosphorus

For Phosphorus, 99.2% of the variability of the response data was explained by the ANOVA model. This is given by the coefficient of determination (R^2) value of 0.992 in table 15. The p-value from the test was <0.0001 indicating a rejection of the study hypothesis.

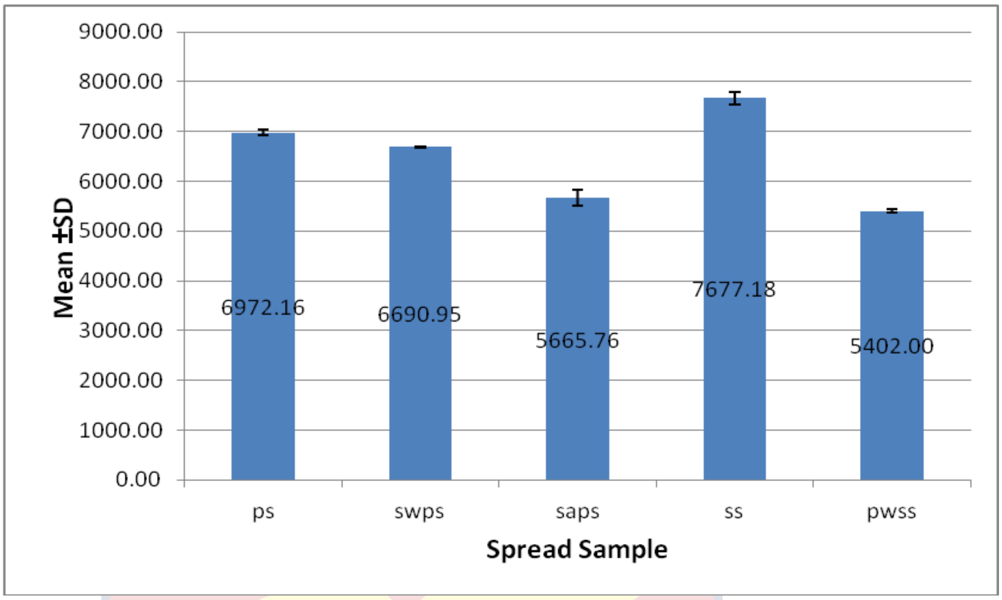

Figure 16: Mean ±SD for Phosphorus of Test Samples

Source: Researcher's production

Table 86: Phosphorus: Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups				
SS	7677.177	54.316	A				
PS	6972.160	54.316		B			
SWPS	6690.945	54.316			C		
SAPS	5665.761	54.316				D	
PWSS	5402.004	54.316					E

Source: Researcher's production

Phosphorus was highest in SS with a content of 7,677.18±125.14ug/g with PWSS having the least phosphorus at 5,402.00±33.9ug/g (table 13 and figure 16). The control (PS) came second with 6,972.16±57.90ug/g. SWPS and SAPS had 6,690.95±12.08ug/g and 5,665.75±154.75ug/g. Each of the samples was found to be significantly difference (P<0.05) from the other resulting in five distinct groups of samples as shown in table 16.

Iron

The model explained 96.1% of the variability of the response data around for iron. This is given by the coefficient of determination (R^2) value of 0.961 in table 14. The highest iron content was found in PWSS as it had 1,175.60±59.83ug/g with a lower amount of 624.72±33.13ug/g found in SS. The control (PS) had the second highest iron content of 1,034.49±82.40ug/g. SWPS and SAPS contained iron of 785.36±30.40ug/g and 624.72±19.31ug/g respectively. Generally, the amount of iron in the spreads was found to decline as the proportion of peanut decreased in the spreads. The study hypothesis was rejected by the test as a p-value of <0.0001 was obtained from ANOVA testing indicating a significant difference in at least two of the samples. No significant difference was found between SWPS and SAPS, and between SAPS and SS. There was a significant difference between the remaining samples arising from multiple comparisons (table 13 and table 18).

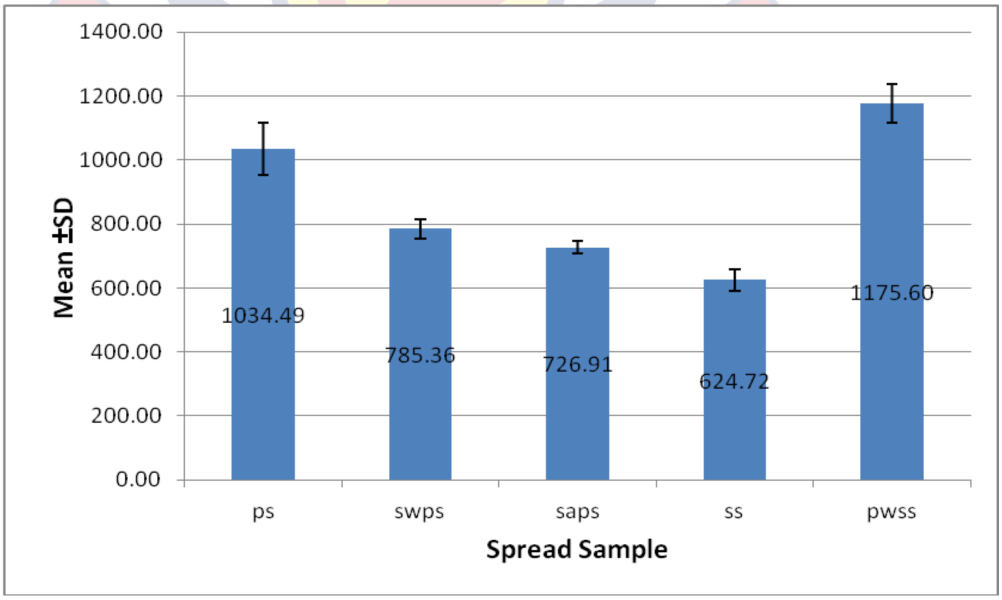

Figure 17: Mean ±SD for Iron of Test Samples

Source: Researcher's production

Table 97: Iron-Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups			
PWSS	1175.602	29.169	A			
PS	1034.490	29.169		B		
SWPS	785.362	29.169			C	
SAPS	726.909	29.169			C	D
SS	624.719	29.169				D

Source: Researcher's production

Copper

The model explained 99.3% of the variability of the response data for copper. This is given by the R^2 value of 0.993 in table 14. As presented in table 13 and figure 18, copper content in the spreads ranged from 46.83ag/g to 289.40ag/g. SWPS was found with the highest amount of copper (289.40±6.67ug/g) whiles PWSS was found with the least amount of 46.83±2.84ug/g. SS had 227.52±17.18ug/g with SAPS and PS having 210.14±12.43ug/g and 56.80±2.77ug/g. Generally, the copper content in the spreads was found to increase as the proportion of sesame increased in the spreads. The hypothesis was rejected as a p-value of <0.0001 was obtained from testing. PS was determined not to be significantly different from PWSS. SS was also found not to be significantly different from SAPS. Apart from these two pairs, all other comparisons of the spreads were found to be significantly different. Three groups of spreads were therefore determined from multiple comparisons in post hoc testing as seen in table 18.

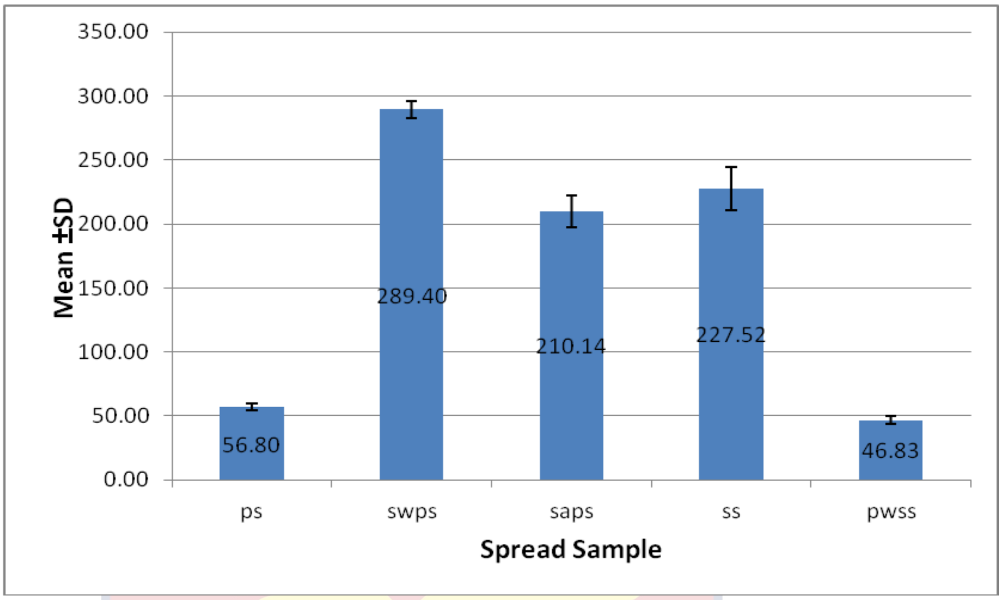

Figure 18: Mean ±SD for Copper for Test Samples

Source: Researcher's production

Table 108: Copper: Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups		
SWPS	289.400	5.831	A		
SS	227.521	5.831		B	
SAPS	210.143	5.831		B	
PS	56.799	5.831			C
PWSS	46.833	5.831			C

Source: Researcher's production

Zinc

The model explained 94.2% of the variability of the response data for zinc. This is given by the R^2 value of 0.942 in table 14. The presence of zinc in the spreads ranged from 84.18ug/g to 116.37ug/g. The highest zinc content of 116.37±9.31ug/g was found in PS whiles the lowest zinc content 63.67±2.69ug/g was found in SAPS. Zinc in SWPS, PWSS and SS were

108.53±4.41ug/g, 89.57±6.30ug/g and 84.18±2.71ug/g (table 13 and figure 19). A p-value of <0.0001 was returned from ANOVA testing therefore calling for a rejection of the hypothesis. The control (PS) and SWPS were not significantly different from each other. Likewise, PWSS and SS were not significantly different from each other. All other samples comparisons were found to be significantly different (P<0.05) from each other. Multiple comparison of spreads resulted in three grouping as found in table 19.

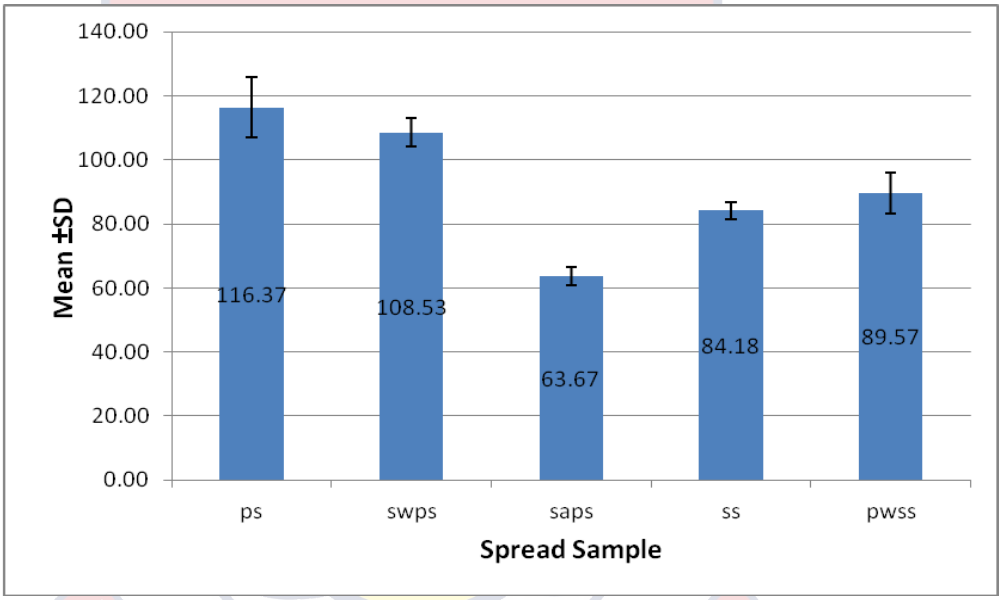

Figure 19: Mean ±SD for Zinc of Test Samples

Source: Researcher's production

Table 19: Zinc-Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups		
PS	116.367	3.270	A		
SWPS	108.529	3.270	A		
PWSS	89.569	3.270		B	
SS	84.183	3.270		B	
SAPS	63.669	3.270			C

Source: Researcher's production

Magnesium

For magnesium, the model explained 97.7% of the variability of the response data. This is given by the R^2 value of 0.977 in table 14. Magnesium in the spreads ranged from 0.10% to 0.23%. A p-value of <0.0001 was determined in from sample testing indicating a significant difference in some of the samples.

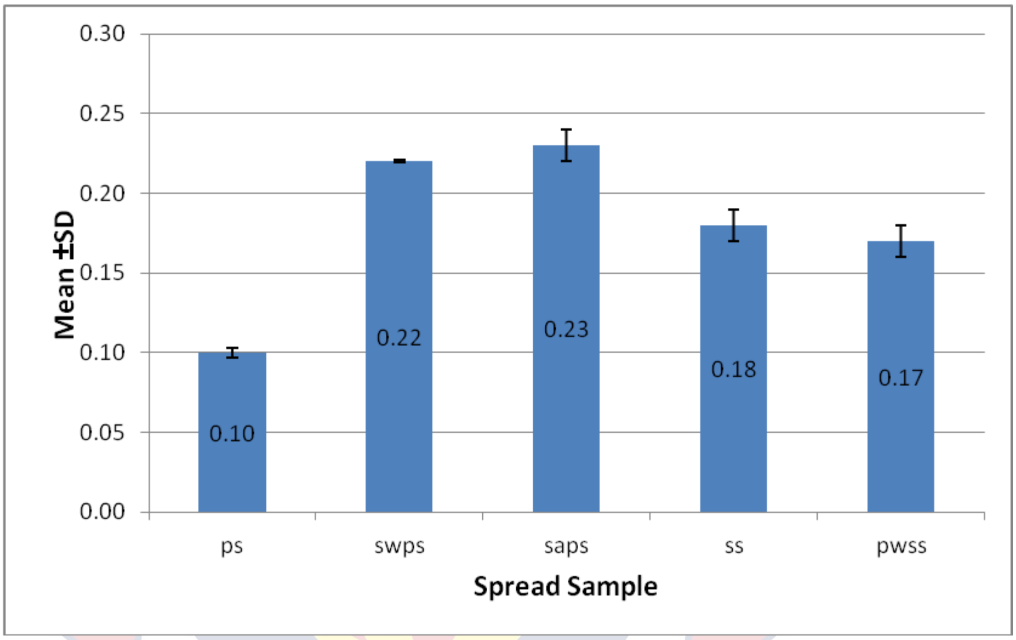

Figure 20: Mean ±SD for Magnesium of Test Samples

Source: Researcher's production

Table 110: Magnesium: Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups		
SAPS	0.229	0.005	A		
SWPS	0.220	0.005	A		
SS	0.181	0.005		B	
PWSS	0.171	0.005		B	
PS	0.104	0.005			C

Source: Researcher's production

The control (PS) had the lowest magnesium of 0.10±0.003% and was significantly different ($P<0.05$) from all the other spreads. Magnesium was highest in SAPS at 0.23±0.01% with SWPS, PWSS and SS recording 0.22±0.0009%, 0.17±0.01% and 0.18±0.01% respectively (table 13 and figure 21). Other spreads were also significantly different from other spreads except for SAPS and SWPS on one hand and SS and SWSS which were found not to be significantly different from each other. Summary of multiple comparisons of the spreads is presented in table 20.

Ash

For Ash, the model explained 97.2% of the variability of the response data. This is given by the R^2 value of 0.972 in table 14. The presence of Ash in the spread was noted to increases as the proportion of sesame in the spreads increased. Hence, SS has the highest ash content of 4.19±0.03% and PS had the lowest content of 2.87±0.02%. The ash content in SWPS, SAPS and PWSS were determined at 4.19±0.06%, 4.14±0.15% and 3.26±0.22% respectively (table 12 and figure 20). A p-value of <0.0001 was determined in from sample testing indicating a significant difference in some of the samples. There was a significant difference between the spreads when compared with each other except for the following pairs (SS and SAPS, SS and SWPS, and SWPS and SAPS) which found not to be significant difference. Multiple comparisons using Tukey (HSD) yielded three distinct groups of spread as shown in table 21.

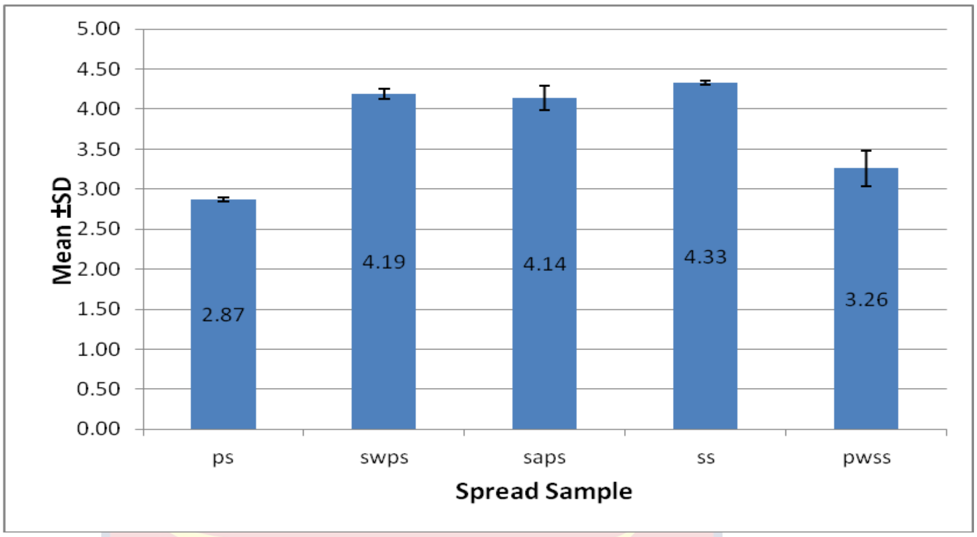

Figure 21: Mean ±SD for Ash for Test Samples

Source: Researcher's production

Table 121: Ash-Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups		
SS	4.332	0.070	A		
SWPS	4.187	0.070	A		
SAPS	4.139	0.070	A		
PWSS	3.258	0.070		B	
PS	2.873	0.070			C

Source: Researcher's production

Fibre

The model explains 96.6% of the variability of the response data around for fibre. This is given by the R^2 value of 0.966 in table 14. Fibre content in the spreads was observed to increase as the proportion of peanut increases in the spreads. Hence PS recorded the highest fibre content of 4.48±0.17% whiles SS recorded the lowest content of 2.70±0.15%. PWSS came second with fibre content of 4.40±0.16% while SAPS and SWPS had 3.45±0.13% and 3.76±0.14% (table 12 and figure 21).

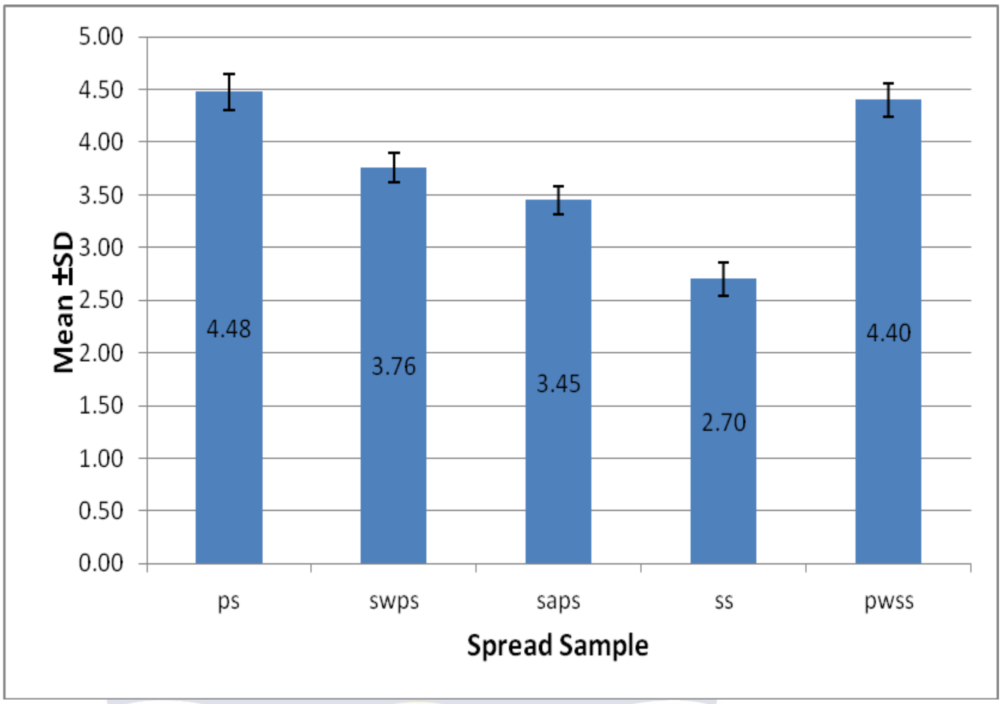

Figure 22: Mean ±SD for Fibre for Test Samples

Source: Researcher's production

Table 132: Fibre Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups		
PS	4.478	0.087	A		
PWSS	4.397	0.087	A		
SWPS	3.758	0.087		B	
SAPS	3.453	0.087		B	
SS	2.700	0.087			C

Source: Researcher's production

A p-value of <0.0001 was determined in from sample testing indicating a significant difference in some of the samples. No significant difference was found between PS and PWSS. Similarly, there was no significant difference between SWPS and SAPS. There was however a significant difference between all comparison of samples. Three groups of spreads were determined from post hoc testing as presented in table 23.

Sensory Evaluation of Spreads

Sensory properties of the spreads were evaluated using 80 panelists drawn mainly from level 400 students of the University of Cape Coast. Biographical information of the panelists is presented in table 24 below. Testing was done using a 5-point hedonic scale as shown below.

1	**2**	**3**	**4**	**5**
Like very much	Like moderately	Neither like nor dislike	Dislike moderately	Dislike very much

Source: Dimple and Rohanie (2014)

Table 23: Distribution of respondents by age and gender

	Frequency			
Age Range	Male	Female	Total	Percentage
15 – 20	2	4	6	8%
21 – 25	26	19	45	56%
26 – 30	13	11	24	30%
31 – 35	3	0	3	4%
36 - 40	2	0	2	3%
Total	46	34	80	100%

Source: Researcher's production

Both gender was considered because gender has been found to influence liking, attitude, affective response, choice, and perception toward food (Ares and Gámbaro, 2007) . Beardsworth, Bryman, Keil, Goode, Haslam and Lancashire (2002) suggested that gender difference may be due to women focusing more on their senses and the actual sensation they experience, while men may be focusing more on any cognitive information they receive about the product. Therefore, the need to include a significant representation of each sex to obtain the best outcome.

Consumer Preference and Overall Acceptability

Mean scores for consumer preference in terms of appearance, taste, texture, aroma, and overall acceptability are presented in table 25 below with significant differences ($p<0.05$) among the spread samples.

Table 144: Sensory evaluation of spreads produced from different proportions of Sesame seed and peanut

	Appearance	Taste	Texture	Aroma	Overall Acceptability
SWPS	1.85 a ±0.71	1.84 a ±0.89	1.90 a ±0.92	1.98 a ±0.9	2.03 a ±0.83
SS	1.60 ab ±0.76	1.93 a ±0.98	1.88 a ±0.92	2.06 a ±0.99	2.14 a ±0.88
SAPS	1.74 ab ±0.81	1.59 ab ±0.82	1.88 a ±0.91	1.76 ab ±0.94	1.95 a ±0.84
PWSS	1.65 ab ±0.75	1.56 ab ±0.81	1.83 ab ±0.88	1.53 b ±0.78	1.54 b ±0.64
PS	1.45 b ±0.65	1.44 b ±0.65	1.48 b ±0.83	1.40 b ±0.67	1.49 b ±0.66
Pr > F(Model)	0.011	0.001	0.013	<0.0001	<0.0001
Significant	Yes	Yes	Yes	Yes	Yes

Values are means ± SD. Means with different alphabets within the same column are significantly different (P< 0.05). swsp= Sesame with peanut spread; ss = Sesame spread; saps = sesame and peanut spread; pwss= peanut with sesame spread; ps=peanut spread. Pr >F = p-value of the test statistics.

Source: Researcher's production

Appearance Preference

The mean score for appearance ranges between 1.45 to 1.85. A p-value of 0.011 was determined in ANOVA testing of consumer's preference for appearance. This indicated a significant difference in preference for some of the samples. The appearance of the control sample (PS) was the most preferred with a means score of 1.45±0.65 and SWPS was the least preferred with a score of 1.85±0.71. These two samples were significantly different ($p<0.05$) from each but not significantly different from other spreads. The remaining spreads, PWSS, SAPS and SS recorded 1.65±0.0.75, 1.74±0.81 and 1.60±0.76 and significantly not different from each other (table 24 and figure 23).

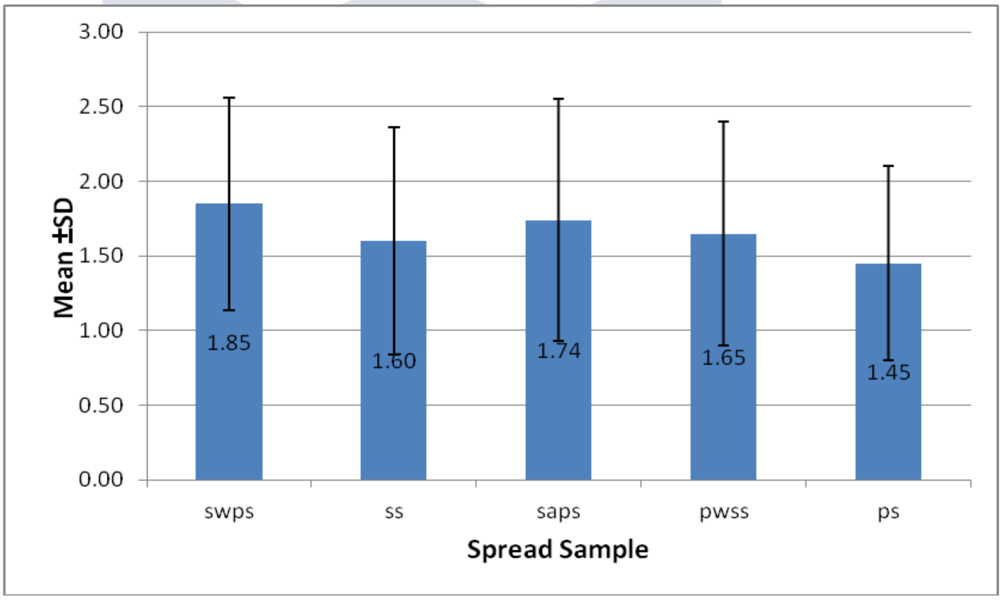

Figure 23: Mean ±SD for Appearance of Test Samples

Source: Researcher's production

Table 155: Appearance -Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups	
SWPS	1.850	0.082	A	
SAPS	1.738	0.082	A	B
PWSS	1.650	0.082	A	B
SS	1.600	0.082	A	B
PS	1.450	0.082		B

Source: Researcher's production

Indeed, all products had means of not more than 2 out of the total score of 5 indicating that panelist had a positive attitude towards all spreads even though some were liked more than others. Preference for appearance through post hoc testing was categorized into two groups as presented in table 25.

Taste Preference

The preference mean score for taste ranged from 1.44 to 1.93. These were not more than 2 indicating that none of the spreads was rejected in terms of taste although some received more favourable rating than others. A p-value of 0.001 was determined from ANOVA testing of consumer's preference for taste. This indicated a significant difference in preference for the taste of some of the samples.

The control (PS) was the most preferred with a mean of 1.44±0.65 and significantly different ($p<0.05$) from SS and SWPS but was determined to be significantly not different from SAPS and PWSS. The remaining samples similarly obtained preference as they also had lower mean scores 1.56±0.81, 1.59±0.82, 1.93±0.98 and 1.84±0.89 (table 24 and figure 24) although PWSS was most preferred after PS with SS being the least preferred. They were also found not to be significantly different from each other (table 24 and table 26)

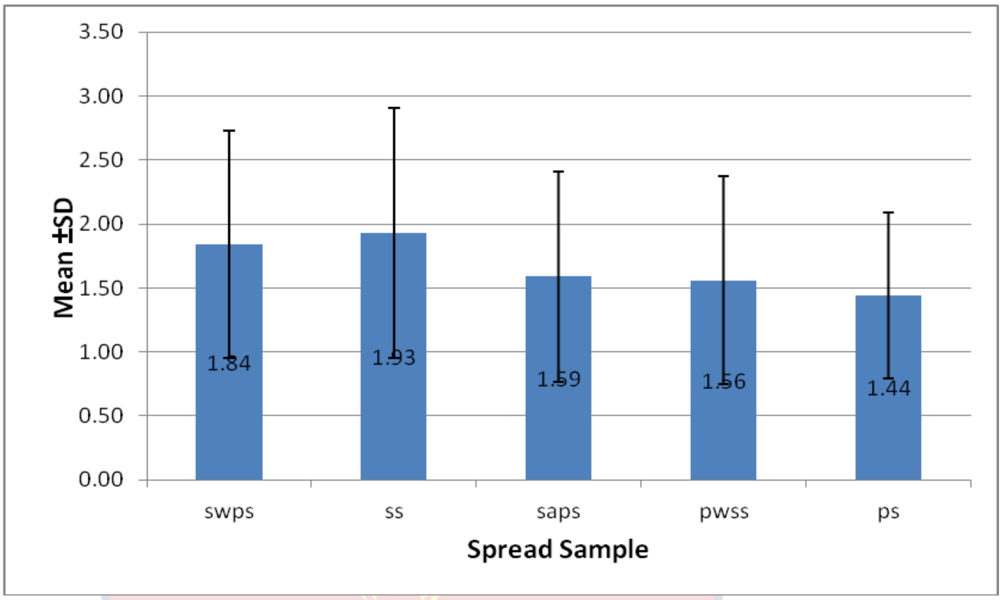

Figure 24: Mean ±SD for Taste of Test Samples

Source: Researcher's production

Table 166: Taste-Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups	
SS	1.925	0.094	A	
SWPS	1.837	0.094	A	
SAPS	1.588	0.094	A	B
PWSS	1.563	0.094	A	B
PS	1.438	0.094		B

Source: Researcher's production

Texture Preference

All products received positive acceptance for texture from panelist with mean scores of not more than 2. A p-value of 0.013 was determined in ANOVA testing of consumer's preference for texture. This indicated a significant difference in consumer's preference for the texture for at least two of the samples.

The mean score for texture for the samples ranged from 1.48 to 1.90. The control (PS) was the most preferred with a score of 1.48±0.83 and was found to significantly different from SWPS, SS and SAPS but not significantly different from PWSS. The other samples were not significantly different ($p>0.05$) from each other. PWSS was the second most preferred spread with a mean of 1.83±0.88 with SWPS being the least preferred with 1.90±0.92. SAPS and SS had average means of 1.88±0.91 and 1.88±0.92 respectively. Panelist taste preference for the sample was put into two groups as presented in table 28.

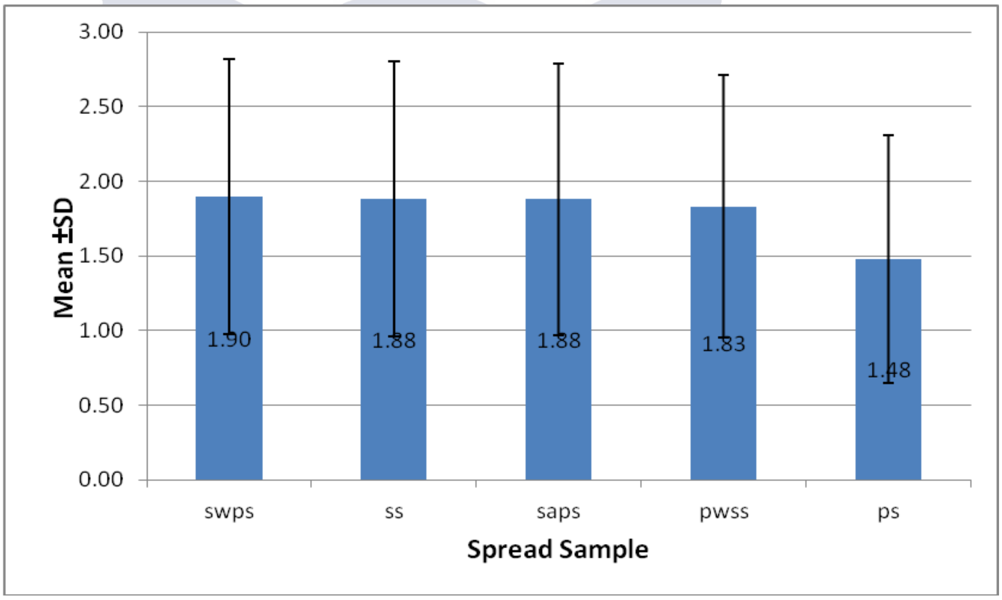

Figure 25: Mean ±SD for Texture of Test Samples

Source: Researcher's production

Table 177: Texture - Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups	
SWPS	1.900	0.100	A	
SAPS	1.875	0.100	A	
SS	1.875	0.100	A	
PWSS	1.825	0.100	A	B
PS	1.475	0.100		B

Source: Researcher's production

Aroma Preference

The means for aroma for the different spreads ranged from 1.40 to 2.06. A p-value of <0.0001 was determined from ANOVA testing of consumers' preference aroma. This indicated a significant difference in preference for some of the samples. With a mean of 1.40±0.67 the control sample (PS) was the most preferred. It was significantly different (P<0.05) form SS and SWPS which scored 2.06±0.99 and 1.98±0.90 but not significant different (p>0.05) from PWSS and SAPS which had means of 1.53±0.78 and 1.76±0.94. PWSS was preferred after the control and was determined to be significantly different (P<0.05) from SS and SWPS but not significantly different (p>0.05) from the others (table 24 and figure 26). SS was least preferred on aroma. All other spreads were liked as they received mean scores of less than 2.

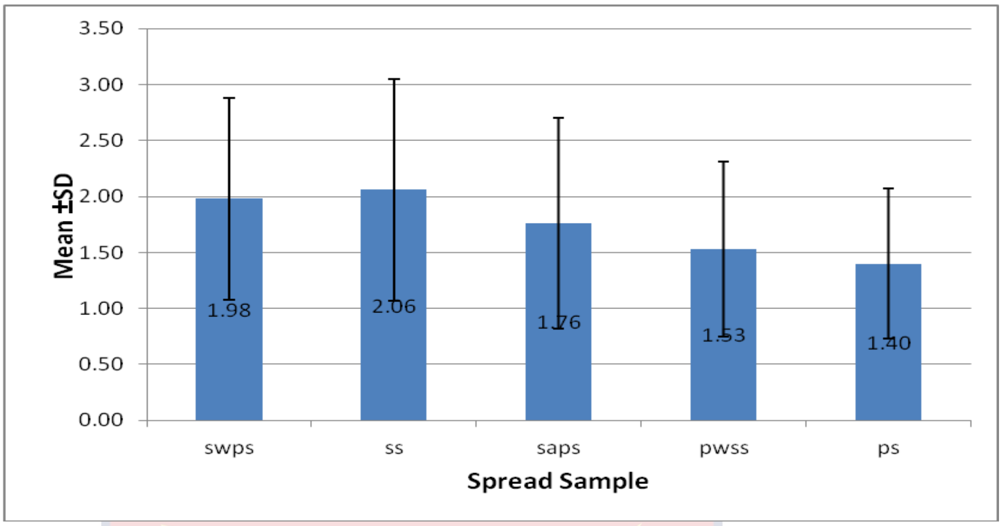

Figure 26: Mean ±SD for Aroma of Test Samples

Source: Researcher's production

Table 188: Aroma-Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups	
SS	2.063	0.097	A	
SWPS	1.975	0.097	A	
SAPS	1.763	0.097	A	B
PWSS	1.525	0.097		B
PS	1.400	0.097		B

Source: Researcher's production

Overall Acceptability

The means for the various spreads ranged from a minimum of 1.49 to 2.14. A p-value of <0.0001 was determined from ANOVA testing of overall acceptability for spreads. This indicated a significant difference in overall acceptability of at least two of the samples. The control (PS) was the most accepted followed by PWSS with mean scores of 1.40±0.66 and 1.54±0.64 respectively. The two were found not to be significantly different from each other.

SAPS was the third product accepted by panelist with a mean of 1.95±0.84. It was however determined to be significantly different PS and PWSS but not significantly different from SS (2.14±0.88) and SWPS (2.03±0.83). SS and SWPS recorded means above the benchmark of 2 but below 3. This means customers did not show a dislike for the two products but simply

It was established from the analysis that acceptability of the spreads declined as the proportion of the sesame in them increased. This could be attributed to the fact that peanut spread is the commonest seed/nut spread consumed in Ghana. As such panelist for the study would have been familiar with the control and felt comfortable with spread samples that were closer to the control resulting in strong acceptance for those samples. McDermott, B (1990), underscore this when he indicated that frequent product users score product liking or acceptance differently than infrequent or non-users. Raynor and Wing (2006) stated that non-users of certain product may experience neophobia, a condition in which consumption of novel foods is avoided, perhaps decreasing hedonic ratings due to unfamiliarity.

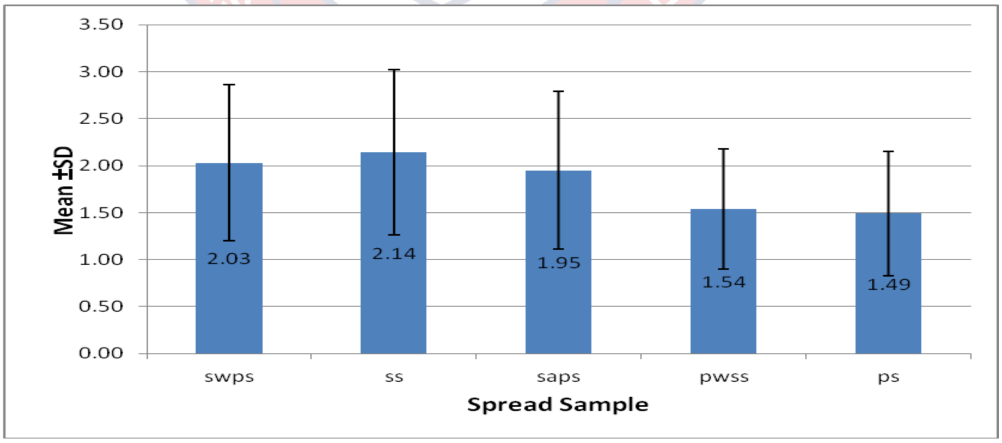

Figure 27: Mean ±SD for Overall Acceptability for Test Samples

Source: Researcher’s production

Table 2919: Overall Acceptability- Pairwise comparison for Samples (Tukey (HSD))

Category	LS means	Standard error	Groups	
SS	2.138	0.087	A	
SWPS	2.025	0.087	A	
SAPS	1.950	0.087	A	
PWSS	1.538	0.087		B
PS	1.488	0.087		B

Source: Researcher's production

Quantitative and Descriptive Profiles of Accepted Spreads

Selected Spread Samples

Determination of selected spread sample(s) was achieved using respondents scoring on overall acceptability of the spread samples. Using the five point hedonic scale, a score of 1 to 2 was deemed as acceptance whiles a score of 3 to 5 was considered a rejection of the sample. From this, an aggregate mean score of not more than 2 on the parameter for a any given spread sample was deemed a favourable consideration whiles an aggregate mean score of more than 2 was considered a rejection of the product.

Overall acceptability of samples from the study is presented in figure 28 below:

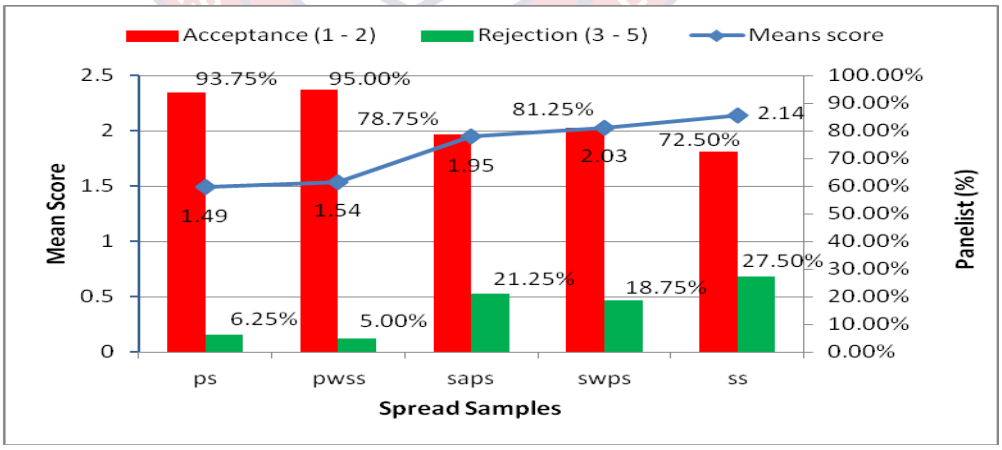

Figure 28: Overall Acceptability of Spread Samples

Source: Researcher's production

From figure 28 bars in red stand for percentage of respondents who preferred/accepted the spread samples (scores from 1 to 2) including the control and these were higher as compared to the bars in green which stand for percentage rejection from panelist (scores from 3 to 5). The rejections did not exceed 27.5% of the panelist with SS, SAPS and SWPS having high rejection percentages. Beside the control, PWSS, SWPS and SAPS had the highest percentage of panelist who preferred them with values of 95%, 81.25% and 78.75%. The line in blue depict the mean scored for the spread samples. PWSS and SAPS had means (1.54±0.64 and 1.95±0.84) within the acceptable limits of not more than 2 even though PWSS was found not to be significantly different ($p>0.05$) from the control whiles SAPS was significantly different ($p<0.05$) from the control. SWPS had a high percentage (81.25%) of panelist rating it high but its total mean score (2.03±0.83) was however more that the acceptable level of 2. SS had the list percentage (72.50%) of panelist scoring it favourably and also had the highest mean (2.14±0.88) score outside the approval limit. The two were also found to be significantly different from the control.

Therefore, based on this data, samples PWSS and SAPS were determined to be the preferred newly developed spreads samples beside the control. It was observed that the two samples were the most closest to the control as they had the highest proportion of peanut in them. PWSS had 75% of its content being peanut whiles SAPS had 50% of its content being peanut. All other samples had less than 50% of their content being peanut. Based on information from the findings the two spread samples can easily be promoted for domestic production and consumption or could be produced for commercial purposes.

Nutritional properties of Selected Spreads

The nutritional properties of the preferred spreads are summarized in table 30 with their ranks on those nutrients.

Table 30: Nutritional properties of Selected Spreads

	Spread			
Particulars	PWSS		SAPS	
Composition:				
Peanut	75%		50%	
Sesame seed	25%		50%	
Nutritional Composition:				
	Content	Rank	Content	Rank
Moisture (%)	3.61	5	7.82	1
Protein (%)	19.44	2	18.92	3
Fat/Oil (%)	21.96	4	23.48	3
Carbohydrate (%)	50.95	1	50.02	2
Calcium (%)	1.24	1	1.12	4
Magnesium (%)	0.17	4	0.23	1
Ash (%)	3.26	4	4.14	3
Fibre (%)	4.40	2	3.45	4
Potassium (ug/g)	5,330.34	2	4,978.72	3
Sodium (ug/g)	1,558.63	5	2,660.58	3
Phosphorus (ug/g)	5,402.00	5	5,665.76	4
Iron (ug/g)	1,175.60	1	726.91	4
Copper (ug/g)	46.83	5	210.14	3
Zinc (ug/g)	89.57	3	63.67	5

Mean Scores of Selected Spreads on Product Attributes

Source: Researcher's production

Out of the five spreads studied, PWSS was ranked first in carbohydrates, calcium, and iron. It had the least moisture content which will be beneficial in the preservation of the product. The spread similarly had lower fat/oil content with only the control sample having the least fat/oil content than it. This could be a unique selling point for the sample if it's consumption is to be promoted. It however had the least content of sodium, phosphorus and copper and was therefore rank fifth for these nutrients.

SAPS appear to be an average product with average proportions of nutrients as determined from the study. It was only ranked first for magnesium but also had the highest moisture content and least amount of zinc. The moisture content of the sample would have an adverse effect on the preservation of the sample.

Table 31 summarizes the mean scores of the selected products and how they were ranked on those attributes. PWSS ranked second after the control (PS) on attributes such as taste, texture, aroma and overall acceptability. The lowest ranking received by the product was on appearance where it came third after PS and SS. Similarly, SAP was ranked third after PS and PWSS on taste, texture, aroma and overall acceptability. It was ranked fourth on appearance after PS, SS and PWSS.

Table 31: Mean Scores of Selected Spreads on Product Attributes

	Spread			
Particulars	PWSS		SAPS	
Composition:				
Peanut	75%		50%	
Sesame seed	25%		50%	
Mean scores:				
	Content	Rank	Content	Rank
Appearance	1.65	3	1.74	4
Taste	1.56	2	1.59	3
Texture	1.83	2	1.88	3
Aroma	1.53	2	1.76	3
Overall Acceptability	1.54	2	1.95	3

Source: Researcher's production

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter summarizes the entire research work considering the outcomes of the study relative to set objectives. It also presents conclusions drawn from the study and gives recommendations.

Summary

This research was undertaken with the view to investigate, innovate and develop a healthy, nutritious and easy accessible spread from sesame seed with different inclusion ratios of peanut. This led to the development of four spreads with different proportions of sesame and peanut. Proximate analysis and sensory evaluation was conducted on the four (4) developed sesame spreads, being SS, SWPS, SAPS, PWSS alongside a control (PS). Food attributes such as taste, texture, flavor/aroma, appearance and overall acceptability were examined. Laboratory testing of the following nutrients; protein, calcium, carbohydrate, crude fiber, fats, magnesium, zinc, potassium, sodium, iron, copper and ash were carried out on the different samples of sesame spread as well.

Analysis of Variance (ANOVA) was used to determine whether there was significant difference between peanut spread and the newly developed spread. Significance was accepted at $p \leq 0.05$ with multiple omparisons through post hoc testing done with Tukey (HSD). The statistical software XLSTAT was employed the analysis. The means for the various spreads ranged from a minimum of 1.49 to 2.14.

Conclusion

This study showed that spread can be developed from sesame seeds with different inclusion ratios of peanuts. The spreads developed had similar qualities as peanut spread. All samples contained high amounts of essential nutrients. The concentration of nutrients were measured between 92.18 – 96.39% dry matter, 3.61 – 7.82% moisture, 17.21 – 24.62% protein, 21.14 – 44.69% fat/oil, 1.07 – 1.24% calcium and 31.07 – 50.95% carbohydrates. Other mineral had concentrations between 4,170.69 – 5,537.79ug potassium, 1,558.63 – 3,215.25ug sodium, 5402.00 – 7,677.18ug phosphorous, 624.72 - 1,175.60ug iron, 46.83 – 289.40ug copper, 63.67 – 1,116.37ug zinc, and 0.23 – 0.10% magnesium. The study also established that beside the peanut spread (control), which is already an established product in the market, panelist preferred PWSS (75% peanut, 25% sesame) and SAPS (50% peanut, 50% sesame).

A p-value of <0.0001 was determined from ANOVA testing of overall acceptability for spreads indication a significant difference in consumers' preference for at least two of the spread samples.

The control (PS) was the most accepted spread followed by PWSS with mean scores of 1.40±0.66 and 1.54±0.64 respectively. These obtained an average score below the threshold of not more than 2 point set for acceptability on the hedonic scale used. The two were also found not to be significantly different from each other.

SAPS was the third product accepted by panelist with a mean of 1.95±0.84. It was however determined to be significantly different from PS and PWSS but not significantly different from SS (2.14±0.88) and SWPS

(2.03±0.83). SS and SWPS recorded means above the benchmark of 2 but below 3. This means consumers did not show outright dislike for the two products but were simply indifferent towards them.

It was established from the analysis that acceptability of the spreads to consumers declined as the proportion of the sesame in them increased. This could be attributed to the fact that peanut spread is the commonest seed/nut spread consumed in Ghana. As such panelist for the study would have been familiar with the control and felt comfortable with spread samples that were closer to the control resulting in strong acceptance for those samples.

This result is similar to a study by Dubost et al., (2003) in which the researcher developed three formulations of peanut soy spreads and used commercial peanut butter and commercial soy nut butter as control. The commercial peanut butter and peanut soy spread with the least soy content were the most acceptable products while the other products received an average scoring.

McDermott (1990), underscored this when he indicated that frequent product users score product liking or acceptance differently than infrequent or non-users. Raynor and Wing (2006) stated that non-users of certain product may experience neophobia, a condition in which consumption of novel foods is avoided, perhaps decreasing hedonic ratings due to unfamiliarity.

In terms of nutritional composition, PWSS was ranked first in carbohydrates, calcium, and iron out of the five spreads studied. It had the least moisture content which will be beneficial in the preservation of the product. It similarly had lower fat/oil content with only the control sample having the least fat/oil content than it. PWSS however had the least content of sodium, phosphorus and copper and was therefore rank fifth for these nutrients. SAPS also had an average nutritional composition which are essential to humans as compared to the other samples.

Recommendations

Sesame spread has been shown to have excellent nutritional, physical, chemical and functional properties. Thus, it may be promoted as a substitute for high diary fat based spreads in the country such as margarines and butters in our food. Doing this will go a long way to promote the consumption of healthy diet among Ghanaians.

This research focused on the consumer acceptability of spreads produced from sesame seeds with different inclusion ratio of peanuts. Since the study results showed that samples with high percentage of sesame were liked moderately, further studies should look at incorporating the sesame seed into different food matrices as bread, candies, cookies or biscuits and other products to assess consumer liking of these products.

In this study, the sesame seeds were dehulled to improve the appearance of the spreads and masks the bitter taste by removing most of the oxalic acid and fiber found in the seed coats. It is recommended that further studies be conducted on the oxalic acid content in the seed to establish ways eliminating the acid without dehulling it since other studies shown that the hull is high in fiber and calcium (Akbulut, 2008).

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APPENDICES

APPENDIX A

SENSORY EVALUATION QUESTIONNAIRE

Sensory Evaluation of Sesame spread produced from sesame seed and peanuts

Date…………………………. No……………………………

Sex…………………………… Age…………………………..

Spread each of the coded spread samples on the bread provided and complete the questioner

based on appearance, taste, texture, aroma and overall acceptability using the scale below. Put the appropriate code against each attribute.

QUESTIONNAIRE:

Please score each product from the scale of 1 to 5 by writing the appropriate number against each attribute.

1- Like very much

2- Like moderately

3- Neither like nor dislike

4- Dislike moderately

5- Dislike very much

Please wash your mouth with the water provided before and after analyzing each sample.

	Attributes				
Coded Sample	Appearance	Taste	Texture	Aroma	Over all Acceptability
ss					
swps					
saps					
pwss					
ps					

Comment:

……………………………………………………………………………………

……………………………………………………………………………………

………………………………………………………………………………….

INFORMED CONSENT FORM

Consent forms for participating in sensory evaluation of spread produced from sesame seed and peanuts.

I am investigating the sensory qualities of spread produced from sesame with different inclusion ratio of peanuts. This product will help maximize the consumption of sesame seed which is healthy and nutritious for people of all walks of life and ages. Responding to the questionnaire will take about 20 minutes of your time. The following is a list of ingredients in the spread: sesame, peanuts, honey, salt and soybeans oil.

Should you be allergic to any of the above ingredients; please do not volunteer for this study.

If you agree to participate in this study please sign the consent form provided. Confidentiality and anonymity is assured. Your participation in this study is voluntary and do not hesitate to withdraw anytime you decide to. If you have any questions regarding this study, please contact:

HICKMATU SULEMANA 0279617404 OR 0557174455

I have read / someone have read and explained to me the information presented above and voluntarily agree to participate in this study.

…………………………………… ………………………………

Participant's signature/ thumbprint Date

APPENDIX B

CONSENT FORM FOR DISCUSSION

Discussion and Evaluation of spread produced from sesame seed and peanuts.

Participant identification number…………………………..

Study Reference number………..…………………………..…

	Yes/NO
I have read and understand the participant information and have had answers to my questions that I am happy with.	
I understand that what I talk about in the discussion will be kept strictly confidential.	
I understand that I have free choice of whether to take part or not.	
If I withdraw from the study, I understand that any data collected from me up to this point will be kept safe and anonymous.	
I understand that I have the right to refuse to answer any question or discuss any topic that I do not want to talk about.	
I give my permission for the interview/discussion to be audio-recorded and pictures. I also understand that the audio-recording and pictures taking will be destroyed at the end of the project and the transcript will be archived.	
I agree to take part in the discussion.	

……………………	…...………………..	………..……………
Name of researcher	Date	Signature/thumbprint

……………………	………………………	...……….……………
Name of participant	Date	Signature/thumbprint

Title: ***Promoting the consumption of sesame seed through the production of sesame spread***.

Principal Investigator: HICKMATU SULEMANA

Address: C/O Bogoso Methodist J.H.S

Post office box 34

BogosoW/R

APPENDIX C

VOLUNTEER AGREEMENT

The above document describing the benefits, risks and procedures for the research title (***Promoting the consumption of sesame seed through the production of sesame spread***) has been read and explained to me. I have been given an opportunity to have any questions about the research answered to my satisfaction. I agree to participate as a volunteer.

________________________ __________________________________

Date Name and signature or mark of volunteer

If volunteers cannot read the form themselves, a witness must sign here:

I was present while the benefits, risks and procedures were read to the volunteer. All questions were answered and the volunteer has agreed to take part in the research.

________________________ ______________________________________

Date Name and signature of witness

I certify that the nature and purpose, the potential benefits, and possible risks associated with

Participating in this research has been explained to the above individual.

____________________ ____

Date Name Signature of Person Who Obtained Consent

APPENDIX D

ETHICAL CLEARANCE

UNIVERSITY OF CAPE COAST

INSTITUTIONAL REVIEW BOARD SECRETARIAT

TEL: 0558093143 / 0508878309/ 0244207814
E-MAIL: irb@ucc.edu.gh
OUR REF: UCC/IRB/A/2016/747
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0009096

C/O Directorate of Research, Innovation and Consultancy

20TH JULY, 2020

Ms. Hickmatu Sulemana
Department of Vocational and Technical Education
University of Cape Coast

Dear Ms. Sulemana,

ETHICAL CLEARANCE – ID (UCCIRB/CES/2020/24)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted **Provisional Approval** for the implementation of your research protocol **Promoting the Consumption of Sesame Seed Through the Production of Sesame Spread.** This approval is valid from 20th July, 2020 to 19th July, 2021. You may apply for a renewal subject to submission of all the required documents that will be prescribed by the UCCIRB.
Please note that any modification to the project must be submitted to the UCCIRB for review and approval before its implementation. You are required to submit 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,

Samuel Asiedu Owusu, PhD
UCCIRB Administrator

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST