AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

ASSESSING THE POTENTIAL USAGE OF CUCURBITA MOSCHATA IN THE PRODUCTION OF BREAD

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JANUARY, 2023

DECLARATION

STUDENT DECLARATION

I, IRENE ASHLEY, declare that this dissertation, except quotation and references contained in published works have been identified and duly acknowledged, is entirely my original work, and it has not been submitted, wither in part o whole, for another degree elsewhere.

SIGNATURE: …………………………………………

DATE:…………………..………………………………...

SUPERVISOR DECLARATION

I hereby declare that the preparation and presentation of this thesis work were supervised by the guidelines and supervision of the dissertation as laid down by the University of Education, Winneba.

MAIN SUPERVISOR: **DR. GILBERT OWIAH SAMPSON**

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DATE:…………………..………………………………...

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DEDICATION

This work is dedicated to the Almighty God who has taken me through this work successfully.

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ABBREVIATIONS

ANOVA	Analysis of Variance
DMRT	Duncan’s Multiple Range Test
EDAIF	Export Development and Agricultural Investment Fund
HCl	Hydrochloric acid
OAC	Oil Absorption Capacity
RDA	Recommended Daily Allowance
SC	Swelling Capacity
SI	Swelling Index
UK	United Kingdom
USA	United States of America
µm	microns
WAC	Water Absorption Capacity
WHO	World Health Organisation

ABSTRACT

There has been a tremendous rise in the prices of bread recently following the scarcity of wheat flour as results of the Russia-Ukraine war. *Cucurbita moschata* (butternut squash) is a versatile fruity vegetable which is grown both locally and internationally. Despite the nutritional and health benefits of *Cucurbita moschata* and being a potential candidate for flour production, there is little to no awareness and assessment of introducing *Cucurbita moschata* flour into bread production. Therefore, this work aimed to assess the potential usage of *Cucurbita moschata* in bread preparation. Other ingredients (eggs, salt, sugar, yeast, butter, and milk were purchased in a supermarket at the Kumasi Asafo market. Approximately 125 kg samples of *Cucurbita moschata* were obtained from the Kumasi Central Market in the Ashanti region of Ghana and was dehydrated and passed through a 63 µm (microns) sized-sieve to obtain butternut squash flour. Proximate composition, functional properties, colour and yield determination of *Cucurbita moschata* were analysed on dry-weight basis. The sensory attributes of the various bread formulations were analysed by 50 untrained panellists. Proximate composition of butternut squash flour was determined prior to the bread making which showed 8.23% moisture, 1.53% crude fat, 5.54% crude fibre, 6.90% ash, 11.90% protein, and 65.9% carbohydrate with energy of 324.4 Kcal. Functional properties of the flour showed 2.59 g/g of water absorption capacity, 1.26 g/g of oil absorption capacity, 3.43 g/g of swelling power and 17.24 g/g of solubility. Results from the sensory analysis showed that the composite bread samples had a significant ($p<0.05$) higher acceptance over the control for all the sensory parameters tested for. The B2 (20:80) bread formulation had the best overall acceptability as well as preferred in terms of the aftertaste which were all significantly ($p<0.05$) different from the other bread samples. The results showed that the participants really preferred the composite bread samples over the control sample. The findings indicate that *Cucurbita moschata* flour could be used to produce acceptable bread.

CHAPTER ONE

INTRODUCTION

1.1. Background to the Study

Nutrients are compounds that give food to organisms so they can live, grow, and reproduce (Bourre, 2006). Humans primarily require carbs, protein, fats, vitamins, minerals, and water for basic body functions. Animal and plant-based sources can both provide these nutrients. Consuming functional foods like fruits and vegetables can help avoid cancer, diabetes, obesity, heart disease, and other chronic illnesses. (Głąbska et al., 2020). In recent times, exploration of the vegetational flora has led to the discovery of new species and varieties of vegetables which have proved to be beneficial to human health. This can be ascribed to the presence of phytochemicals that are responsible for such benefits (Teng et al., 2021). One such plant is *Cucurbita moschata* which is thought to begin in Southern Mexico and spread to Central America (Shah & Feldman, 2022).

A fruit or vegetable in the Cucurbitaceae family, butternut pumpkin is also known by the scientific name *Cucurbita moschata*. Like other plants in the Cucurbitaceae family of vegetable plants, which also includes pumpkin, cucumber, and cantaloupes, it is a swiftly growing vine that emerges from the earth. It has high levels of vitamins A, C, B6, and E. Additionally, it provides 63 kcal of energy and minerals including potassium, magnesium, salt, and calcium, all of which are crucial for maintaining regular bodily functions. Vegetable is also known to produce a sizable amount of protein, iron, nutritional fibre, and carbohydrates. (Men et al., 2021).

Cucurbita moschata is a versatile vegetable that also has decorative or aesthetic uses. plant. Its sizes, shapes, patterns, and radiating colours are responsible for its usage for ornamental purposes. The health benefits include its antioxidant, anti-inflammatory, and anticancer effects. It's also known to reduce fatigue and contribute to building stronger bones (Ponce et al., 2008).

The health benefits of the plant could be well exploited when incorporated into food systems. Bread is a common food item that is easily accessible and enjoyed by many people in Ghana and other nations. Control of the production and distribution of bread has been used as a means of exercising political influence over the populace for at least the last two millennia (Mondal & Datta, 2008). Its preparation is relatively easier and requires mainly water and flour for its preparation. Successful incorporation of *Cucurbita moschata* into bread production would expand its acceptance (Mondal & Datta, 2008).

Due to the global trend in this industry, Ghana just began producing and exporting cucurbits. Investment in *Cucurbita moschata* in Ghana has increased because of the increased demand for cucurbits both domestically and globally.(Messelink et al., 2020). Cucurbit investment and production have grown in popularity in Ghana. Cucurbit production and cultivation are possible in Ghana in all seasons. Other varieties of squash can even endure dry spells or periods when the soil moisture level is low (Messelink et al., 2020). The Export Development and Agricultural Investment Fund (EDAIF) and Ghana's Export Promotion Council worked together to promote *Cucurbita moschata* as a new export good from Ghana as part of their given duty (Whitaker, 2019).

1.2. Statement of the Problem

A fruity vegetable with several uses, *Cucurbita moschata* is planted both domestically and abroad (Whitaker, 2019). Though it is a rich source of vitamins and minerals and has been used for generations in Europe and Asia, its nutritional benefits have not been fully utilized in Ghana. This is because most people are oblivious to its nutritional and health benefits and as such neglect its use as food. However, the plant contains numerous nutrients which could be beneficial to Ghanaians regarding health and cost. Second, because bread is a significant staple food in Ghana, the amount of wheat flour imported and the associated prices have grown, placing a strain on the nation's meagre financial resources.

For instance, the annual cost of importing wheat flour into Ghana is about US$117 million (Komlaga et al., 2012). Because wheat flour is the only primary raw material used by the majority of the nation's baking sectors, demand for it tends to outstrip supply, which drives up the price of essential raw materials (wheat). Additionally, the high tariffs on wheat importation that are ultimately passed on to customers and bakery companies raise the price of pure wheat bread. (Owusu et al., 2017). Therefore, it's important to raise knowledge of the possible use of *Cucurbita moschata* flour in bread making. This will exhibit the versatility of its usage thereby articulating its substantial usage.

1.3. Main Objective

To assess the potential usage of *Cucurbita moschata* in bread preparation.

1.4. Specific Objectives

1. To quantify the flour yield from *Cucurbita moschata*
2. To determine the proximate composition of *Cucurbita moschata* flour
3. To determine the functional properties of the flour obtained from *Cucurbita moschata*
4. To determine the consumer acceptability of bread prepared from composite *Cucurbita moschata* flour
5. To determine the proximate composition of the overall accepted composite prepared bread

1.5. Significance of the Study

In the majority of Ghanaian houses, *Cucurbita moschata* is rarely utilized. The tiny minority of people who eat it also substitute it for other veggies when their favourite vegetables aren't available. The use of *Cucurbita moschata*, which is a great source of vitamin A and carotenoids, may improve consumers' ocular health. Although many fruits and vegetables contain vitamin C, it has been found to deteriorate when exposed to heat and oxygen in the air.

However, compared to other vegetables, *Cucurbita moschata* retains an extremely high amount of vitamin C after cooking, which distinguishes it from other vegetables (Mondal et al., 2020). These qualities, along with others, emphasize how crucial it is to promote the usefulness of this significant vegetable. A food that is being thought about for inclusion should be particularly well-liked and well-known by customers to increase its consumption. *Cucurbita moschata* is made more convenient by being added to foods like cakes, smoothies, and bread and by being processed into a powder. This convenience will not only expand its consumption but will also improve its nutritious qualities. Also, with the high cost of wheat flour (over US$117 million is spent annually) observed over an ever-demanding generation in hard economic times, it is necessary to investigate alternative sources of flour for bread production because it is a staple food in Ghana (Komlaga et al., 2012). Hence, *Cucurbita moschata* if well incorporated into making bread using its flour, would reduce the demand for wheat flour and alleviate the high-cost burdens imposed on importers. Also, the export of it could generate some funds for local farmers and the government

CHAPTER TWO

LITERATURE REVIEW

2.1. Nutrients

An organism needs nutrition to survive, develop, and procreate. Nutrients must be consumed by all living things, including plants, animals, fungi, and protists. Nutrients can enter cells for metabolic purposes or can be ejected out of cells to create non-cellular structures like hair, scales, feathers, or exoskeletons.

Some nutrients, like proteins, lipids, and products of fermentation (like ethanol or vinegar), can undergo metabolic changes into smaller molecules in the process of creating energy, which ultimately leads to the production of water and carbon dioxide (Kirkby, 2011). Examples of nutrients include carbohydrates, proteins, fats, vitamins, minerals among others.

The dietary intake of nutrients is primarily obtained through food. These nutrients are usually obtained from plants and animals. Carbohydrates which are the main energy-providing nutrient are mainly obtained from plants. Proteins required to repair and build body tissues are obtained from both plants (beans, sorghum, etc.) and animals (eggs, meat, etc.). Vitamins and minerals likewise are obtained from plants (fruits, vegetables, etc.) and animals as well as fats and oils.

Fruits and vegetables, aside from their provision of nutrients such as vitamins, and minerals among others also function as roughages that cleanse the colon and ensure a healthy digestive system. Their importance even in health cannot be overemphasized as they are known for their antioxidant (Hidalgo & Almajano, 2017), anti-inflammatory (Zhu et al., 2018), anticancer (Iqbal et al., 2017), antimalarial (Amponsah et al., 2012;

Baah et al., 2020), antimicrobial (Aziz & Karboune, 2018), etc. properties. As such, their incorporation into foods is a major deserving practice in many countries. Nutrients function to provide energy to humans, build and repair body tissues, promote digestion, and maintain a healthy body among others. These nutrients also sometimes are responsible for the treatment/management of diseases in humans (Ahmad et al., 2014; Iqbal et al., 2017).

2.2. Bread Making

Food is a basic need of all organisms. Primarily, they obtain their energy to carry out all life processes from food. Hence, different types of food vary from one culture to another. One example of a type of food that can be found in a majority of cultures is bread.

Wheat- and the water-based dough is used to make bread, which is then typically baked. It has played a significant role in many cultures' diets all around the world and throughout recorded history.

It is one of the oldest foods produced by humans, having been important since the beginning of agriculture, and it is a crucial part of both secular and religious rites. The ability of wheat proteins to produce gluten and bakers' innovation in modifying the gluten structures generated in the dough led to the development of numerous types of bread. The manufacture of bread and all fermented foods depends heavily on the flexible gluten mass because of its versatility in deforming, stretching, recovering from shape changes, and trapping gases. Among all cereals, wheat is essentially unique in this regard.

Because the term "bread" is used to refer to a wide range of commodities with varied sizes, forms, textures, crusts, colours, softness, eating characteristics, and flavours, the descriptors "great" or "bad" quality frequently only mean what the person making the assessment thinks they mean. (Cauvain, 2007).

2.2.1. Quality of bread

Even if there are as many varied opinions about what constitutes "great" bread as there are bakers and consumers, it is nevertheless true that certain quality traits are required for various bread types to be preferred by the majority of people.

The quality of the bread is influenced by the complex interactions between the raw components, their qualities and proportions utilized in the recipe, and the method used to produce the dough. As a result, it is impossible to pinpoint a single aspect of breadmaking as the factor that will determine the quality of the bread (Cauvain, 2012). The sensory evaluation of bread's appearance, surface, crust, porosity, texture, crumb, taste, and flavour, as well as proximate analyses of its moisture content, crude fat, crude protein, crude fibre, ash, and crude carbohydrate determinations, as well as functional evaluations of its water and oil absorption capacities, solubility index, and swelling power, are some of the quality tests done on it (Feldsine et al., 2002). The following are some of the crucial ingredients that affect bread quality.

2.2.1.1.Flour

Given that the production of gluten is a crucial step in the production of bread and that wheat is the source of the proteins required for its development, it is obvious that a sizeable amount of the quality of the completed loaf comes from wheat via the flour from the mill. The type of wheat, agricultural practices, environmental factors, and milling techniques all have a significant impact on the quantity and quality of the gluten-forming proteins. In general, the more protein there is in the wheat, the more protein there is in the flour generated from it, and the more protein there is in the flour, the better the flour's ability to trap and retain carbon dioxide gas, and the more bread it will yield (Cauvain & Young, 2009).

2.2.1.2.Yeast

Numerous types of baker's yeast (Saccharomyces cerevisiae) are available (Williams & Pullen, 2007). About 28–30% of compressed yeast is made up of dry materials. The other two main types of yeast are dry yeast and cream or pumpable yeast, which are both typically employed in smaller bakeries in warmer areas, respectively. The yeast produces carbon dioxide gas at every stage of the dough's processing, especially during proof and the initial few minutes of baking, which causes the dough to expand (Cauvain, 2012).

2.2.1.3. Salt (sodium chloride)

Salt's primary role in bread dough is to impart flavour, but it also inhibits the development of gluten during mixing. The impact is minimal in high-speed mixing systems, but it grows as the mixer speed decreases. To provide more precise measurements and assure quick dissolution, many plant bakeries now add the salt via a brine system. As a result of recent tendencies to reduce salt levels in the UK and internationally, more focus has been placed on the role that salt plays in influencing the quality of dough and bread. (Cauvain, 2007).

2.2.1.4. Sugar (sucrose)

Basic bread is often made with little to no sugar in the UK and many other nations, although the sponge and dough bread made in the USA may contain as much as 6% flour by weight. Up to 15% of the sugar in rolls and other tiny fermented goods comes from sugar. Despite being ultimately fermentable, high sugar concentrations inhibit yeast activity. Sugars are used in modern bread making to increase product sweetness and crust colour. In bread recipes, high fructose corn syrups and dextrose can be used in place of or in addition to sucrose (Cauvain, 2012).

2.2.1.5. Fat

Compound bakery fats (combinations of oil and solid fat at a specific temperature) are widely used to increase the gas retention of dough and, as a result, increase volume and softness. The amount will vary depending on the type of flour used, with wholemeal flour typically requiring two to three times as much fat as white flour (Williams & Pullen, 2007). It has become more popular recently to use fractionated or inter-esterified oils instead of partially or fully hydrogenated fats. These oils are thought to be more palatable in terms of human nutritional needs even if they perform similarly to the more conventional compound bakery shortenings (Cauvain, 2012).

2.2.1.6.Water

Depending on the amount of water, the dough's characteristics will change. If it is too little, the dough will be firm and challenging to shape, resulting in small-volume loaves with unappealing crusts (Cauvain & Young, 2009). Too much dough will result in a mushy, difficult-to-mould dough that will flow in the prover and produce bread of inferior quality. The "optimum" amount of water is the most that can be added to the dough while still allowing us to shape the pieces and produce bread with acceptable quality (Cauvain, 2012).

2.2.2. Incorporation of actives into bread

Since the rate of population expansion and climate change mean that there isn't enough food for everyone, it is vital to locate and utilise neglected and underutilized plant species for food production (Konadu et al., 2021). The high demands of meeting the nutritional and dietary requirements in food have enlightened product manufacturers on the potential usage of products such as bread, cake, and muffins among others as vehicle carriers of active ingredients in plants (Kolawole et al., 2013). The encouragement of higher fruit and vegetable intake is also motivated by the need for the world to transition to diets with reduced carbon footprints that include fruits and vegetables (Amoah et al., 2022).

Kolawole et al., (2013) added the leaves of Moringa oleifera to cakes to improve their nutritional and dietary composition in response to children's and teenagers' love of sweets. Three different kinds of organic butternut squash flour were produced by Mahmoud & Omur A. Mehder, (2022) to investigate their effects on the creation of some oat-gluten-free items. De Escalada Pla et al., (2013) employed the fibres from *Cucurbita moscahata* to evaluate the impacts of bread production, its quality, and staling.

In the incorporation of various plant and their products to meet nutritional and dietary requirements, these products could be added as chemical additives which is a future possibility in bread production (Cauvain, 2012). The actives could also be utilized as flour for bread production. In this instance, not only does it provide nutritional and dietary supplements, but it also provides an alternative source of flour acquisition which could meet the upsurge demands of flour in the baking industry. The conventional flour mostly employed in bread production is wheat flour. However, the writers of (Roshana, 2020) used sweet potato flour instead of wheat flour to make muffins. The results showed that the content of moisture, ash, fibre, vitamin A, and calcium increased while the level of fat, protein, iron, and phosphorus decreased as the percentage of sweet potato flour increased from 0 to 50%. The total antioxidant capacity rose from 542.2 to 786.4 mg AA/100 g after the amount of sweet potato flour was raised from 0% to 50%. A muffin's capacity decreased as sweet potato flour substitution increased, going from 105.3 cm3 to 91.9 cm3, while its weight increased, going from 87.12 g to 96.36 g. The sensory evaluation revealed that the treatments differed significantly ($p<0.05$) in terms of colour, texture, taste, scent, and general acceptance. As a result, employing sweet potato flour has improved functional, immediate, aesthetic, and health qualities. This point is re-emphasized from the work by Kolawole et al., (2013) and Mahmoud & Omur A. Mehder, (2022).

In regards to the incorporation of actives into bread which is usually labelled as functional ingredients, various studies have reported its significance and necessity. Such studies include bread supplementation with the flour from the fruit of doum (*Hyphaene thebaica* L.) (Aboshora et al., 2015), *Garcinia mangostana* pericarp (Ibrahim et al., 2015), baobab fruit (Coe et al., 2013), saskatoon berry (Lachowicz et al., 2021) among others which resulted in enhanced concentrations of polyphenols (Coe et al., 2013), total phenolic and flavonoid content of the supplemented bread (Aboshora et al., 2015).

2.2.3. Functional properties of foods and flours

Functional properties are the fundamental physicochemical characteristics of meals that represent the intricate relationships between food component composition, structure, and molecular conformation as well as the context in which these characteristics are measured and correlated (Chandra & Samsher, 2013). To demonstrate whether novel proteins, fats, carbohydrates (starch and sugars), and fibres can be used to stimulate or replace conventional proteins, fats, carbohydrates (starch and sugars), and fibres in specific food systems, as well as to predict and precisely evaluate how they may behave in those systems, functional characteristics are required (Chandra & Samsher, 2013; Siddiq et al., 2009). Functional properties include things like swelling, water and oil absorption, foam stability and capacity, gelatinization, bulk density, dextrinization, preservation, denaturation, coagulation, gluten formation, jelling, shortening, plasticity, flakiness, moisture retention, aeration, and sensory attributes.

2.2.3.1.Water absorption capacity (water hydration or water absorption)

The water absorption capacity (WAC), also known as water absorption, is the amount of water (moisture) that food or flour can absorb to reach the necessary consistency and generate high-quality food items.

The threshold amount is the appropriate quantity of water to add to a dough before it becomes too sticky to handle. Water absorption may lower the quality of food products if it is either excessively low or excessive. The weight of the food or flour is often used to describe how much water is absorbed. When the water absorption is 60%, for instance, 100 pounds of flour are hydrated with 60 pounds of water. (Godswill et al., 2019). The glutenin and gliadin proteins, along with the damaged starch and other water and flour are combined to hydrate the components. When the molecules of protein and starch engage hydrophilically and form hydrogen bonds with the molecules of water, the process of hydration is accomplished. Particles hydrate by rubbing up against one another and coming into contact with water molecules It is necessary to use process variables including pressure, beating arm, water flow, and mixer type. To expose new layers of particles to add water and continue the water diffusion process. Water absorption levels in a basic white bread recipe typically range from 60–62% to 80–90% to 50–54% in a cookie recipe. Any increase in the flour's enzyme activity when using sprouted flour will enhance the food's ability to absorb water and start the Maillard reaction. The ability to absorb water is a crucial functional requirement for foods, especially ones that involve handling the dough.

The granular structure's weak associative forces and the tenuous connection between amylopectin and amylose in the starch granules may affect WAC (Iwe et al., 2016).

2.2.3.2.Oil absorption capacity (Oil absorption)

The oil absorption capacity (OAC), often referred to as water absorption, is the capacity of proteins' non-polar side chains to bind fat. The ability to absorb oil is a crucial functional trait that helps improve mouth feel and preserve flavour of food products (Iwe et al., 2016). Foods with a high protein content absorb oil at a very rapid rate. The structure, amino acid makeup, and surface polarity or hydrophobicity of a protein are its intrinsic properties that determine its ability to attach to both oil and water in food (Chandra & Samsher, 2013). Flours are excellent in food applications when the best oil absorption is needed because of their capacity to combine with oil. They could therefore help make foods like croissants and sausage. The flour's capacity to absorb oil when used in food preparation also qualifies it for use in enhancing flavour and mouth feel. These characteristics make wheat with a good OAC an advantageous addition to foods like sausages, whipped toppings, angel food and sponge cakes, chiffon desserts, etc. (Chandra & Samsher, 2013). The existence of more non-polar side chains, which may bond the oil hydrocarbon side chains in meals and flours, is one explanation for the potential rise in the OAC of flours. The structural interactions of meals may benefit from flours with high OAC, especially for improving palatability, extending shelf life, and retaining flavour, especially in meat or bread goods where fat absorption is desired. (Chandra et al., 2015).

2.2.3.3.Swelling capacity (swelling index or swelling power)

The amount, expressed in millilitres, that is occupied by the swelling of one gram (1 g) of food material under particular circumstances is known as the swelling index (SI), also known as swelling capacity (SC). Each different food source's test protocol specifies whether water or an agent that causes swelling should be provided before making any conclusions (whole, pulverized, or cut). The swelling capacity shows the strength of the associative forces at work inside the starch granules and assesses the starch's capability to absorb water and swell. Some food products, including bread goods, have a swelling capacity (index) that is viewed as a sign of quality.

The ratio of -amylose to -amylopectin is affected by some factors, one of which is an indication of the non-covalent links between the molecules in the starch granules (Iwe et al., 2016). Particle size, species diversity, and the type of processing, or unit activities, all have an impact on the swelling capacity of flours (Chandra & Samsher, 2013). Meals and flours with a high starch content have a higher swelling capacity (index), especially when the starch has a higher branching amylopectin concentration. The glucose molecule chains known as amylose and amylopectin make up starch. While amylopectin is a branching chain, amylose is a linear chain. Granules are usual, which are incredibly tiny starch packets.

Depending on the plant's origin, different amounts and ratios of amylose and amylopectin can be found in starch. This explains why the swelling properties of various flours derived from various (plant) sources and species vary (Godswill et al., 2019).

2.2.3.4.Solubility

Solubility in the food system refers to a substance's capacity to dissolve in liquid, gaseous, or solid solvents. These substances are frequently referred to as solutes. Pressure, pH, temperature, the presence of other substances in the solution, as well as the chemical and physical properties of the solvent and solute, all have an impact on a material's solubility. When determining how much a food component, like flour, is soluble in a given solvent, the saturation concentration—the point at which the addition of more solute causes the surplus solute to precipitate instead of raising the concentration of the solution—is typically utilized. Lipid-rich foods (such as flour) have a decreased capacity to absorb water, which can affect how easily they swell and become soluble. (David et al., 2015). A meal's high solubility may be a sign of excellent digestion, which may imply that it is ideally suited for use as food and infant formula. If a food cannot dissolve in a liquid, gas, or solid solvent, it is regarded as insoluble.

The term "solubility" refers to how much flour may dissolve in a solution, frequently using water as the solvent. One of the functional features that are routinely studied while developing and examining a novel flour or flour composite is flour solubility.

It is necessary to identify the solubility of novel meals or their constituent parts as a useful feature. (Godswill et al., 2019). There are many different levels of solubility, ranging from slightly soluble, such as silver chloride in water, to indefinitely soluble (without limit, totally miscible) substances like ethyl alcohol in water. Insoluble is a term frequently used to describe substances with poor or very poor solubility. To describe the solubility range for a specific culinary use, additional adjectives are also utilized.

A food ingredient is particularly categorized as being insoluble if its solubility is less than 0.1 g per 100 ml of the solvent. (Clugston & Flemming, 2000).

2.3. Butternut Squash (*Cucurbita Moschata*)

2.3.1. Geographical distribution

Geographical distribution Since ancient times, *Cucurbita moschata* has been widely cultivated in numerous nations. The family Cucurbitaceae includes the genus Cucurbita. In South and Central America's warmer regions, butternut squash is the most widely grown variety of winter squash The majority of Africa's tropical nations, particularly Southern Africa, cultivate it. China is the world's leading producer of pumpkins, generating 8, 427, 68 tonnes annually, while Egypt is placed 14th with 406, 78 tonnes produced annually**.** (Mahmoud & Omur A. Mehder, 2022).

The fruit is frequently used to make desserts such as steaming meal flesh with grated coconut and sugar, pumpkin pie, and sweets. For extended preservation, ripe butternut flesh is dried in Zambia.

During the rainy season, butternut leaves are consumed daily as a relish by almost 40% of Zambian families. Butternut squash is mostly grown in Cameroon and other regions of Central and West Africa for its ripe seeds. There are numerous uses for seed oil in China and Thailand.

Butternut has recently been grown in Ghana's Northern, Volta, Upper East, and Upper West Regions mostly for export. They also sometimes blend it and use it in making soups, chewing it

2.3.2. Morphological description

A seasonal trailing plant with yellow blooms and lobed leaves, winter squash is also known as butternut pumpkin or butternut squash. When fully grown, the fruit features an edible seed and orange flesh. The squash plant's leaves and delicate shoots are among the many edible parts. Butternut squash yields 3-6 fruits per plant, weighing 2–5 kg each, and matures in 80–140 days. (Valdés Restrepo et al., 2014). Its flavour is comparable to that of a pumpkin—sweet and nutty.

It features orange meaty pulp with tan-yellow peel and a compartment of seeds at the blossom end. It grows richer, sweeter, and more intensely orange as it ripens. In addition to being a source of vitamin A, it is also an excellent source of fibre, vitamin C, magnesium, and potassium.

2.3.3. Varieties of Butternut Squash

There are numerous varieties of butternut squash. In terms of appearance and flavour, most cultivars only differ a little. There are two main categories of squash: Winter Squash: These tend to have a thicker skin and can be stored for quite a while (all through the winter). Summer Squash: These, on the other hand, have more tender skins and do not store for as long. Think zucchini and yellow squash.

Table 2.1: Varieties of butternut squash

Butternut Squash Varieties	Images	Brief Description
Rogosa Violina Gioia		This is an Italian heirloom variety that produces very large squash that averages 10+ pounds. It develops in around 95 days and has vines that extend 30 feet. The flesh is rich orange in colour, delicious, nutty, dry, and practically stringless. It has dumpy skin and an hourglass-like form.
Butter Boy Hybrid		This type yields squash that weighs 2 to 3 pounds and is pale orange. The 80-day-old fruit's soft flesh is vivid orange in colour and has a nutty, extremely sweet flavour. It is a plant of the vining variety and is suitable for traditional gardens.
Waltham Butternut		This is most likely the most popular type of butternut squash. It is an heirloom cultivar that grows on shorter plants and yields squash weighing 2 to 3 pounds. The sweet orange flesh is soft and string-free, matures in 85 days, and keeps extremely well.

Burpee's Butterbush		This type matures in 75 days, has compact plants that work well in containers or traditional gardens, squash weighing between one and two pounds, and has a sweet flavour and buttery texture.
Autumn Glow		This kind of butternut squash has stocky fruit that is 8 inches long on average and has golden yellow skin. The flesh is delicate and has a mildly sweet and nutty flavour. The compact plant is suitable for both container and traditional gardens.
Argonaut Hybrid		Large vining plants only found in traditional vegetable gardens, usually in warm climates with long growing seasons, produce very large fruits often weighing more than 20 pounds, are ready in 140 days, need a lot of space, are bright orange, and have the classic butternut shape, store well for several months, and have orange flesh that is tender and meaty, as well as squash that is very sweet and nutty.

Apollo		viral resistance that is intermediate. fruit with excellent consistency and yield potential. attractive Waltham shape that is elongated.
Atlas		The processing standard used by the industry. high. Potential yield. excellent storage capacity. good fruit consistency and size. matures in 90–105 days.
Barbara		Early butternut of the tropics. In terms of young vegetables, immature fruit is particularly appealing. robust, healthy vines with brown and dark green stripes. Plants have tremendous potential for output and are widely adaptable. Excellent fruit set that spans a long bearing period The tremendous vigor of the plants has been found to make them less prone to illnesses.
Cosmos		bush plant habit with vigor. Fruit of a very consistent size and shape. Early fruit harvesting and concentrated fruit set. matures in 80–100 days.

Pluto		outstanding yield potential. high fruit consistency a benchmark for the fresh market industry. excellent storage capacity.
Quantum		outstanding yield potential. tall fruit Uniformity. a new standard for the fresh market industry. excellent storage capacity. ideal for supermarkets and export
Titan		New types of processing. great potential yield. good storage capacity. Very homogeneous fruit quality. short, bulbous, cylindrical flower end
Veenas		The tiny fruit size and good homogeneity make them perfect for pre-packing for export. outstanding yield potential. possesses very good storage capacity.

(*Butternut Squash Lasagna*, 2011)

2.3.4. Nutritional and dietary constituents

Several studies have examined *Cucurbita moschata's* chemical makeup, including its moisture, protein, lipid, crude fibre as well as ash levels. The plant has been shown in various studies to have high amounts of pectin, mineral salts, carotene, vitamins, and other substances beneficial to human health (Jacobo-Valenzuela et al., 2011). *Cucurbita moschata* is a good source of vitamin A and its high contents of carotenoids particularly beta carotene and lutein both of which are known to be important nutritionally among other benefits (González et al., 2001).

Cucurbita moschata has also been shown to have significant amounts of phenolic compounds such as flavonoids known to have very good antioxidant activities (Vijaya et al., 2010).

2.3.5. Health benefits of butternut squash

Consuming butternut squash lowers the risk of diabetes, heart disease, and other chronic illnesses.

The leaves are traditionally used to cure burns, conjunctivitis, diarrhoea, and sore throats (Li, 2020; Mahmoud & Omur A. Mehder, 2022). More studies demonstrate that butternut consumption improves skin and vitality while reducing the chances of obesity, diabetes, heart disease, and death (Mashitoa et al., 2021). The potassium in butternut squash lowers the chance of dying from cardiovascular disease and all forms of strokes, as well as excessive blood pressure.

Butternut squash contains beta-carotene and other carotenoids that reduce the chance of developing asthma and colon cancer. The cucurbit's vitamin A content promotes healthy hair development and enhances skin colour.

The fruit and vegetable include vitamin C, which helps to preserve and develop collagen, which gives skin and hair structure. The cucurbit's dietary fibre reduces bodily inflammation, avoids constipation, and lowers cholesterol levels. Additionally, beta-carotene and vitamin C support the immune system. (Choi et al., 2020).

2.3.6. Incorporation of butternut squash into foods

The use of butternut squash as flour for incorporation into foods such as cakes, muffins, bread, etc. would ensure the absorption of its variety of health, nutritional and dietary benefits. In terms of yield, price, and quality, it might also be used as an additional source of flour, if not one that is superior.

For some oat gluten-free products, butternut squash peel, unpeeled pulp, and peel were all combined to create flour (muffins, cookies, and waffles). The scientists discovered that organic butternut squash flours were low in calories but high in vitamins, minerals, beta-carotene, and antioxidants. They concluded that their research will contribute to the advancement of understanding of and support for the utilization of butternut squash flour in the manufacture of gluten-free goods that can satisfy celiac disease patients' dietary requirements. (Mahmoud & Omur A. Mehder, 2022).

Additionally, the impact of several enriched fibre products made from butternut squash on bread production and quality (specific volume, crumb hardness, crumb, and crust colour), as well as bread shelf life, were studied. The use of butternut fractions at concentrations ranging from 5 to 15 g fibre per kilogram of wheat flour, according to the study's authors, is promising for improving bread texture after baking and throughout storage. (De Escalada Pla et al., 2013).

2.3.7. Economic significance of production with butternut squash

Due to the global trend in this industry, Ghana just began producing and exporting cucurbits. Investment in *Cucurbita moschata* in Ghana has increased because of the increased demand for cucurbits both domestically and globally. In Ghana, the buying and growing of cucumbers have become more common. In Ghana, cucurbit production and cultivation are possible all year long. Other types of cucurbits may even withstand times of drought or low soil moisture. (Messelink et al., 2020). *Cucurbita moschata* is being marketed as a fresh export good for Ghana by the Export Development and Agricultural Investment Fund (EDAIF) and the Export Promotion Council of Ghana. (Whitaker, 2019).

2.3.8. Other uses of butternut squash

Long used as a food source, butternut squash is now widely acknowledged as a useful vegetable. Steaming, soups and desserts are popular ways to serve butternut squash. Due to its medicinal and nutritional qualities, it is a required fruit (Mahmoud & Omur, 2022) Adding butternut squash to your meals is an excellent way of decreasing hunger and boosting your fibre intake. This vegetable/ fruit has other functional uses such as hydrating hair: If you have dry and dull hair, you need to moisturize it daily to keep it hydrated, shiny, and beautiful. A great way to do this is by adding pumpkins. You must make a butternut squash conditioner at home for this. Again, the component of the butternut squash that is used the most is the pulp, which may be used to produce preserves, beverages, pickles, desserts, and pastries. The fruit pulp is used in the treatment of enteritis, indigestion, and dyspepsia. The high fibre and polyphenol content of fruit peels may make food more nutrient-dense. These specifics make it clearer why butternut squash is utilized in a variety of foods (Batista et al., 2018). Butternut squash can be dried as a quick and simple seasoning adjustment. Make flour from dried butternut squash to extend its shelf life. It is applied to improve the nutritional value and aesthetics of baked goods (See et al., 2007). In addition to substituting cereal flour in baked goods like cookies, cakes, and bread, it is frequently used as a natural colorant in flour blends, sauces, soups, noodles, and seasonings.

CHAPTER THREE

MATERIALS AND METHODS

3.1. Source of Raw Materials

Cucurbita moschata was obtained from the Kumasi Central Market in the Ashanti region of Ghana. Other ingredients (eggs, salt, sugar, yeast, butter and milk were purchased in a supermarket at the Kumasi Asafo market.

3.2. Sample Preparation

3.2.1 Preparation of *Cucurbita moschata* flour

Peeled, cleaned, and thinly sliced butternut squash (*Cucurbita moschata*) was purchased. The slices were dehumidified for 24 hours at 60 °C after 90 minutes of water soaking. The sample was then grinded using an electric grinder (Kimatsu, Spectra 750 W, Mumbai, India). A 63 µm (microns) sieve was used to separate the dry chips into flour, which was then packaged in airtight containers and kept until it was needed. (Roshana, 2020).

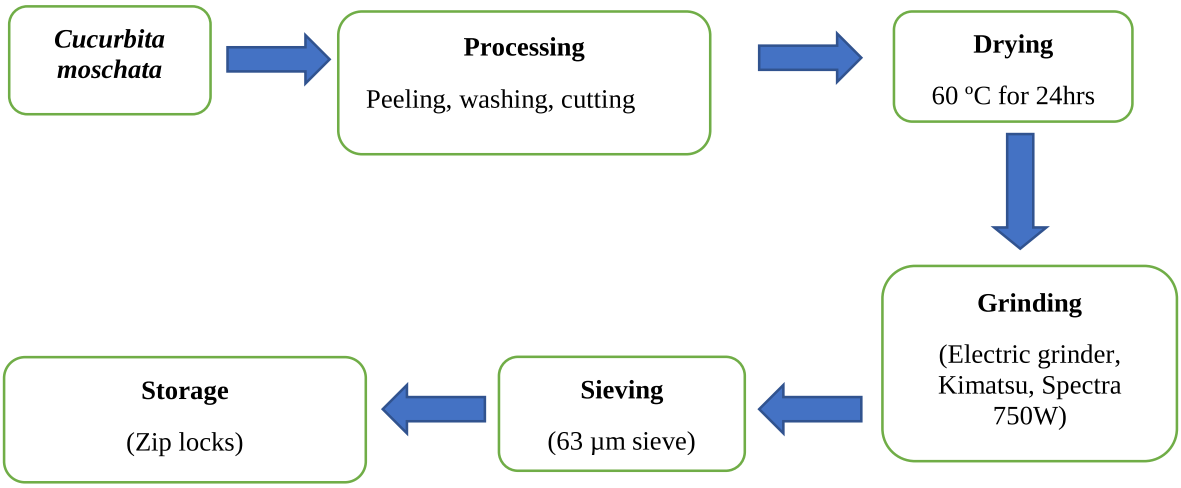

Figure 3.1: Flow chart of the method of preparation of *Cucurbita moschata* flour

3.3. Product Formulation

Table 3.1: Recipe for the different formulations

Ingredient	Treatment code				
	A1	B2	C3	D4	E5
Butternut squash (%)	0	20	30	40	50
Wheat flour (%)	100(control)	80	70	60	50
Butter (g)	10	10	10	10	10
Yeast (g)	5	5	5	5	5
Milk (ml)	63	63	63	63	63
Sugar (g)	1	1	1	1	1
Salt (g)	1	1	1	1	1

3.3.1. Preparation of butternut squash and wheat flour composite bread

The butternut squash and wheat flours were sieved to a particle size of 63 µm. The sieved flour and all other ingredients thus salt, sugar, butter, water, and milk were accurately measured and mixed thoroughly. The milk, yeast, and water were added whiles warm and mixed in with the flour, for kneading. The mixing bowl was covered with plain cloth and the dough was left to rise in a warm draft-free spot for an hour. The dough was then punched down, turned out onto a floured board, and kneaded again. It was then moulded into a desired shape and placed on a baking sheet. The oven was preheated to 230°C. The kneaded dough was covered and allowed to rise for about thirty (30) minutes. The bread was washed and baked for about 25 minutes. (Thus, an egg was cracked into a clean bowl and a pastry brush was dipped into it to lightly brush on top of the risen or proofed bread).

3.4. Sensory Evaluation

A panel of fifty people including students and staff of AAMUSTED were employed for the Sensory Analysis based on a hedonic scale of 1-7; where 1 = Dislike extremely and 7 = like extremely (Ihekoronye & Ngoddy, 1985); under the following criteria: colour, taste, after taste, hardness and overall acceptance. Panellists were then familiarized with the score sheets for the evaluation as in Appendix I.

3.5. Proximate Composition of Samples

3.5.1. Moisture Content Determination

The samples were divided into four grams (4 g) each, which were weighed using an analytical balance (Mettler Toledo). The samples were then dried for eight hours at 105ºC in a thermostatically controlled forced air oven to maintain weight (Binder GmbH, Germany). Before being weighed, the Petri dishes were removed and placed in desiccators to cool. Averages were computed after repeating the samples. Listed below is the determined moisture content. (AOAC, 2000):

$$\% \text{ Moisture content} = \frac{W2-W3}{W2-W1} \times 100\%$$

W1 = Weight of empty petri dish

W2 = Weight of dish + wet samples (before drying in oven)

W3 = Weight of dish + dried samples (after drying in oven)

3.5.2. Crude Fat Determination

Each of the bread samples was weighed out at two grams (2 g) before being folded into smaller papers, which were then glass wool-plugged at the entrance and set into thimble holders.

Each 250 ml round bottom flask had been dried out and weighed before being filled with 150 ml of Petroleum ether B.P. 40-60ºC, the thimble holders, and their contents. The Soxhlet Extractor was linked to quick-fit condensers, which were refluxed on a heating mantle for six hours at low heat. The thimbles were removed after extraction to distil the solvent.

To evaporate the solvent, the flask and fat were heated in an oven at 103ºC. To estimate the weight of the fat obtained, flasks were weighed after being chilled to room temperature in a desiccator with their contents (AOAC, 2000).

$$\% \text{ Crude fat} = \frac{W3 - W2}{W1} \times 100\%$$

W1 = Weight of sample
W2 = Weight of flask
W3 = Weight of flask + fat

3.5.3. Crude Protein Determination

Using the Kjeldahl method, the crude protein content of the bread samples was ascertained (AOAC, 2000).

Digestion: Two grams (2g) of the dried and milled samples were weighed into a digestion flask and 0.5 g of selenium catalyst was added. Once the samples were completely moist, 25 ml of concentrated H2SO4 was added and the tubes were shaken. The flasks were heated for two hours (at about 410°C) to make the resulting solutions transparent. The digested sample solution was then transferred into a 100 ml volumetric flask and built up to the required concentration after the samples had cooled to room temperature.

Distillation: For around 10 minutes, distilled water was used to flush the distillation equipment. 250 ml conical flasks (8 of them for duplication) were filled with 25 ml each with 2% boric acid and 2 ml of mixed indicator, respectively until a pink colour it was achieved.

The conical flasks were positioned beneath a condenser, the tip of which was submerged entirely in the boric acid solution. Twenty millilitres (20 ml) of a 40% NaOH solution and ten millilitres (10 ml) of each digested sample's solution were placed in the breakdown flask of the Kjeldahl apparatus. The pink ammonia (NH3) that was produced during the distillation was tinted bluish-green by the boric acid solution. When the colour turned pink, the distillates were titrated with an O.1 N hydrochloric acid (HCL) solution. The initial colour of the solution was bluish-green.

The endpoint was recorded, and the amounts of total nitrogen and crude protein were determined using the titre readings (AOAC, 2000).

$$\text{\% Total nitrogen} = \frac{100 \times (Va - Vb) \times Na \times 0.01401}{W \times 10} \times 100\%$$

Va = volume in ml of standard acid used in titration

Vb = volume in ml of standard acid used in blank

Na = normality of acid

W = weight in grams of the samples taken

Crude protein = % total nitrogen × 6.25

3.5.4. Crude Fibre Determination

Two grams (2 g) of each sample from the crude fat determination samples were weighed and placed into a 750 ml Erlenmeyer flask. The flask was immediately put on a heated plate and attached to the condenser to start boiling for 30 minutes after adding

200 ml of 1.25% H_2SO_4. The solution was quickly filtered using a funnel and a linen cloth before being properly washed with water when the flask was removed. The filtrates were washed back into the flask using 200 ml of 1.25% NaOH solutions. A flask condenser was connected and heated for 30 minutes.

After that, they underwent a thorough cleaning with 15 ml of water and 96% alcohol before being filtered using Fischer's crucible. The crucibles and their contents were dried at 105°C for two hours. After cooling in the desiccator, they were weighed (AOAC, 2000).

$$\% \text{ Crude Fibre} = \frac{W2-W3}{W1} \times 100\%$$

W1 = Weight of samples
W2 = Weight of crucible + sample
W3 = Weight of crucible + ash

3.5.5. Ash Determination

The duplicate 2 g bread samples were weighed into a porcelain crucible that had already been tarred, dried, and weighed. At Gallenkamp in England, the samples were heated in a muffle furnace for two hours at 60°C. The crucibles were cooled to around 105°C after ashing.

To fast cool to room temperature, the crucibles were placed in a desiccator with a porcelain plate and desiccant. The weight of the crucibles and their contents was reported as their percentage ash content (AOAC, 2000).

$$\% \text{ Ash content} = \frac{W3-W2}{W1-W2} \times 100\%$$

W1 = Weight of crucible + sample

W2 = Weight of empty crucible

W3 = Weight of crucible + ash sample

3.5.6. Carbohydrate Determination

The amount of carbohydrates present was determined by adding and subtracting from 100 the amounts of the sample's crude protein, crude fibre, crude fat, moisture, and ash components. Carbohydrate = 100 - (% Moisture +% Ash+% Crude Protein +% Fat + Crude Fibre)

3.6. Functional Properties

Functional properties were determined according to a method (Arivuchudar, 2018) with modifications.

3.6.1. Determination of Water Absorption Capacity (WAC)

The sample was weighed at 1 g and put into a centrifuge tube.10 ml of distilled water was then added to create a suspension. Using a vortex, the tube and the samples were shaken for five minutes at a speed of ten revolutions per minute. For 15 minutes, the fluid was centrifuged at 3000 rpm.

The centrifugation process's supernatants were carefully transferred to a beaker and discarded, while the sediments were weighed separately. Based on the weight difference between the initial sample and dried supernatant, water absorption capacity was estimated (Arivuchudar, 2018)

$$\text{WAC} = \frac{weight\ of\ sediment}{weight\ of\ dry\ flour}$$

3.6.2. Determination of Oil Absorption Capacity (OAC)

A weight of 1 g of the flour sample was weighed into a pre-weighed clean and dry centrifuge tube. A volume of 10 ml of sunflower oil was mixed thoroughly with the sample and poured into the tube. The tube was shaken at a speed of 10rpm for 5 minutes using a vortex. After that, the suspension was centrifuged for 30 minutes at 3000 rpm. The supernatant was discarded and the tube and its content were reweighed. The grain in weight expressed as a percentage of oil bound was calculated as the oil absorption capacity of the sample (Arivuchudar, 2018).

3.6.3. Determination of Solubility Index

The sample was weighed at 1g and put into a centrifuge tube. To create a suspension, 10 ml of distilled water was then added. The tubes and samples were shaken by the vortex for 5 minutes at a speed of 3 rpm. The next 30 minutes were spent in a 90℃ water bath. The resultant mixture was centrifuged for five minutes at 3000 rpm.

Then, as the sediments were being weighed, the supernatants were carefully poured into Petri dishes for 4 hours of drying at 105℃ in an oven. Based on the weight difference between the initial sample and dried supernatant, water absorption capacity was estimated (Arivuchudar, 2018).

$$SI = \frac{weight\ of\ dry\ supernatant}{dry\ weight\ of\ flour}$$

3.6.4. Determination of swelling power

Zero point five grams (0.5 g) of the sample weight was inserted in a centrifuge tube (pre-weighed) and diluted with 15 L of distilled water to determine the swelling index. The suspension was centrifuged at 4000 rpm for 20 minutes after being heated in a water bath at 80℃ for 30 minutes. The supernatants were centrifuged, then moved to known-weight Petri plates and dried for ten hours at 105°C. The supernatants and sediments from the centrifuge tube were weighed after complete dehydration. Rice flour's wet sediment and dry supernatant were used to compute the swelling index (Arivuchudar, 2018).

$$SP = \frac{weight\ of\ sediment}{weight\ of\ flour - weight\ of\ dried\ supernatant}$$

3.7. Yield Determination

The flour yield of the powdered sample from *Cucurbita moschata* was calculated from the weight measurement of the powder obtained after drying and the weight of *Cucurbita moschata* taken. The yield was calculated as:

$$\%\ \text{yield} = \frac{weight\ of\ powder\ obtained}{weight\ of\ sample} \times 100\%$$

3.8. Colour Determination

According to Gayin et al., (2015), colour was determined. The colour of the sample was measured using a Minolta Chroma Meter (CM 3500-d, Konica Minolta Sensing Inc., Mahwah, NJ, USA). The Minolta Chroma Meter is used to assign each sample a colour coordinate in the CIE (Commission Internationale l'Eclairage) L-a-b three-dimensional (L*a*b*) colour space. Pure red is represented by a CIE a* value of +60, whereas pure blue is represented by a CIE b* value of -60. (Pure white). On a scale from 0 (pure black) to 100 (pure white), CIE L* values represent brightness (pure yellow). The average of three readings is used to determine each printed CIE L*, a*, and b* value.

3.9 Texture Profile Determination

Sample of Butternut Squash bread was cut into slices of equal size. A scale was used to measure the weight of each slice and was recorded. The Texture Analyzer was set up with a cylindrical probe depending on the expected texture of the bread. The Texture Analyzer was calibrated before testing. The Texture Analyzer was set to compress each sample to a distance of 50% of its original height at a speed of 1 mm/s. The force range was set to 0-20 N. Each sample was placed on the Texture Analyzer platform and applied the test conditions. Deformation, force, and time data for each sample were recorded.

3.10 Data Analysis

Analysis of Variance (ANOVA) was used to analyse the nutritional parameter data (α =0.05) and Duncan's Multiple Range Test was used to examine mean differences (DMRT).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Proximate Composition of Butternut Squash Flour

The current study evaluated the proximate and energy content of the sample before incorporation into the development of the bread samples.

Table 4.1: Results of Proximate analysis on the Butternut squash flour

Components (%)	Composition (%)
Moisture	8.23±0.07
Crude Fat	1.53±0.09
Crude Fibre	5.54±0.03
Crude Ash	6.90±0.05
Crude Protein	11.90±0.04
Carbohydrate	65.9±0.03
Energy (Kcal)	324.4±0.05

Results presented as mean ± standard deviation, (n=3).

4.1.1. Moisture Content

The moisture content of a sample is referred to as the total volume of water present, thus, it influences the texture, appearance, and shelf stability of the sample because of the possibility of microbial growth (Eze et. al, 2020). The moisture content of the butternut squash flour was 8.23%, the results are in tandem with the assertions of Konadu et al., (2021) indicating a moisture content ranging from 6.17% to 7.79% for butternut squash flour. However, Adekunle & Oluwo, (2008) reported values of 4.50% moisture content, though (Karanja et al., 2017) reported a range of 4.4-15%. The relatively low moisture content reported in the current study shows that the drying of the sample was effective. Olusegun (2018) purported that the moisture content of plant foods has been reported to be affected by maturity, freshness, and agronomic practice during cultivation. The temperature, processing method, and milling technique all have an impact on the flour's moisture content (Jamal et al., 2016).

4.1.2. Crude Fat

The lipids are food components that are soluble in organic solvents but insoluble in water (Ahmed et al., 2022). Lipids include but are not limited to glycerol, free fatty acids, phospholipids, sterols, and the types with crucial values are triacylglycerol and phospholipids. The amount of crude fat obtained in this study was 1.53% inferring that butternut squash flour has considerably low-fat content. The minimum fat intake for adults should be 15% of their total energy intake. According to this estimate, the crude fat content of butternut squash was lower. Similar to the range of 0.95 to 2.1% in crude fat content that Dari and colleagues, (2018) found when studying the nutritional makeup and storage of butternut squash. The presence of fat contributes to the human body's energy requirement, but excess dietary fat consumption has some well-established health consequences, particularly for itthe overweight, increasing cholesterol levels and development of other cardiovascular diseases.

4.1.3. Crude Fibre Content

Carbohydrates are not complete without fibre, which is the term for all food substances that are difficult to digest (Bisratewongel Tegegne, 2020). ums, cellulose, hemicellulose, lignin, pectin, and hemicellulose are the main forms of dietary fibre (some hemicelluloses and storage polysaccharides) as reported by (Vunain et. al., 2020). The percentage of Crude fibre obtained in this study was 5.54%. The results of this study were in sync with the assertions of (Ndidi et al., 2014) (2.55-6.80) and were higher than that reported by Konadu et al., (2021) who obtained 1.15 to 2.06%. Dietary fibre includes polysaccharides, oligosaccharides, lignin, and associated plant substances. When incorporated into food systems, the significant amount of crude fibre contained in butternut squash may have positive physiological effects on consumers, including taxation and blood cholesterol and glucose regulation.

4.1.4. Ash content

When organic things including proteins, lipids, carbohydrates, and moisture contents are burned, an inorganic substance known as ash is what is left behind (Harris & Marshall, 2017). Ash is the inorganic residue of material left over after water and organic matter have been removed from it by heating in the presence of oxidizing agents, according to Oyelakin et al., (2022) and it regulates the number of minerals in food. In this investigation, ash was measured at 6.90%. The values obtained for ash in this study was 6.90%. Javed et al., (2022) observed a value of 4.87%, in contrast to Konadu et al., (2021) who reported a value of 5.57 %. Additionally, a range of 2.23-3.97% was noted by Ndidi et al., (2014). When assessing the quantities of vital minerals in a food sample, the amount of ash present is crucial.

4.1.5. Crude Protein

Proteins are the building blocks of the body's muscles and are essential components of body tissues and cells, as well as essential micronutrients for human health. Particularly in rural and low-income locations, the protein level of the flour may be effective in food formulation systems where customers would benefit from the butternut squash to promote health and complement the pricey protein sources. The acquired protein percentage of 11.9% is equivalent to the claims made by Oyelakin et al., (2022), who reported a value of 11.33%. The values obtained were higher than that reported by Konadu et al., (2021) indicating 3.7-4.8%. According to the (World Health Organization., 2007) and the United States, the recommended daily allowance (RDA) for protein per kilogram of ideal body weight per day should be 0.45 g and 0.8 g, respectively. Protein acts as an immune booster, allowing the body to produce antibodies that aid in the fight against infectious diseases, as well as for the growth and repair of worn-out tissue. To ensure proper nutrient intake and a healthy balanced diet, it is also necessary to be aware of the protein content of the food consumed.

4.1.6. Carbohydrate content

Carbohydrate is the most abundant macronutrient in butternut squash flour recording 67.9% Oyelakin et al., (2022) reported a carbohydrate content of 70.27% which is close to the findings of this study. However, the values obtained in this study were higher than the assertions of Ndidi et al., (2014) with values of 31-58% carbohydrate content. Also, Konadu et al., (2021) reported a value of 72.9%.

4.1.7. Energy Content

Energy values are influenced by the proportion of fat, protein, and carbohydrate, thus, the higher fat, protein, and carbohydrate content the higher the energy value of the food sample (Teye et al., 2018). Comparing the energy content of flours, Teye et al., (2018) recorded a range of 321.4 Kcal/100g to 369 Kcal/100g from orange-fleshed sweet potato flour fortified with increasing soybean content. Verem et al., (2021) recorded 328.40 Kcal/100g for wheat flour and 321.28 Kcal/100g for a combination of wheat, soybean, and moringa, thus the energy value of butternut squash flour recorded in this study (324.4 Kcal/100g) is comparatively a recommended choice for use. Oyelakin et al., (2022) reported an energy content ranging from 331 Kcal/100g to 341 Kcal/100g of butternut squash, which is close to the findings of this study (324.4 Kcal/100g).

4.2. Functional Properties of Butternut Squash Flour

The components of food materials, particularly carbs, proteins, lipids, and moisture, as well as the microstructure of these components, have an impact on the functional qualities of food and flour. (Somtochukwu et al., 2018). The study assessed the butternut squash flour's ability to absorb water, oil, and other liquids as well as its swelling strength and solubility index. Table 4.2 shows the average results of functional properties obtained from triplicate analysis of the butternut flour samples.

Table 4.2: Results of functional properties of the Butternut squash flour

Functional properties	Composition (g/g)
Water Absorption Capacity	2.59±0.02
Oil Absorption Capacity	1.26±0.09
Swelling power	3.43±0.12
Solubility	17.24±0.08

Results presented as mean ± standard deviation, (n=3).

4.2.1. Water Absorption Capacity (WAC)

Water absorption capacity represents the ability of a product to associate with water under conditions where water is limited (Jamal et al., 2016) and is a critical function of protein in various food products like dough and baked products. Shad et al., (2013) reported that water-holding capacity is an essential functional property of protein which depend on pore size and the charges on the protein molecules. High WAC shows the hydrophilic nature and high hydrogen bonding of protein molecules. The water absorption capacity obtained in this study was 2.59g/g, which is considered favourable for the preparation of viscous foods such as bakery products, soups, and gravies (Shad et al., 2013) therefore, butternut squash flour would be ideal for such products. Oyelakin et al., (2022) reported a range of 3.3g/g to 4.9g/g which corroborates with the findings of this study. The difference in water absorption capacity could be attributed to differences in starch structure which results in varying internal associative forces maintaining granule structure and, degree of engagement to form hydrogen and covalent bonds between starch chains and thus the degree of availability of water binding sites (Falade & Christopher, 2015).

4.2.2. Oil Absorption Capacity

According to Falade et al., (2014), the oil absorption capacity is due predominantly to the physical entrapment of oil within the starch structure, since starch does not possess nonpolar sites akin to those found in proteins. The mechanism of oil absorption may be explained as a physical entrapment of oil related to the non-polar side chains of proteins. Oil absorption obtained for this study was 1.26g/g, which are similar values to the assertion of Oyelakin et al., (2022) reporting a range of 1.43-1.75g/g. Falade & Christopher, (2015) found that the oil absorption capacity is important because the oil acts as flavour retainer and enhances the mouth feel of foods. Variations in the presence of non-polar side chains, which may bind the hydrocarbon side chains of oil among the flours, explain differences in the oil binding, an occurrence suspected to be due to the presence of oil-soluble purple phytochemicals present in the endosperm. The ability of these flours' proteins to bind with oil makes them useful in food systems where optimum oil absorption is desired. Because of this, these flours may be used to make dishes like sausage and other items that require significant oil absorption. Because of the flour's capacity to absorb oil, it can be utilized to improve flavour and mouthfeel in food preparations. These qualities make the protein a useful component in dishes like whipped toppings, sausages, chiffon sweets, angel food, sponge cakes, etc. (Meherunnahar et al., 2018). The oil absorption capacity indicates the emulsifying capacity, a highly desirable quality in products like mayonnaise (Falade et al., 2014).

4.2.3. Swelling Capacity

While Oyelakin et al., (2022) reported a range of 8.68 to 8.89 g/g, the swelling capacity measured for this experiment was 3.34 g/g. The amount, expressed in millilitres, that is occupied by the swelling of one gram (g) of food material under particular circumstances is known as the swelling index (SI), also known as swelling capacity (SC) (Somtochukwu et al., 2018). The test methodology for each distinct food material specifies whether water or an agent that produces swelling should be added before drawing any conclusions (whole, pulverized, or cut). The swelling capacity, a measurement of the starch's capability to absorb water and swell, reveals the number of associative forces present in the starch granules. Some foods, especially bread products, have a swelling capacity (index) that is thought to be a quality indicator. It is evidence of noncovalent bonding between one of the components controlling the amylose-to-amylopectin ratios and the starch granules (Iwe et al., 2016). The swelling capacity (index) of flour is a characteristic that depends on factors such as particle size, species variety, processing technique, or unit operations (Chandra & Samsher, 2013). Greater swelling capacity denotes lesser binding forces in the starch granules. The results were in line with those published by Jamal et al., (2016) (3.74 g/g to 7.64 g/g) who hypothesized that amylose and protein concentration would affect flour's ability to swell. Protein's disulphide and intermolecular bonding, which form a broad and strong network, and amylose's protein concentration prevent granular enlargement. The swelling capacity of flour depends on the size of particles, types of variety, and types of processing methods (Meherunnahar et al., 2018).

4.2.4. Solubility Index

The ability of a solid, liquid, or gaseous food substance—known as a solute—to dissolve in a liquid, gaseous, or solid solvent is known as solubility in the food system. Commonly, the saturation concentration is used to gauge how much a food substance (such as flour) will dissolve in a given solvent. At this point, adding more solute will no longer raise the concentration of the solution but will instead cause the surplus solute to precipitate. (Somtochukwu et al., 2018). Lipids make flours less able to absorb water, which can diminish their ability to swell and, as a result, their solubility (Beyuo et al., 2015).). A food's high solubility can indicate its great digestion, which may point to its outstanding suitability as food and infant formula. A food is considered to be insoluble if it cannot dissolve in a liquid, gas, or solid solvent. The amount of flour that can be dissolved into a solution often using water as the solvent is referred to as its solubility. The solubility index values for this study were 17.4g/g. According to Jamal et al., (2016) factors that affect water solubility include the presence of protein, temperature, amylose, and starch lipids complex, which reduces solubility.

Two of the key factors influencing a substance's water solubility are the milling techniques used and the amount of damaged starch. Degradation of the starch granules increased the water solubility (Falade & Christopher, 2015).

4.3. Physical Properties (Determination of Colour)

According to Moses Ayodele and Beatrice, (2015), the physical properties of food materials are prerequisite factors for developing and improving equipment for harvesting, storing, handling, conveying, separating, drying, aeration, and mechanical extraction of oil and other processes.

Table 4.3 shows the average results of the determination of colour obtained from triplicate analysis of the butternut flour samples.

Table 4.3: Results of determination of colour of the Butternut squash flour

Sample	L*	a*	b*
Butternut Squash	55.73±0.02	8.56±0.05	22.69±0.09

As shown in Table 4.3, L*, a*, and b* values of 55.73, 8.56, and 22.69 respectively were reported for the butternut squash flour. The brightness or lightness value, known as the L* value, averaged 55.73. Also, a* value which expresses the redness was averaged at 8.56. Yegrem et al., (2021) propounded that the growing environment and post-harvest factors affect the colour of flour produced. Pongjanta et al., (2006) recorded L* values to be 57.81 which corroborates with the findings of this study. Also, for a* value, Pongjanta et al., (2006) recorded 8.31 and had b* value ranging from 23.26 to 34.39. The b* value, which expresses yellowness averaged 22.69. According to Rosniyana et al., (2016). Since the colour of the flour usually impacts the appearance of the finished product while baking, dazzling white flour is one of the many flour attributes that end users need.

4.4. Yield Determination of Butternut Squash

In any industry, effective resource management is essential to the workflow. Any increase in flour yields results in more money being made. At the same time, it's critical to keep a high level of efficiency to guarantee that finished goods are supplied with the ideal allowable moisture levels (Sarkar et al., 2018). The difference in pricing between flour and by products in each market has a significant impact on flour yield. Table 4.4 displays the average results of the determination of flour production based on the study of three samples of butternut flour.

Table 4.4: Results of Butternut squash flour yield determination

Sample	Flour yield %
Butternut squash flour	14.25 ± 0.02

Krampa et al., (2003) asserted that flour yield depends on the maturity of the plant at the time of harvest, initial root moisture content, and the variety used for processing into flour. The study's flour yield was 14.25 percent. A mix of cassava and soybeans generated flour with a yield of 18 to 19.9%, according to Eriksson, (2013). According to Sarkar et al., (2018)), the three main variables that affect flour yield are raw material, equipment, and procedure. According to Komlaga et al., (2021) the yield of cassava flour ranges from 13 to 19%. Offiah et al., (2019) found a somewhat higher figure of 20.67%, and Udoro et al., (2020) observed a substantially greater range of 36.15–37.03%, which was strongly influenced by peel thickness. According to Apea-Bah et al., (2011) the age, wetness, and variety of the root all affect the amount of flour produced. The recovery of flour is also influenced by the milling and sieving procedure. Sarkar et al., (2018) that while flour yield is crucial, the benefit of any improved yield produced is of little value if it is unusable. Analytical, rheological, and end-use quality features are some of the elements that are impacted as flour yield increases. The utility of flour changes significantly as flour production rises.

4.5. Sensory Evaluation of Composite Bread Samples

50 untrained panellists evaluated the sensory characteristics of the control bread CB and the composite bread samples. A1 (Control), which had 100% wheat flour, and B2, C3, D4, and E5, which contained butternut squash flour and wheat flour, respectively. The results are shown in Table 4.4 below. Colour, texture, flavour, aftertaste, and general acceptance of the samples were all assessed. From to Table 4.4 below, all the composite bread samples were significantly ($p<0.05$) more accepted than the control across all of the sensory parameters examined. The favoured bread sample emerged as B2 in terms of the colour, texture, and flavour. B2 was significantly ($p< 0.05$) preferable in terms of an aftertaste than the other bread samples and had the best overall acceptance. The outcomes revealed that the participants preferred the composite bread samples over the control samples. This result agrees with Kampuse et al., (2015) who found out that considering sensory attributes, bread crumb porosity, elasticity, and colour, he concluded that the bread composition with 20% of pumpkin flour had the best bread qualities. The addition of butternut squash to bread could improve the nutritional quality of bread since butternut squash is rich in carotene, vitamins, minerals, and dietary fibre.

Table 4.5: Sensory attributes of composite bread samples assessed by 50 panellists

Bread Sample	Colour	Texture	Flavour	Aftertaste	Overall Acceptance
A1	5.70 ± 0.87	5.92 ± 0.97	5.40 ± 1.43	5.16 ± 1.36	5.38 ± 1.42
B2	6.16 ± 1.12	6.54 ± 0.78	6.28 ± 2.37	6.44 ± 2.58	6.16 ± 1.97
C3	4.58 ± 1.10	3.96 ± 1.52	4.18 ± 1.91	4.04 ± 2.32	4.04 ± 2.00
D4	2.20 ± 1.80	2.48 ± 1.64	3.08 ± 2.36	2.92 ± 2.32	3.06 ± 2.51
E5	2.14 ± 2.31	2.36 ± 1.79	2.86 ± 1.84	2.92 ± 1.87	2.60 ± 1.80

Results presented as mean ± standard deviation. n = 3, No statistical significance observed at $p<0.05$.

The outcome of the sensory analysis indicating B2 had the best overall acceptability as well as preferred in terms of the aftertaste which were all significantly($p<0.05$) different from the other bread samples influenced a further action of determining the physical properties of the bread as well the proximate composition.

In the ANOVA table, "Bread Sample" is the source of variation, and the other variables are included in the error term. SS represents the sum of squares, df represents the degrees of freedom, MS represents the mean square, F-ratio is the ratio of the variance between the groups to the variance within the groups, and p-value is the probability of obtaining a F-ratio as large as the one observed if the null hypothesis (no significant differences between groups) were true.

From the ANOVA table, we can see that the p-value for Bread Sample is greater than 0.05, which means that there is no significant difference between the groups. Therefore, we cannot reject the null hypothesis that there are no significant differences between the groups in terms of colour, texture, flavour, aftertaste, and overall acceptance.

4.6. Proximate Composition of Butternut Squash Composite Bread

Proximate composition of the Butternut Squash Composite Bread was determined and reported in Table 4.6 below. The information on the proximate composition will help determine how the butternut squash flour and the wheat flour interaction affect some physical properties such as the specific volume and colour as well as some sensory attributes such as mouthfeel and aroma. Incorporating butternut squash flour into the wheat flour (AB) led to an increase in the nutritional value as compared to control bread which only contained wheat flour.

4.6.1. Moisture Content

It can be observed that the moisture content of the composite bread (AB), 15.79 ± 0.007 was shown to have a higher moisture content as compared to the control bread (CB), 12.46 ± 0.54. The moisture content of the butternut squash composite bread was shown to be significantly ($p<0.05$) higher than the control bread. According to Alkurd et al., (2020) moisture constitutes a higher percentage of bread weight, therefore lowering its energy density. Thus, the energy density of bread is dependent on its moisture content. This shows that the control bread was shown to have a higher energy content as compared to the butternut squash composite bread

4.6.2. Crude Fat

The fat composition was also shown to be higher in the control bread, 11.8±0.02 as compared to the composite bread, 2.57±0.403. The fat content of the control bread was shown to be significantly ($p<0.05$) higher than composite bread. This result indicates that the fat content has a lot to do with the energy content of the bread since the fat contributed to the high energy percentage among the macronutrients of the control bread samples. This result can be confirmed by a finding by Alkurd et al., (2020).

4.6.3. Crude Fibre

The composite bread (4.45±0.22) was found to have a higher fibre content as compared to the control bread (0.41±0.11). The fibre content of the composite bread was significantly ($p<0.05$) higher than the control bread. The inclusion of the butternut squash in the wheat flour improved the fibre content since the butternut squash bread was shown to have a high fibre content. This could be a result of the interaction between the wheat and the butternut flour or the processing method in the preparation of the bread.

4.6.4. Crude Ash

From Table 4.4, It can be observed that the composite bread (10.32±0.310 had a significantly ($p<0.05$) higher crude ash as compared to the control (2.22±0.08). According to Mbatchou & Dawda, (2013), the crude ash content indicates the levels of essential mineral acids after the organic materials are combusted. Therefore, it can be inferred that the composite bread had more minerals as compared to the wheat bread. Bread is usually high-energy food with little to no mineral and vitamin content, the composite bread provides a healthier alternative to wheat bread in terms of mineral content.

4.6.5. Crude Protein

The composite bread (11.20±0.16) was also found to have a higher crude protein content as compared to the control bread (11.20±0.21). The composite bread contains wheat flour which contains a good level of protein such as gluten and also butternut flour which also contains a high amount of protein ultimately producing a higher protein content.

4.6.6. Carbohydrates

Carbohydrates were found to be significantly higher in the control bread (73.52±0.09) as compared to the composite bread (55.67±0.31). The Energy value is influenced by the carbohydrate content as well as protein and fats. This shows that wheat bread has a higher energy index as compared to composite bread. These results can be confirmed by a study by Tiimub, (2013). Though wheat bread was shown to contain other nutrients such as proteins and fibre it is seen that its major nutrient is carbohydrates but then the composite bread although also possessed majorly carbohydrates had higher levels of protein and ash which signifies its richer nutritional composition and shows as a healthier option.

A statistical comparison of the proximate analysis data for butternut squash bread compared the means of each parameter between the two bread samples (CB and AB) using a two-sample t-test with a significance level of 0.05. The null hypothesis is that there is no significant difference between the means of the two bread samples for each parameter, while the alternative hypothesis is that there is a significant difference.

The results indicated that there is a significant difference between the means of the two bread samples for most parameters, except for crude protein, which has a p-value greater than the significance level. The butternut squash bread (AB) has a significantly lower moisture, crude fat, crude fibre, and crude ash content, but a significantly higher carbohydrate content compared to the reference bread (CB).

Table 4.6: Proximate Analysis on Bread samples

Parameters	Bread Samples	
	CB	**AB**
Moisture	12.46 ± 0.54^{b}	15.79 ± 0.007^{a}
Crude Fat	11.8 ± 0.02^{b}	2.57 ± 0.403^{a}
Crude Fibre	0.41 ± 0.11^{b}	4.45 ± 0.22^{a}
Crude Ash	2.22 ± 0.08^{b}	10.32 ± 0.31^{a}
Crude Protein	10.49 ± 0.21^{a}	11.20 ± 0.16^{b}
Carbohydrate	73.52 ± 0.09^{b}	55.67 ± 0.31^{a}

Results presented as mean ± standard deviation. Values are statistically significant at [1] $^{a}p<0.001$, $^{b}p<0.05$ when AB was compared to CB using Sidak's multiple comparison test.

AB stands for the composite bread which contains butternut squash bread and wheat bread in a ratio of 20:80 respectively. CB also stands for the reference bread which contains 100% wheat flour.

4.7. Physical Properties of Composite Flour Samples

4.7.1. Colour determination of composite bread samples

The colour of the crust and crumb of the composite bread samples were measured to determine their lightness or darkness as compared to the control bread. The results for the colour are shown in Tables 4.7, 4.8 and 4.9.

The Hunter L values indicated the lightness of the crust and crumb parts of the control and composite bread samples. From Table 4.6, the Crust (Under) of the composite bread (AB) bread can be observed to have a higher L value, 54 ± 0.141 as compared to the control. This result indicates that the crust (Under) of the composite bread was significantly ($p<0.05$) lighter in colour than that of the control bread. Again, the composite bread was shown to have a significantly ($p<0.05$) higher L value as compared to the control bread to the top crust as shown in Table 4.8. The vibrant colour of the butternut squash flour and its effect on the general qualities of the bread are the causes of the lightness of the crust. However, the control bread was also shown in Table 4.9 to have a higher colour intensity, 68.56 ± 0.099 as compared to the composite which had an L value of 58.01 ± 0.495, showing a significant($p<0.05$) difference between them. Higher crumb colour intensity is preferable since it denotes a whiter or lighter tint, which is typically found in traditional wheat bread.

The positive a value also indicated the degree of redness of the bread samples. Apart from the Crust (Under), the results indicated a significant ($p<0.05$) difference between the redness of the Crust (Top) and the Crumb as the composite bread exhibited a higher degree of redness. However, the control was shown to have a significantly higher degree of redness at the crust (Under) according to the results observed in Table 4.7 below. The composite bread had a significant level of redness due to the colour of the butternut squash flour. The results also showed a significant ($p<0.05$) difference in the b value between the composite bread and the control bread as the composite bread exhibited a higher degree of yellowness. As indicated by the L value, the composite bread was observed to have a higher colour intensity than the control which is usually desired by consumers (Rosniyana et al., 2016). This result is confirmed by Kampuse et al., (2015) who confirmed that the increase of the butternut squash in the composite bread yielded an increase in the yellowness of the bread product.

Table 4.7: Colour of composite bread Crust (Under)

	Crust (Under)		
	l	**A**	**b**
CB (Control)	46.995±0.078	7.99	14.235±0.0353
AB (Composite)	54.35± 0.141	6.645± 0.049	25.255±0.078
P-value	0.000241	0.000676	3.00545E-05

Table 4.8: Colour of composite bread Crust (Top)

	Crust (Top)		
	l	**A**	**b**
CB (Control)	57.64±0.226	2.725±0.177	10.58±0.198
AB (Composite)	63.915± 0.106	6.21±0.014	28.23±0.04
P-value	0.000792	0.001292	6.5799E-05

Table 4.9: Colour of composite bread Crumb

	Crumb		
	l	**A**	**b**
CB (Control)	68.56±0.099	0.63±0.141	20.35±0.113
AB (Composite)	58.01±0.495	3.95±0.057	24.37±0.057
P-value	0.00114	0.000154	0.00049467

4.7.2. Texture profile of composite bread

The composite bread sample's texture profile study was done, and the results are shown in Table 4.7. The force or load necessary to crush the bread by 1mm was represented by the hardness of the bread samples. The composite bread (AB), as was clear from the results, was substantially softer than the control bread. The control bread had a springiness of 0.90 mm, which was comparable to the composite bread in terms of its capacity to rebound or regain its original shape after distortion. The composite bread sample supported (Moore et al., 2004) assertion that higher springiness scores are favoured because they indicate high-quality bread. Between the control and composite bread samples, there was no discernible difference in terms of springiness. ($p>0.05$).

The cohesiveness of the majority of wheat bread is due to the structure of gluten that is created during baking. A bread's cohesiveness gauges how well it can endure compression and how strong its internal linkages are. Higher cohesiveness is much preferred in bread, according to Onyango et al., (2010) as it can form a bolus rather than crumble after mastication.

According to the findings, AB was more cohesive than the control, which may have been due to the interaction between the partially gelatinized starch and the proteins in the wheat and butternut squash flours as well as the water content.

Table 4.8: Results showing the texture profile of the composite bread sample

Bread Sample	Hardness (g)	Springiness (mm)	Adhesiveness (mJ)	Cohesiveness
CB	25.20±0.60	0.90±0.28	0.004±0.001	0.88±0.04
AB	23.13±0.51	0.90±0.31	0.007±0.002	0.91±0.02

Values are reported as mean ± standard deviation of duplicate determinations. CB sample indicates the control bread sample containing 100% wheat flour whiles AB indicates the composite bread containing wheat flour and butternut squash flour in a ratio of 80:20 respectively.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The study successfully showed the potential of the incorporation of butternut squash flour in bread which can help improve the nutritional composition and sensory qualities of the bread product as well as help reduce the price involved in the production of bread products. The results showed that the determination of butternut squash flour yield was fairly good as compared to other flours, thus butternut squash flour would positively be a good option to help reduce the cost of bread production which has considerably increased in recent times. The results demonstrated that B2 which contained both wheat flour and butternut squash flour in a ratio of 80:20 respectively had the best overall qualities even preferred over the control bread samples which contained only wheat flour. This shows a good alternative for wheat flour which can help reduce the cost of the product which is skyrocketing due to the price of wheat flour from importation. The bread's baking loss, texture, hardness, appearance, aroma, and general acceptance were all improved by the composite flour. The studies were able to show the great potential of *Cucurbita moschata* in the preparation of bread.

5.2. Recommendation

Optimization of various possible concentrations of butternut squash in various bakery products can be studied to promote its application in the bakery industry. The shelf life of the most accepted composite bread (B2< 20:80 – butternut squash flour: wheat flour) can also be studied. Finally, the concentrations of the various ingredients in bread or other bakery products such as levels of water, yeast, sugar, etc. along with the accepted composite bread formulations can be studied to find the preferable levels of concentrations for the bread products.

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APPENDICES

AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT (AAMUSTED)

APPENDIX 1

Score sheet for sensory evaluation data

Sample: Butternut squash bread

Name: ………………………………………………. Sex: ……………….

Yon have been provided with butternut squash bread and are expected to make a fair assessment based on a seven-point hedonic scale. That is;

1 = dislike extremely

2 = dislike very much

3 = dislike moderately

4 = neither like nor dislike

5= like moderately

6 = like very much

7= like extremely

The assessment is to be done based on the following food characteristics; Colour, texture, Aftertaste, and overall acceptance as shown below.

Sample	Colour	Texture	Flavour	Aftertaste	Overall acceptance
A1	…………..	…………….	…………….	…………..	……………
B2	…………...	……………	……………	…………..	…………...
C3	……………	……………	……………	…………..	……………
D4	....	....	....	....	....
E5	……………	……………	……………	…………..	……………

Any other comments:

………………………………………………………………………………………

………………………………………………………………………………………

Thanks very much for your co-operation.

Figure 4.1 one-way ANOVA with "Bread Sample" as the factor and the other variables (Colour, Texture, Flavour, Aftertaste, Overall Acceptance) as the response variables

Source of Variation	**SS**	**df**	**MS**	**F-ratio**	**p-value**
Bread Sample	17.89	4	4.47	0.81	0.54
Error	958.78	20	47.94	-	-
Total	976.67	24	-	-	-

APPENDIX 2

Summary of sensory analysis of composite bread

The summary tables indicate the average, sum, count and variance. The count has to do with the number of data utilized which in this case stands for the data provided by the 50 participants. In analysis of variance (ANOVA), the total sum helps express the total variation that can be attributed to various factors; it quantifies the total variability in the observed data.

The Average indicates the average of the data for the various bread samples for instance the average for A1 for the flavour is the average for all the 50 participants on the flavour for the bread sample. The variance also has to do with how spread the data is. How they differ by each other. So, for the data for the flavour for A1 how the judgments of the panellists differed from one another.

Raw data

Sensory Analysis of Composite bread

Parameter	A1	B2	C3	D4	E5
Colour	5.70	6.16	4.58	2.2	2.14
Texture	5.92	6.54	3.96	2.48	2.36
Flavour	5.40	6.28	4.18	3.08	2.86
Aftertaste	5.16	6.44	4.04	2.92	2.92
Overall Acceptance	5.38	6.16	4.04	3.06	2.6

Sensory analysis - Flavour

Groups	Count	Sum	Average	Variance
A1	50	96	1.92	0.509472
B2	50	127	2.54	0.659736
C3	50	128	2.56	0.218376
D4	50	124	2.48	0.066720
E5	50	118	2.36	0.052200

Sensory analysis - Colour

Groups	Count	Sum	Average	Variance
A1	50	120	2.4	0.534600
B2	50	164	3.28	0.543744
C3	50	169	3.38	0.191040
D4	50	154	3.08	0.092928
E5	50	143	2.86	0.072000

Sensory analysis - Aftertaste

Groups	Count	Sum	Average	Variance
A1	50	108	2.16	0.4392
B2	50	172	3.44	0.5928
C3	50	152	3.04	0.1416
D4	50	146	2.92	0
E5	50	146	2.92	0

Sensory analysis – Overall acceptance

Groups	Count	Sum	Average	Variance
A1	50	119	2.38	0.4656
B2	50	158	3.16	0.5592
C3	50	152	3.04	0.1416
D4	50	153	3.06	0
E5	50	130	2.6	0

APPENDIX 3 – Bread making process

Peeling of butternut squash

Dehydrating of butternut squash

Sieving of butternut squash flour through sieving machine

Sieved butternut squash flour

Weighing of ingredients for bread

Weighed ingredients for bread

Kneading of bread

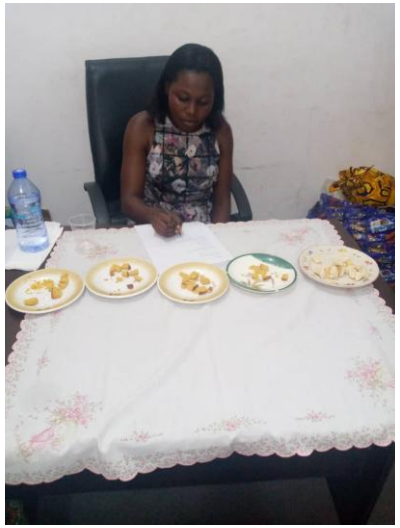
Kneaded bread dough allowed to proof

Bread put in oven for baking

Baked bread

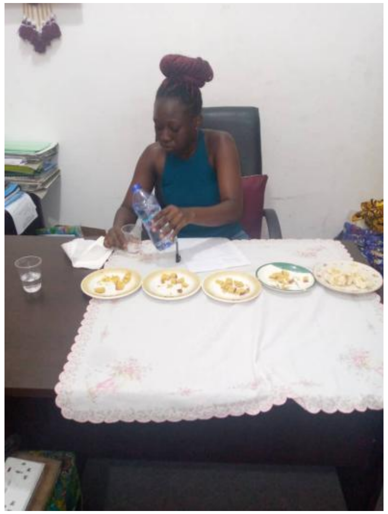
Baked bread

SENSORY EVALUATION



Participant tasting butternut squash bread

Participant tasting butternut squash bread



Participant tasting butternut squash bread

Participant tasting butternut squash bread