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THE POTENTIALS OF BUTTERNUT SQUASH AS FOOD

by

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DECLARATION/ CERTIFICATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma at Kwame Nkrumah University of Science and Technology, Kumasi or any other educational institution, except where due acknowledgment is made in the thesis.

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ABSTRACT

A survey was conducted to find the knowledge gap pertaining to butternut squash. The result obtained revealed consumers are not abreast with the nutritive value of butternut squash. Butternut squash cakes with either reduced sugar, margarine or flour was compared with rich cake without butternut squash.

Proximate and sensory analyses showed that there were significant differences ($p<0.05$) in the values of moisture, ash, fat, carbohydrate, crude fibre, energy, calcium, magnesium and potassium of the butternut squash cakes and the rich cakes.

However, no significant differences ($p>0.05$) were recorded in the values of protein and sodium.

The reduced flour butternut squash cake had the best sensory qualities and was the most preferred in terms of sweetness, aroma, firmness, colour, moistness and texture. The next to it was the reduced sugar butternut squash cake. From the results obtained, reducing the quantity of either flour or sugar in rich cake making and replacing them with butternut squash can be an innovative method of producing quality and more nutritious cakes with low calories.

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CHAPTER ONE

1.0. GENERAL INTRODUCTION

1.1. Background

Nutrients are substances used by organism to survive, grow, and reproduce. In humans the main nutrients used for life processes are carbohydrates, protein, fats, vitamins, minerals and water. These are obtained from animal and plant sources. Vegetables are part of a category of plant food sources which provide a variety of nutrients like vitamins, minerals, carbohydrates, fibre, protein, fat as well as water of which are essential for human development, maintenance, repair and protection. Consumption of vegetables and fruits play a positive role in the prevention of obesity, heart diseases, stroke, cancer and other chronic diseases (Boffeta *et al,* 2010). In Ghana, there are several traditional vegetables and as well imported vegetables, they include garden eggs, okro, tomatoes, carrots, cucumber, spring onions, lettuce, cabbage, etc.

Butternut squash (Cucurbita moschata) also known as 'butternut pumpkin' is a fruit vegetable from the family cucurbitaceae and genus cucurbita. It is a fast growing vine that creeps along the surface in a similar fashion as that of other cucurbitaceae family of vegetables and fruits like pumpkin, cucumber, cantaloupes and others. This widely grown vegetable is very rich in vitamin A, C, B6 and good source of minerals like potassium, magnesium, sodium and calcium which are very necessary for normal life processes. Aside these nutrients, this vegetable produces a considerable amount of carbohydrate, dietary fibre, iron and protein (Stewart, 2008).

Butternut squash is a multi-faceted vegetable which can also serve as an ornamental or decorative cucurbits aside it's nutritional and health benefits. According to Wikipedia (2018), farm entertainment sector or business has created a niche for the patronage of

decorative or ornamental cucurbits: the sizes, shapes, patterns, radiating colours of cucurbits fulfil its ornamental purposes. Winter squash or butternut squash present a lot of opportunities in current dispensation to farmers or growers. Preferred varieties are cultivated for the purpose of commercial canning and serving of other purposes. In advanced countries like the United State, there is buoyant market for ornamentals in entertainment farming. In the class of cucurbits, butternut squash and pumpkins are very strong and resistant to diseases and insects. Pumpkin and butternut squash are good sources of β-carotene for human consumption.

Ghana in recent times has embarked on the production and exports of cucurbits because of the global trend in this sector. The astronomical demand for cucurbits both locally and internationally has boosted the investment in butternut squash in Ghana (Gyamena, 2013). The investment and production of cucurbits has gained popularity in Ghana. The production and cultivation of cucurbits can be done throughout all seasons in Ghana. Other varieties of cucurbits can even survive during dry seasons or in seasons with limited moisture content in the soil (Gyamena, 2013). In exercising their mandatory roles, the Export Development and Agricultural Investment Fund (EDAIF) and Ghana's Export Promotion Council have collaborated to introduce butternut squash as a new export commodity from Ghana (Gyamena, 2013). EDAIF has invested an amount of GH₵ 37,000 which is equivalent USD 18,439.7 in the production and export of cucurbit specifically butternut to the United Kingdom (GNA, 2012). For the purpose of poverty alleviation and betterment of livelihood, international organizations such as International Fund for Agriculture Development (IFAD), the African Development Bank (AfDB) and other farmers' associations such as the Northern Rural Growth Programme have financed the

production and growing of cucurbits, particularly butternut squash. This was to encourage farmers in the northern part of Ghana to help improve their standard of living (GNA, 2012; IFAD, 2012). Through social intervention programmes, the Government of Ghana through the Savannah Accelerated Development Authority (SADA) has invested an amount of GH₵ 50 Million in the production of butternut squash in the three Northern regions (Ghana Gov, 2012; GNA, 2012; GBN, 2011; GNA, 2011).

1.2. Statement of Problem

Butternut squash is a versatile fruit vegetable which is grown both locally and internationally. Though it has been used for centuries in Europe and Asia, this cannot be said of it in Ghana. In spite of it being a rich source of vitamins and minerals, it is mostly neglected to be used as food. More to its nutritional benefits, its bulky nature enhances satiety and it is very cheap to buy which can be a source of food security. There is therefore a need to create awareness of the food potentials of Butternut squash. To enhance its use as food, butternut squash could be incorporated into common foods that are readily consumed to ensure food quality.

1.3. Main Goal

To ascertain the potentials of Butternut squash as food.

1.4. Specific Objectives

Specifically;

1. To document the knowledge gap pertaining to butternut squash.
2. To incorporate Butternut squash into different types of cakes

3. To assess the sensory and basic nutritional profile of the cake

1.5. Justification of Project

Butternut squash is rarely used in most Ghanaian homes. The very few people who consume it also use it as an alternate vegetable when some preferred vegetables are unavailable. Butternut squash is an excellent source of vitamin A and carotenoids which when utilized could contribute to enhancing ocular health of its consumers. Though many vegetables and fruits have vitamin C, exposure to atmospheric oxygen and heat have been noted degrade it. However, the vitamin C retention in butternut squash after cooking is unusually high as compared to other vegetables which makes it unique.

These qualities together with others call for the need to make known the usefulness of this important vegetable. In making its consumption more enhanced, a food to consider for its incorporation should be very popular and highly preferred by consumers; cakes satisfy this description. The incorporation of Butternut squash into cakes will not only enhance its use, it will as well increase the nutritional characteristics of cakes.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1. The Origin and Locations of Cucurbitaceae

Cucurbitaceae is a family name encompassing predominantly tropical plants of about 125 genera and 960 species (Gyamena, 2013). The earliest use of cucurbits dates back to 500 BC in Mexico (Botgard, undated).Cucurbits have significant use in the food, medical, and agrochemical industry (Schaefer and Renner, 2011; Wehner and Maynard, 2003)

cucurbitaceae of Africa and Asia origin are called old world cucurbits and they include cucumber, water melon and muskmelon. Those of America origin are termed New World cucurbits and they include butternuts squash and zucchini squash. Cucurbitaceae grow very well in tropical and subtropical, climates like in South America (Mexico) south- East Asia, West Africa and Madagascar, due to their intolerance to frost, although they are cultivated in parts of all the five main continents, (Wehner and Maynard, 2003).

2.2 Mostly Cultivated Cucurbits in the World.

2.2.1 Cucurbits Cucumis

The cucurbits cucumis originated from cucumerinae and other general species melothrieae. The characteristics of cucumis are; they have the tendency to climb, they are rough to touch and are covered with scales or scurf and it mostly has a slender stem-like structure by which some twining plants attach themselves to an object for support. They are circular and leafy in shape. The cucumis which include; cucumis sativus popularly known as cucumber and cucumis melo also called melon has an African origin.

2.2.1.1 CucumisSativus

Cucumis sativus or cucumber has its origin from India. It is associated with the family of gourd. It has the tendency to climb or creep. It has a drooping, nodding or pendulous fruits. The fruits vary according sizes. It has a greenish colour and its fruit can serve as vegetable. It takes up to four (4) months for it to mature after planting. It thrives well in rich soils and areas with full sun (Mendoza, 2002). It is an edible vegetable that can be cultivated for domesticate purposes and commercial reasons. Its usage is very common in our environs. Its nutritive components make it highly patronized.

2.2.1.2 CucumisMelo

Melon as scientifically called cucumis melo has its origination from Africa. The texture varies so do the sizes and shapes. The colour is mostly yellowish; there are enormous seeds in the mesocarp. The seeds are furrowed and white in nature (Dadshani, 2002).

2.2.2 Cucurbits Momordica

The Momordica cucurbits are classified under the tribe of Joliffieae. It has the tendency to creep. Momordica leafs are mostly egg-like and heart-like in shape. It has male and female reproductive organs in the same plant or separate plants (Anmin et al., undated). Momordica is very economical when it comes to charantia, basalmina, cochinchinensis, etc. It is predominantly cultivated in the Eastern part of Asia.

2.2.2.1 Bitter Gourd (Momordicacharantia)

Bitter gourd is predominantly in Asia specifically China and India. It is cultivated through the tropic lands. The fruits are always in nodding or pendulous position. It is domestically used in Himayans and Yunnan. (Dahal, 2002).

2.2.2.2 Bottle gourd

Bottle gourd probably originated in Africa or India. The fruits are of variable shapes and sizes ranging from 10 cm -100 cm or more in length with hard and durable rind. The fruits are usually either flattened, globular, bottle-club shaped or crook-necked or coiled, with

many seeds. The white or tan seeds are compressed and ridged and are approximately 2 cm long (Kpongor, 2002).

2.2.3.1 Watermelon (Citrulluslanatus)

The cultivation of watermelon is mostly done in tropical regions. Watermelons are usually elongated which deviates from a square or circle or sphere; this means watermelon are neither spherical nor circular. Its outer covering or rind is smooth with green colour. The seeds available in watermelon are sweets (Bastas, 2002).

2.3 The Butternut Squash (CucurbitaMoschata)

Butternut squash also known as butternut pumpkin or winter squash is a trailing seasonal plant which produces yellow flowers with lobed leaves. It is bottle shaped when matured and the fruit has orange flesh an edible seed. Cucurbitamoschata is intolerant to cold temperatures, it requires warmer climates and therefore grows very well in rich and well-drained soil in the sun. Every part of the squash plant can be eaten including leaves and tender shoots. Butternut squash matures between 80-140 days and yields are 3-6 fruits per plants with each crop weighing 2-5 kg. (Tindall 1983). The hard nature of butternut squash enables the crop to tolerate moderately harsh environmental conditions and resistant to many pests of cucurbits (Bonjour et al, 1990). The documentation of the uses and ancestry of butternut squash has been established in America as a continent, the butternut can serve as an ornamental crop and edible crop (Piperno et al. 2000; Piperno and Stothert 2003; Piperno, 2011 and Ortiz et al. 2013)

Figure 2.1. CucurbitaMoschata (Butternut Squash)

2.4 Ghana in the Production and Exports of Cucurbits

The astronomical demand for cucurbits both locally and internationally has boosted the investment in butternut squash in Ghana (Gyamena, 2013). The investment and production of cucurbits has gain popularity in Ghana. The production and cultivation of cucurbits can be done throughout all seasons in Ghana. Other varieties of cucurbits can even survive during dry seasons or with seasons with limited moisture content in the soil which can be a source of food security during the lean season. The Export Development and Agricultural Investment Fund (EDAIF) under the auspices of the Ministry of Trade and Industry of the Government of Ghana provide financial resources and assistance for the development of the export trade of Ghana (Growafrica, 2018). In exercising their mandatory roles, the Export Development and Agricultural Investment Fund (EDAIF) and Ghana's Export Promotion Council have collaborated to introduce butternut squash as a new export commodity from Ghana. Export Development and Investment Fund has pump in an amount of GHC 37,000 which is equivalent USD 18,439.7 in the production and export of cucurbit specifically butternut to the United Kingdom (GNA, 2012). For the purpose of poverty alleviation and betterment of livelihood, international organizations such as International Fund for Agriculture Development (IFAD), the

African Development Bank (AfDB) and other farmers association such as the Northern Rural Growth Programme have financed the production and growing of cucurbits, particularly butternut squash, to encourage farmers in the northern part of Ghana to help improve their standard of living (GNA, 2012; IFAD, 2012). Through social intervention programmes, the Government of Ghana through the Savannah Accelerated Development Authority (SADA) has pump in an amount of GHC50Million in the production of butternut squash in the three Northern regions. (GoG, 2012; GNA, 2012; GBN, 2011;
GNA, 2011).

2.5 Health Benefits of Butternut Squash

Cucurbits such as butternut squash is fruit but is sometimes regarded as vegetables. The required intake of fruits and vegetables has a positive effect on our health conditions. The consumption of butternut squash reduces the risk of heart related diseases, diabetes, etc. According to Leung (2007), butternut squash leaves and other cucurbits leaves serve as medicinal purpose, these leaves are used in the treatment of sore throat disorders, diarrhea, conjunctivitis, burns etc. of infants. Current researches in medicinal plants have discovered the medicinal properties in butternut squash and other cucurbits. Bitter gourds produce chemical elements such as hypoglycemic, this compound has effect in men and mostly used in the treatment of diabetes (Ananya and Raychaudhuri, 2010). Further research by Dhiman *et al* (2012) indicates that, water extract from cucurbits minimizes the risk of diabetes. Cucurbits have gained prominence when it comes to the development and manufacturing of antiviral drugs. Some cucurbits extract when tested on rabbits exhibited Anti-HIV activity (Ananya and Raychaudhuri, 2010).

Butternut consumption decreases the risk of obesity, diabetes, heart disease and mortality as well as complexion enhancement and increase in energy (Hanif and Iqbal, 2006). The potassium found in butternut squash prevents high blood pressure, reduce the risk of death from all types of stroke and cardiovascular disease (Ananya and Raychaudhuri,2010). The beta-carotene and other carotenoids present in butternut squash lower the risk of asthma and colon cancer. Vitamin A content in the cucurbit boosts proper hair growth and improve complexion of skin. The presence of vitamin C in the fruit vegetable helps builds and maintains collagen which provides structure to skin and hair. Dietary fibre in the cucurbit prevents constipation, decrease inflammations in the body and lower cholesterol-levels. Vitamin C and beta- carotene also help boost immune system.

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2.6 Dietary Use of Butternut Squash

The varieties of cucurbits can be utilized as vegetables, fruits etc. In the case of cucurbita moschata (butternut squash) it can serve both as vegetables and fruit. Cucurbita moschata (butternut squash) and other cucurbits are multi-functional. According to Deyo and O`Malley (2008) virtually every part of cucurbita moschata or butternut squash as popularly called serves as food, from the leaves, fruits, flowers etc. Watermelon, pumpkin and other cucurbits can be used as confectionary, in baking of pastries, making of soaps, fodders etc (Rahman et al., 2008; Lira and Caballero, 2002).

2.7 Importance of vitamin and minerals salts to human nutrition

Vitamins and minerals are essential nutrients because they perform a number of roles in the body. These serve as raw materials which the body use to perform its numerous

functions together with other dietary components. They help shore up bones, heal wounds, boost immune system, convert food into energy and repair cellular damage. Vitamins and minerals are needed in smaller quantities by the body, however, failure to obtain the needed quantities of these micro nutrients will result in deficiency diseases. Vitamins are organic and can be broken down by heat, air, or acid due to their fragile nature whereas minerals are inorganic and hold on to their chemical structure. Vitamins are grouped into two, water. Soluble vitamins and fat soluble vitamins. The water-soluble vitamins include thiamine (vitamin B1) Riboflavin(vitamins B2) niacin (vitamin B3), pantothenic acid (vitamins B5), pyridoxine (vitamins B6), biotin (vitamins B7)Folic Acid (vitaminsB9) cyanocobalamin (vitamins B12) and ascorbic acid (vitamin C). These are packed in watery portions of the plant foods that are consumed and they are directly absorbed into the bloodstream as food is broken down during digestion. Several of the B vitamins are components of certain coenzymes that help release energy from food; thiamin, Riboflavin, niacin, pantothenic acid and biotin produce energy; pyridoxine, cynocobalamin and folic acid metabolize amino acids and help cells to multiply and ascorbic acid help make collagen, which knits together wounds, supports blood vessel walls and forms a base for teeth and bones. (Hanif and Iqbal, 2006) Fat soluble vitamins include retinol(vitamin A), cholecalciferol (vitamin D) tocopherol (Vitamin E) and phyloquinone (vitamin K). These are found in fatty foods and oils. After digestion fatsoluble vitamin enter the blood by the lymph channels in the intestine wall and travel through the body only under escort by proteins that act as carriers (Stewart,2010). Fat tissues and the liver act as the main holding pens for these vitamins within in the body and are released when needed. These nutrients help keep the eyes, skin, lungs, gastrointestinal tract and nervous system in good repair. They also help in bone formation, keeping of cell healthy and proper vision. Macro minerals like sodium, chloride

and potassium maintain the proper balance of water in the body. Calcium, phosphorus and magnesium help in proper bone formation. Sulphur helps stabilize protein structure, including some of those that make up hair, skin and nails.

Some micro minerals such as iron is best known for carrying oxygen throughout the body; fluoride strengthen bones and wards of tooth decay; zinc helps blood clot, is essential for the sense of and smell as well as boost immune responses and copper helps form enzymes one of which assists with iron metabolism and the creation of haemoglobin, which carries oxygen in the blood. The best way to get sufficient amount of the vitamins and minerals salt is eating a healthy diet.

2.8 Nutritional Quality and Benefits of Vegetables

The significance of vegetables in our foods cannot be underestimate, every balanced diet is being encapsulate by vegetables. There is an element of phytonutrients and phytochemicals in vegetables which makes them distinct from other vegetable groups. According to Dias (2012), consumption of healthy vegetables positively influences our body system, it improves our sights, eradicate or minimize heart related diseases and other chronic diseases that we embattle with. The phytochemical elements in vegetables produce antioxidants that facilitate the modifications of metabolisms and detoxifications of chemicals such as carcinogens.

For the perfect functionality of the body, the maintenance and upkeep of our body system and active reproduction, vegetables always come into play. Every vegetable has its unique component and elements, some vegetables possesses enough starches, others possesses high protein content, most vegetables lacks fats which is essential or good for obese patients, other vegetables also possess fibres, minerals such as potassium, sodium,

phosphorous are embedded in some vegetables which helps in our body functions (Hanif&Iqbal, 2006). The fibres can serve as a stock feed for dogs and cats. Intake of the rough fibres address issues pertaining to digestive problems.

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2.9 Nutritional constituents of butternut squash

Studies have shown that the compositions of pumpkin and butternut squash have essential elements such as β-carotene which is good for human consumption. β-carotene, as one of the compositions in butternut squash contains carotenoids which influence the prevention of heart related diseases, cancer ailments because of their antioxidant properties (Edge et al., 1997; Fraser and Bramley, 2004; Chen, 2015). β-carotene and α-carotene possesses vitamin A which enhances human vision, boost immune system function, and growth and development of our body make up (Chen, 2015). Butternut squash comprise of many vital, polyphenolic antioxidants and vitamins but rather has very low calories, 100g provides just 45 calories. It contains no saturated fats or cholesterol but is a rich source of dietary fibre and phytonutrients (Gyamena, 2013).It contains more vitamin-A 10,630Iuper 100g constituting about 354 % of RDA which when consumed would ensure quality food intake. Vitamin A is known to be a powerful natural anti-oxidant which is required for maintaining healthy skin and hair. Cucurbita moschata contain polyphenolic flavonoid compounds like α andβ carotenes,cryptoxanthin-β and lutein. These are converted into vitamins A in the body. It is rich in the B-complex group of vitamins such as folates riboflavin, niacin, pyridoxine, thiamin and pantothenic acid. It also contains adequate levels of minerals like iron, zinc, copper, calcium, potassium, phosphorus and magnesium.Carbohydrates and proteins are also found in butternuts.

2. 10 Fermentation and Phytoactives of Butternut Squash

Fermentation of butternut squash can be done in so many ways. Generally, the squash needs to be peeled, the peelings can be reserved for the fermentation process. Chop the squash into preferred size, the chopped squash is then placed in a jar or container, the peelings can be added to the chop squash with other ingredients and cover with water, make sure the squash stays beneath the water, allow the fermentation process to thrive at a room temperature for specified period of time (Aubrey, 2018).

2. 11 Cucurbits as Ornamental or Decorative Plants

Butternut squash is a multi-faceted vegetable, apart from its nutritive and other health benefits, it can also serve as an ornamental or decorative cucurbits. According to Wikipedia (2018) farm entertainment sector or business has create a niche for the patronage of decorative or ornamental cucurbits, the sizes, shapes, patterns, radiating colors of cucurbits have fulfilled its ornamental purposes. Winter squash or butternut squash present a lot of opportunities in current dispensation to farmers or growers.

Preferred varieties are cultivated for the purpose of commercial canning and serving of other purposes. In the advance countries like the United State, there is buoyant market for ornamentals in entertainment farming. In the class of cucurbits butternut squash and pumpkins are very strong and resistant to diseases and insects.

2.12 Sensory Acceptability of Cucurbits in Baking Cake

The experiences of chefs are mostly epitomized with baking skills. Baking exploits justifies the expertise of chef's. Cakes come with varieties; these varieties are meant to suit taste

and preference of individual consumers. The varieties are also enriched in key nutrients that help individual growth (Marcos, 1995). Cakes are predominantly in every bakery shops, a lot of designs and decorations can be done with few cakes. Cakes are adorned or embellished based on the occasion. The occasion mostly determines the type of cake. Cakes are easily adaptable. The production of cakes requires a clear understanding with respect to the ingredients used and the method of mixing the ingredients. An in-depth knowledge in cake making is always a prerequisite when it comes to cake production (Labensky et *al* 2006). The vital point to consider in cake baking is the mixture of ingredients. The available ingredients to be used must be of equal temperature. Equal measurements of ingredients such as egg, sugar and flour are a basic necessity. The modification or variation in cakes sometimes occurs through the addition of baking powder and milk. The weight differentials of the ingredients must be considered (Dogshun and Peters, 2008).

Butternut squash is associated with cucurbitaceae group. Beyth *et al*. (2006), describes butternut squash as a lively and fleshly food specifically vegetable secured by hard smooth natural covering. Butternut squash possess least calories content; this makes them desirable in our foods and diet patterns. Blanco (1883) shared the view that, most countries such as Philippines used butternut squash flowers and young shoots as vegetables. Squash contains an appreciable amount of nutrients. Watson (2003) also emphasized that, squash related products are pleasant and nourishing, it healthy for human consumption and body build up. He recommended it to be used in our daily diets.

The varied quantities of butternut squash in baking of cake influences the sensory acceptability. The sensory evaluation based on mouth feel, sponginess or texture, aroma, colour, sweetness, appearance etc were influenced by the proportions or quantities of

butternut squash. The sensory acceptability was varied because of the variations in squash quantities. Squash is easily accessible, very economical and on top very nutritive. For profit oriented purposes, major stakeholders and other interested partners who are into the production of cake needs to factor squash as one of their major ingredients (Borro and Gemora, 2016).

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CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1. Source of Butternut squash

The butternut squash was obtained from Tanoso market Kumasi Ashanti Region of Ghana. The riped ones were obtained which had light brown skin with orange fruit colour and weighed between 2 kg and 2.5 kg.

3.2. Sample Preparation

The butternut squash after collection were washed under running tap to clean all dirt and finally washed with brine (5%). They were peeled, cut into pieces and grated. The pieces were blended with addition of water (500g of grated butternut squash to 200ml of water).

The water in the pulp was extracted (70%) using a fine muslin to squeeze out the water to reduce the moisture content in order to incorporate it into rich cake mixtures.

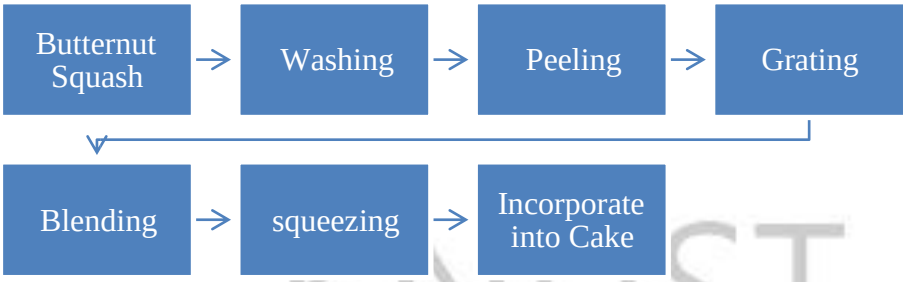

Fig 3.1.1. Flow diagram of butternut squash preparation and incorporation into rich cake mixtures

3.2. Cake Preparation

Basic recipe of 100g rich cake mixture was used as control to be compared with other three recipes of 100g rich cake mixtures of which each had ingredients such as sugar, flour and margarine reduced and butternut squash replaced. The sugar and fat were creamed together until fluffy, the eggs were whisked until foamy and added to the fluffy mixture and stirred. The flour was sifted together with the baking powder and folded into the mixture (for the normal rich cake). Vanilla essence was added and baked at 180^0C for 40minutes. The rest which had the butternut squash, the pulp of the butternut squash was added after the eggs before the flour. Then the rest of the procedure followed just like the normal rich cake. The modified ingredients are shown below.

Table 3·1·1: Modified Formulations for rich cake with Butternut Squash Incorporated

Rich Cake	Reduced Sugar	Reduced Margarine	Reduced Flour
100g sugar	25g sugar	100g sugar	100g sugar

100g margarine	100g margarine	25g margarine	100g margarine
	75g butternut squash	75g butternut squash	30g butternut squash
¼ tea spoon baking powder	¼ tea spoon baking powder	¼ tea spoon baking powder	¼ tea spoon baking powder
2 eggs	2 eggs	2 eggs	2 eggs
100g flour	100g Flour	100g flour	70g flour
2 drops of vanilla essence	2 drops of vanilla essence	2 drops of vanilla essence	2 drops of vanilla essence

3.4. Proximate Analyses on Cakes

Proximate analyses were carried out on the various cakes; the rich cake without the butternut squash as well as those with the proportions of butternut squash with a reduction of one particular ingredient such as flour, margarine and sugar respectively.

3.4.1 Moisture Content Determination

Four (4g) grams each of the samples were weighed with the Analytical balance (Mettler Toledo) on to pertri dishes previously dried and weighed. The samples were then dried in a thermostatically controlled forced air oven (Binder GmbH, Gernany) at 105^0C for 8 hours to constant weight. The petri dishes were removed and transferred into desicators for

cooling after which they were weighed. The samples were duplicated and the averages taken. Moisture content was determined as shown in Appendix I (AOAC, 1990)

3.4.2 Crude Protein Determination

The Kjeldahl method (AOAC, 1990) was used for the determination of crude protein content of the cake samples.

Digestion: Two (2g) grams each of the samples, (duplicated) were weighed and placed in Kjeldahl digestion flasks together with a small amount of selenium-based catalyst and few anti-bumping agents. Concentrated H_2SO_4 of volume 25ml was added and the tubes shaken until the entire samples were thoroughly wet. The flasks were placed on a heated (approximately 410^0C) for 2 hours until the resulting solutions were clear. They were then cooled to room temperature and the digested sample solution transferred into 100ml volumetric flask and made up to the mark.

Distillation: The Distillation apparatus was flushed with distilled water for about 10 minutes. Twenty-five (25ml) millilitres each of 2% boric acid was pipetted into 250ml conical flasks (8 of them for duplication) and 2 drops each of mixed indicator added, until pink colour is obtained.

The conical flasks and their contents were placed under condenser with the tip of the condenser completely immersed in the boric acid solution. Ten (10ml) millilitres each of the digested samples solution and about 20ml of 40% NaOH solution were transferred into the decomposition flask of the Kjeldahl unit and fixed. Ammonia (NH_3) liberated during the distillation was collected, the boric acid solution changing it from pink to bluish-green. The distillates were titrated with O.1N hydrochloric acid (HCL solution until the solution

changed from bluish-green to pink. The end point was recorded and the titre values obtained were used to calculate the total nitrogen and the percentage crude protein determined (Appendix I), (AOAC, 1990)

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3.4.3 Crude Fat Determination

Two (2g) grams each of the cake samples were weighed into folded fitter papers plugged at the opening with glass wool and placed into thimble holders. Petroleum either/ spirit of 150ml. B.P 40-60^{O}C (each) were measured into a previously dried and weighed 250ml round bottom flask and these were assembled together with the thimble holders and their contents.

The Quickfit condensers were connected to the Soxhlet, Extractor and refluxed for six hours on low heat on heating mantle. After extraction the thimbles were removed to recover solvent by distillation. The flask and fat were heated in oven at 103^{0}C to evaporate the solvent. Flasks and their content were cooled to room temperature in a desicator. Flaks were weighed to determine the weight of fat collected. (Appendix I), (AOAC, 1990)

3.4.4 Ash Determination

Two (2g) grams of each of the cake samples in duplicate were weighed into a tarred and pre-dried previously weighed porcelain crucible. The samples were placed in muffle furnace (Gallenkamp, England) and ignited for 2 hours at 600c. After ashing, the crucibles were cooled to about 105^{o}C. The crucibles were quickly transferred into a desicator with a porcelain plate and desiccant to cool to a room temperature. The crucibles and their content

were weighed and the weight reported as percentage ash content (Appendix I), (AOAC, 1990).

3.4.5 Carbohydrate Determination

Carbohydrate content was determined by the difference method ,where the value of the crude protein, crude fibre, crude fat, moisture and ash constituents of the samples were added and subtracted from 100.

%Carbohydrate=(100-[%Moisture+ %Ash+ %Crude Protein+%Fat +Crude Fibre])

3.4.6 Crude Fibre Determination

Two (2g) grams samples each was weighed from crude fat determination samples into 750ml Erlenmeyer flask. Two hundred (200ml) millititre of 1.25%H_2SO_4 was added and immediately the flask was set on hot plate and connected to the condenser to boil for 30 minutes. The flask was removed and the solution was immediately filtered through linencloth in funnel and washed with large volume of water. Filtrates were washed back into flask with 200ml 1.25% NaOH solutions. Flask condenser was connected and boiled for exactly 30minute. They were then filtered through Fischer's crucible and wash thoroughly with water and 15ml 96% alcohol, Crucibles and their contents were dried for 2 hours at 105c. They were cooled in desiccator and weighed. (Appendix 1), (AOAC, 1990).

3.4.7 Mineral Elements Determination (Ca, Mg, K, Na)

0.15g of each samples were weighed and digested like the protein and cooled.

Concentrated HCL (37%w/w) was obtained from Surechem Products (England). Deionized water (Siemens Water Technologies- Ultra Clear RO EDI 10 was used in the

preparation of the diluted acid. Standards for the calibration was prepared by serially diluting the stock solution with 0.1%HCL to obtain calibration solutions of different concentration. Analyte-free solution (0.1% HCL) was used as the blank during the instrument calibration.

Instrumentation; Flame atomic absorption Spectroscopy (FAAS) measurements were carried out on an Analytikjena model novAA400P atomic absorption spectrophotometer using thesingle-beam optical mode. Hollow cathode lamp (HCL) for the respective elements were used as light source for the analysis. Compressed air and acetylene (N26 quality, Air Liquid, Ghana) was employed as the oxidant and fuel gas respectively for the flame. The integration time for all the measurement was 3.

The measurement procedure: The samples were aspirated using a pneumatic nebulizer into a flame where the ions were reduced to elements and vaporized. The elements present in the samples absorbed light generated from the HCL at specific wave-length in the ultraviolet spectrum. The transmitted light was detected with a detector after going through on monochromator.

Calibration curve: Prepared standard solutions of at least five (5) different concentration were used to calibration the instrument before all the analysis. The measured absorbance of these standard solutions were used to prepare a linear calibration curve. The curve was used to determine the unknown concentration of elements in the samples (Appendix I), (AOAC, 1990)

3.4.8 Energy Content Determination

The energy value was determined based on the Atwater factor and was obtained by multiplying the values for percentage composition of carbohydrate, fat and protein expressed as calories per gram or kilojoules per gram. The calorific values of various food components as well as the formula for calculating the energy value of foods are shown in Appendix I.

3.5 Sensory Assessment

A sensory evaluation score sheet was used to retrieve data base on the Five-point Hedonic scale. The following scores and their descriptions were used to evaluate each sample : one(1)as Disliked very much; Two (2)as Disliked; Three (3)as Liked slightly; Four (4)as Liked moderately; Five (5)as Liked very much. These scores were assigned for the evaluation of the products in the sense of taste, aroma, firmness, colour, texture and moistness.

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CHAPTER FOUR

4.0. RESULTS AND DISCUSSION

4.1. The Knowledge of Butternut Squash

In order to document the knowledge gap pertaining to butternut squash a survey was conducted within Kumasi Metropolis to find out from respondents their knowledge level about butternut squash (*cucubitaMoschata*.). Questions of keen interest were asked to find out if consumers of vegetables have any knowledge about butternut squash, its nutritive value and other essential benefit of it. The survey also sought to find out if respondents know of any product made from butternut squash.

Table 4.1. Demographic characteristics of respondents on the survey conducted.

	Category	**Frequency**	**Percentage**
Gender	Male	87	28.9%
	Female	213	70.9%
Age Range	15 – 25	125	41.7% 31.3%
	26 – 35	94	17.3%
	36 – 45	52	9.3%
	45 and above	29	
Educational level	Tertiary	48	16%
	O'level	21	7%
	SSS/SHS	128	42.7%
	Vocational/ Technical	37	12.3%
	JSS/SHS Primary	35	11.7%
	Illiterate	29	9.7%
		2	0.6%

Demographic characteristics of respondents captured in the study include age, gender, nationality and educational level. These were analyzed based on the total number which is 300. From the results obtained all respondent were Ghanaians. Considering the age groups, those who fall within 15-25 obtained the largest value which is 125 (41.7%) out of which 25 (8.3%) were males and 100 (33.3%) were females. Those who fell within the ages of 26-35 followed with 94 (31. 3%) out of which 40 (13.3%) were males and 54 (18 %) were female. The age group which fell within 36 -45 obtained 52 (17.3%) out of which 15(5%) were males 37(12.3%) were females. The age group which fell within 45 and above obtained the least value of 29 (9.3%) out of which 7 (2.3%) were males and 22 (7.3%) were females. From the results, it could be inferred that the age groups were not fairly represented. Majority fell within the 15-25 age group, owing to the fact that they were people who were willing to respond to the questionnaire.

The educational level captured illiteracy, primary, JHS, SHS, O'level and tertiary.

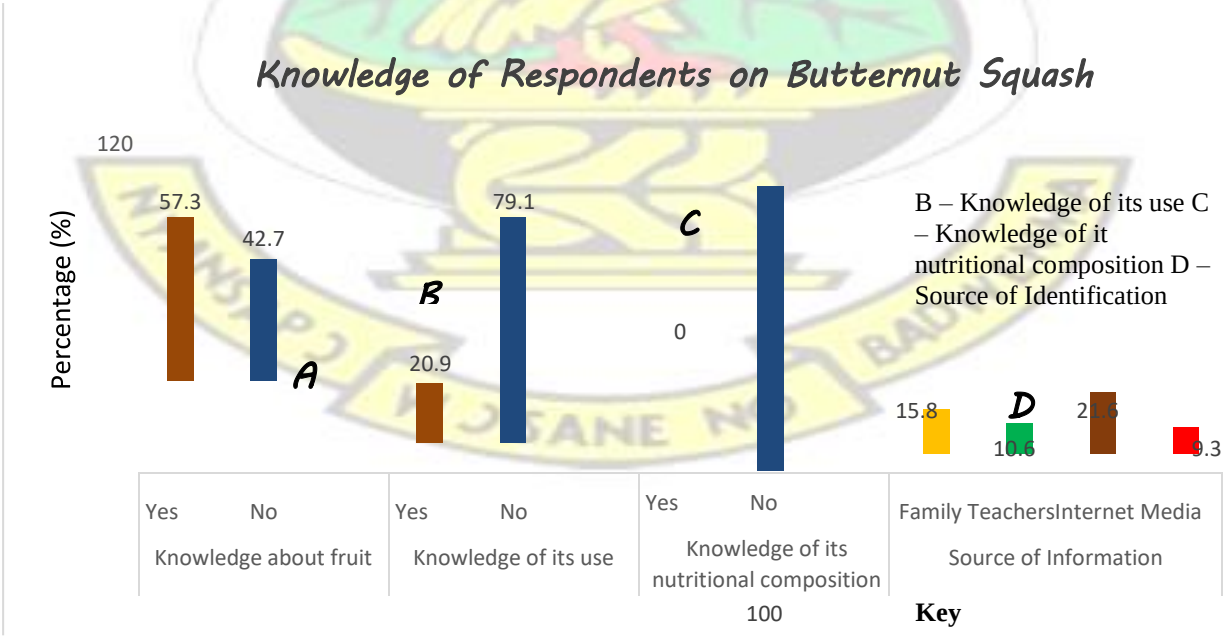

Fig 4.1.1 Distribution of responses of the knowledge of Respondents

From the results, 128 out of the three hundred respondents representing 42.7%, irrespective of their educational background had no knowledge about the butternut squash. Which meant that they had not heard, seen or used butternut squash before. From the table, 47.7% of the 172 respondents who had heard about butternut squash got the information from their teacher representing, followed by 23.8% who had the information from the internet and 7.6% had their information from the media. Upon further enquiries, some respondents professed to have just heard or seen it but they have not actually used vegetables butternut squash and therefore could not tell of any known product that could be made from butternut squash. These respondents can be said to partially belong to those who have no knowledge about butternut squash since apart from hearing and seeing the vegetables nothing else is known about it to them. Statistically, it increased the number of respondent who have no knowledge about the vegetables.

Few of the respondent (36 out of the 172) representing 20.9% who claimed to have had the information from family members, professed that they knew of butternut squash, it can be used for soups, stews or just cooked and eaten. Per the responses given, it was assumed that these respondents used butternut squash in their homes. In seeking the level of

knowledge of these few (36) respondents about butternut squash, the researcher inquired from respondents if they knew the nutritive value of butternut squash and other essential benefits of it. Per the responses given, the respondents were not abreast with the nutritive value of the butternut squash.

It can be inferred from the discussion that butternut squash is not a household name when it comes to vegetables in the Ghanaian home setting, and the few people who consume it will not eat it often since they do not know the nutritional benefits of it.

4.2 Basic Nutritional Analysis of Cakes

The moisture, ash, protein, fat, crude fibre and carbohydrate content is shown in the table below.

Table 4.2.1. Proximate Analysis of the Various Cakes

Samples	Moisture%	Ash%	Protein%	Fat%	Crude fibre %	Total CHO%	Energy KJ/100g
Rich Cake	16.5117±0.25^{a}	1.124±0.00^{b}	4.958±0.11^{a}	26.330±0.72^{b}	0.1060±0.17^{a}	50.969^{a}	1924.97^{a}
Reduced Margarine	24.888±0.47^{b}	0.951±0.03^{a}	8.197±1.14^{a}	13.165±0.20^{a}	1.249±0.23^{b}	51.551^{a}	1502.82^{b}
Reduced sugar	27.562±0.23^{c}	1.234±0.01^{c}	7.676±1.97^{a}	29.450±1.70^{b}	0.418±0.03^{a}	33.659^{b}	1792.34^{c}
Reduced flour	22.913±0.41^{d}	1.131±0.04^{b}	4.955±0.41^{a}	28.732±1.18^{b}	1.096±0.05^{b}	41.172^{c}	1847.24^{c}
Butternut Squash	82.15±0.01^{d}	9.90±0.05^{d}	0.86±0.10^{d}	0.13±0.05$_{d}$	1.45±0.01$_{d}$	5.51	188.28

Mean values with different superscript (a, b, c, d) in column are statistically different at P>0.05
CHO= Carbohydrate.

The moisture contents of the different cakes samples differ comparatively. The value for the rich cake without the butternut squash had low moisture content as compared to those with the butternut squash, there was significant difference ($p<0.05$) in the moisture content. It could be said that if more butternut squash had been added, the moisture content would have increased. Butternut squash has high moisture content (Jenson, 1978). Fruits and vegetables usually contain moisture as high as 85%, however butternut squash has high moisture content 82% (Dari *et al*, 2016).

The percentages of ash in food samples give an indication of the quantities of element present in the food. In this study the value for ash for the reduced flour butternut squash cake was higher (1.131 mg) as compared to the rich cake without the butternut squash (1.124mg) though statistically, there was no significant difference at $p<0.05$. The reduced margarine butternut cake and the reduced sugar butternut cake rather had lower values for ash which is contrary to the findings of Dari et al. (2016) which presented the ash content of butternut squash 9.90g/100g. It also contradicts the affirmation of (FAO,1968) that vegetable species are good sources of minerals.

This may be due to unfavorable climatic and soil conditions of the location at which the butternuts squash was grown (MOFA, 2013). I f the climatic conditions and soil requirement as specified by (MOFA,2013) were good the ash content should have been higher to boost immune health and general life processes.

Protein content of the cake samples with the butternut squash increased comparing it to the rich cake without the butternut squash though statistically there was no significant difference with regards to their p values ($p>0.05$). The protein values were within the

World Health Organization (2007) and the United States Recommended Daily Allowance (RDA) minimum (0.45g) and maximum (0.8g) per kilogram of an ideal body weight per day, confirming (Dari et al, 2016) that butternut squash has appreciable amount of protein. Therefore, butternut squash can be a good source of vegetable protein supplementary in our diet.

Fruit and vegetables are mostly poor source of fat but when combined with foods that contain fat their nutritive quality can be improved. Comparing the rich cake without the butternut squash to reduced flour butternut squash and reduced sugar butternut cakes, the fat content increased although statistically, the increase was not significant at $p>0.05$. However, the samples with reduced margarine was significantly reduced ($p<0.05$). It confirms the conclusion drawn by Dari et al (2016) that butternut squash is a poor source of fat 0.13g/100g and (ABC, 2015)0.14g/100g. Meaning that when butternut squash is combined with foods that contain fat, then the minimum intake of fat according to (FAO,1995) of 15% of adult's energy intake would be met.

Crude fibre obtained from all the samples (2.8g) were lower than the Recommended Daily Intake which is 25- 35g per day as reported by Dari and Mahunu (2010). These results also confirm that butternut squash is a poor source of dietary fibre according to ABC (2015). The fibre content though lower can still assist in low absorption of sugar levels into the blood stream and contribute to decrease in concentration of high cholesterol level in the body (Onwordi et al, 2009). The values obtained were

significantly difference. ($p<0.05$).

Butternut does not have high concentration of carbohydrate and this can be seen from the values obtained confirming the 8g/100g reported by Tindall (1983) and the 9g /100g

recommended by USDA (2013). This makes butternut squash good and healthy food for weight reducing diet. Significant difference ($p<0.05$) existed in their value.

The values obtained presents the rich cake without the butternut squash as having the highest value of energy content i.e. 1924.97ks/100g with significant difference ($p<0.05$) when the butternut squash replaced some of the ingredient, the energy level depreciated confirming the report by USDA (2013) that butternut squash is a low calorie vegetable (219.43KJ/100g). It can be inferred from the values that butternut squash can be incorporated into foods like cakes to reduce the calories to makes cake consumption safe for those on weight reducing diet.

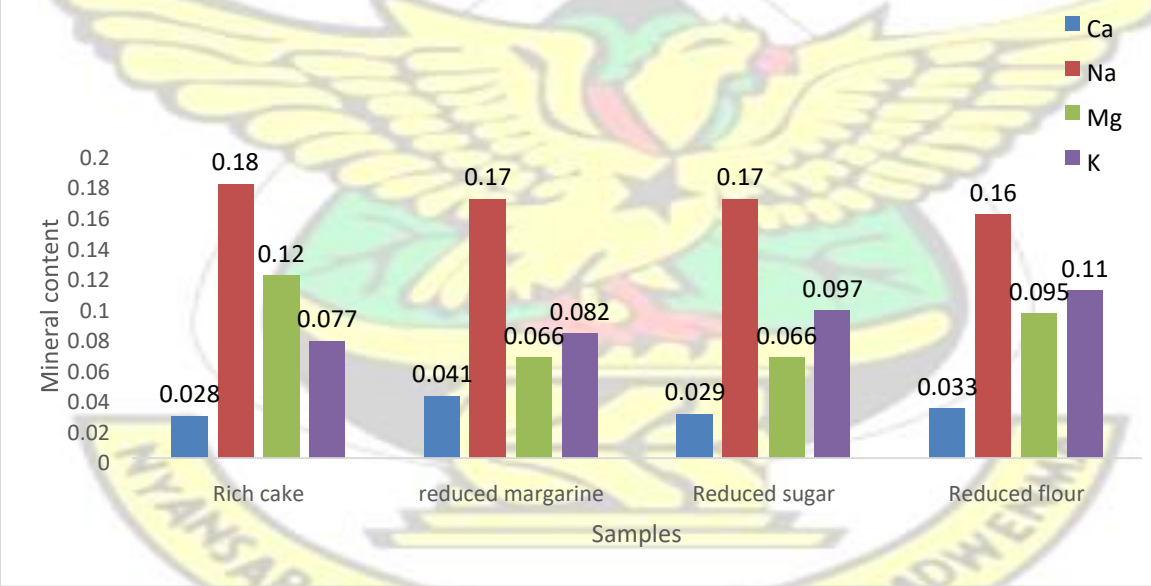

Fig 4.2.1. Graph 1 Metal Analysis of mineral content of the four cake samples (Ca, Na, Mg, K)

The ash content of the cake samples from the proximate analysis gave lower values, but the metal analysis gave a clearer view of the various metals analyzed which included calcium (Ca), sodium (Na), Magnesium (Mg) and Potassium (k).

Comparing the calcium content of the butternut cakes with the rich cake without butternut squash it could be observed that the cakes with the butternut squash had higher calcium content which also showed a statistically significant difference at $p<0.05$, confirming USDA's (2013) recommended value of 48mg/100g. The sodium content of butternut cakes compared with the rich cake without butternut squash placed all of them at par without significant difference at $p>0.05$ confirming USDA's (2013) report that butternut squash has lower value of sodium i.e. 4g/100g comparatively to the other metals but it is equally important.

Magnesium content of the butternut cakes when compared with the rich cakes samples were lower contradicting the USDA's (2013) value of 34mg/100g. This may be due to poor climatic and soil conditions as already stated. There was significant difference at $p<0.05$.

Potassium provided significant difference at $p<0.05$ among the values and comparatively, potassium content of the butternut squash cakes was higher than that of rich cake, confirming USDA's (2013) report that butternut squash has high potassium nutritive values of 352mg/100g.

Deductively, butternut squash has a large store of mineral element which can boost immune system and regulate body processes, therefore, there is the need to consume it.

4.3 Sensory Assessment of the Cakes

Taste (Sweetness) is a sensation produced when a small quantity of something eaten or drunk asses its effect on the sensory receptors location on taste buds on the oral cavity (tongue).

Table 4.3.1 Sensory Preference for Butternut Squash Cakes and rich cakes Samples Parameters Determined

Samples	Sweetness	Aroma	Firmness	Colour	Texture	Moistness
Rich Cake	4.3191[b]	4.3542[a]	3.9184[a]	4.1020[a]	4.0612[a]	4.3878 [b]
Reduced Margarine	3.6522[a]	3.8750[a]	3.9375[a]	3.9583[a]	3.7959[a]	3.6735 [a]
Reduced sugar	4.2340[b]	4.0833[a]	4.1702[a]	4.2245[a]	4.0408[a]	4.2449 [b]
Reduced flour	4.3043[b]	4.2653[a]	5.0816[a]	4.375[a]	4.3125[a]	4.2449 [b]

Evaluators preference to the reduced sugar butternut cake, reduced flour butternut and the rich cake without the butternut squash was high as compared to the reduced margarine butternut cake. Which was significant different from the rest at $p<0.05$.

Aroma is a distinctive pervasive and usually pleasant smell that determines flavors of food or other substance. Evaluators preference to the reduced sugar butternut, reduced flour butternut and the rich cakes as compared to the reduced margarine butternut cake was high though statistically there was no significant difference ($p>0.05$). This might be due to the fact that the less fat does not affect the product as desired.

Firmness is having a solid or compact structure that resist stress or pressure. The reduced sugar butternut cake was rated as being firm, followed by the reduced flour butternut cake. The rich cake was rated last as being firm. Preference for the butternut cakes were high though significantly there was no difference ($p>0.05$).

Colour is a visual sensation that depends on the light reflected and is perceived as white, yellow, blue and different shades. Physical specification of colour are also peripheral with objects based on their physical possession such as light absorption or reflection. Value obtained indicate preference of the reduced sugar butternut, reduced flour butternut and the rich cake to the reduced margarine butternut though significantly not different ($p>0.05$).

Texture refers to the feel and appearance of a surface i.e. its smoothness or roughness. In the sense of food, it is the structure of the substance when felt, touched or chewed. This is sometimes interchanged with mouthfeel which deals with the substance's physical and chemical interaction in the mouth, from initial perception on the palate to first bite, through mastication to swallowing and after taste. The mean rating on the table indicate preference of the reduced sugar butternut, reduced flour butternut and rice cake to the reduced margarine though significantly there is no difference ($p>0.05$) among the values.

Moistness refers to the humidity of a substance, slightly or moderately wet. Preference of the moist nature of the butternut squash cakes were high as compared to the rich cake. There existed significance difference ($p<0.05$) between the value of the butternut cakes and the rich cake. It can be deduced from the analysis that evaluators preferred the butternut squash cakes (except the reduced margarine) to the rich cake in terms of taste, aroma, texture, colour, firmness and moistness.

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CHAPTER FIVE

5.0. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

In conclusion, butternut squash is not a house hold name when it comes to vegetable in our Ghanaian home setting the survey revealed.

Butternut squash when added to the cakes increased the moisture, crude protein, fat and crude fibre content, though carbohydrate, energy ash and mineral element did not appreciate. The reduction of some vital ingredients such as flour, sugar and margarine in baking rich cakes were replaced with butternut squash at varying proportions. The sensory evaluation resulted in significant difference in the acceptability of the taste and moistness of the samples with the butternut squash. There was significance differences in terms of colour, firmness, texture and aroma as some of the vital ingredients were not reduced.

Butternut squash being nutritious should be maximized as key ingredient in baking cakes with the correct quantities of the chief ingredient like flour, sugar and fat (though the last

two can be reduced slightly) to ensure food quality. It will be expedient more research work is conducted on butternut squash to help unravel the nutritional, medicinal and economic values of it to ensure food safety and security. The need to incorporate butternut squash into food and drinks in our daily dietary pattern should be emphasized.

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5.2. Recommendations

A further investigation to use the butternut squash as a main ingredient in baking cakes and pastries as well as determining the shelf-life of the products is recommended.

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7.0. APPENDICES

7.1QUESTIONNAIRE FOR CONSUMERS OR CUSTOMERS

I hope you can supply me with some information which would be used for research purposes only. Confidentiality of the information provided will be upheld. I therefore seek your support and cooperation to complete the questionnaire. Thank you.

SECTION A: RESPONDENTS BIO-DATA (DEMOGRAPHIC CHARACTERISTICS)

Instructions: In order to answer the questions as honestly as possible, your name need not appear anywhere on the questionnaire. Please, note that there is no right or wrong answer. Your help in completing the questionnaire is of vital importance although participation is entirely voluntary.

Please tick (√) the appropriate boxes or write short sentences where necessary.

1. Gender: [a] Male [b] Female
2. Age: [a] 15 -25 [b] 26-35 [c] 35-45 [d] 45 and above
3. Nationality: [a] Ghanaian [b] Non-Ghanaian
4. Educational level: [a]Tertiary [b] 'O'level[c] Senior secondary [d] Vocational l[e] Junior secondary [f] Middle school[g]Primaryschool [h] Illiterate.

SECTION B: Knowledge about Butternut Squash

5.Have you heard about butternut squash? Yes [ ] No [ ]

6.If Yes to Q5 how did you hear it?

From family members [ ]

From the media [ ]

From the internet [ ]

From teachers [ ]

From friend [ ]

From market women[ ]

7. Have you seen butternut squash before Yes/ No

……

……

……

……

8. If yes can you describe it? Yes [ ] No [ ]

9. Do you know any food product made from butternut squash? Yes [ ] No [ ]

10. If yes what kind of product, mention it…….

11. Can you give any nutritional value of butternut squash?

…….....

12 .How did you use the butternut squash?.....

13.Do you know any benefit of butter nut squash ?..... ....

14.Would you appreciate if butternut squash is incorporated into foods like juices[ ] pies [ ] cakes[ ] drinks [ ] pastries [ ] biscuits [ ]?..... .....

15.Any further suggestions?..... .....

7.2 Proximate Composition Calcuations

Moisture content Determination

Weight of dish = W_1

Weight of dish + wet samples = W_2

Weight of dish + dry samples = W_3

$$\% \text{ moisture} = \frac{W_2 - W_3}{W2 - W_1} \times 100\ \%$$

Crude protein content Determination

The formula below was used to calculate the total percentage of nitrogen:

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

$$W \times 10$$

Where

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 gram of the samples taken

The percentage total nitrogen calculated was then converted to percentage crude protein by multiplying with the factor 6.25

Thus, Crude protein = % total nitrogen x 6.25

Crude Fat Content Determination

Weight of sample = W_1

Weight of flask = W_2

Weight of flask + fat = W_3

$$\% \text{ Fat} = \frac{W_3 - W_2}{W_1} \times 100\%$$

Ash Content Determination

Weight of crucible + sample = W_1

Weight of crucible = W_2

Weight crucible + ash sample = W_3

$$\% \text{ Ash} = \frac{W_3 - W_2}{W_1 - W_2} \times 100\%$$

Total carbohydrate determination

Total carbohydrate = 100 – (% protein + % fat + % ash + % moisture)

Table 1: Calorific values of foods and energy value determination

Constituents	Calorific value (KJ/g)	Kcal/g
Available carbohydrate	17	4.2
Protein	17	4.3
Fat	37	9.5
Alcohol	29	

Polyols (e.g. sorbitol in dietetic foods)	10
Organic acids	13

Source: James (1995)

Energy value (KJ/100g) =

(% available carbohydrate x 17) + (% protein x 17) + (% fat x 37)

Crude Fiber Determination Weight of samples = W_1

Weight of crucible + sample = W_2

Weight of crucible + ashing = W_3

$$\% \text{ crude fibre} = \frac{W_2 - W_3 \times 100\%}{W_1}$$

Mineral Elements Determination (Ca, Na, Mg, K)

$$\% \text{ Mineral Element} = \frac{\text{concentration in mg/l} \times 50 \times 100}{1000 \times 1000 \times \text{weight of sample}}$$

$$\% \text{ FAT (dry basis)} = \frac{\text{fat/oil collected} \times 100}{\text{Weight of sample}}$$

$$\% \text{ FAT (dry basis)} = \frac{(\text{wt of flask + oil}) - \text{wt. of flask} \times 100}{\text{Weight of sample}}$$

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

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 of sample taken

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1. Nitrogen free extract (NFE)

Calculation

NFE (%) =100 - (% moisture +% fat + % crude +% protein +% ash)

2. Carbohydrate

Calculation

Carbohydrate (%) = % crude fibre + % NFE

OR

Carbohydrate (%) =100 - (% moisture +% fat +% protein +% ash)

x. Calculation for dry basis = $\frac{(100\text{-}\%\ \text{moisture}) \times \text{wet basis}}{100}$

7.3 Statistical Tables

ANOVA

		Sum of Squares	Df	Mean Square	F	Sig.
SWEETNESS	Between Groups	14.091	3	4.697	4.434	.005
	Within Groups	192.812	182	1.059		
	Total	206.903	185			

TEXTURE	Between Groups	6.481	3	2.160	1.670	.175
	Within Groups	247.006	191	1.293		
	Total	253.487	194			
FIRMNESS	Between Groups	44.093	3	14.698	1.001	.394
	Within Groups	2774.798	189	14.681		
	Total	2818.891	192			
AROMA	Between Groups	6.491	3	2.164	1.767	.155
	Within Groups	231.447	189	1.225		
	Total	237.938	192			
COLOUR	Between Groups	4.535	3	1.512	1.612	.188
	Within Groups	178.187	190	.938		
	Total	182.722	193			
MOISTNESS	Between Groups	14.750	3	4.917	4.167	.007
	Within Groups	226.531	192	1.180		
	Total	241.281	195			

Post Hoc Tests Multiple Comparisons

Tukey HSD

Dependent Variable	(I) SAMPLE	(J) SAMPLE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound

SWEETNESS	375	421	.08511	.21232	.978	-.4654	.6356
		650	.01480	.21347	1.000	-.5387	.5683
		724	.66698*	.21347	.011	.1135	1.2205
	421	375	-.08511	.21232	.978	-.6356	.4654
		650	-.07031	.21347	.988	-.6238	.4832
		724	.58187*	.21347	.035	.0283	1.1354
	650	375	-.01480	.21347	1.000	-.5683	.5387
		421	.07031	.21347	.988	-.4832	.6238
		724	.65217*	.21462	.014	.0957	1.2087
	724	375	-.66698*	.21347	.011	-1.2205	-.1135
		421	-.58187*	.21347	.035	-1.1354	-.0283
		650	-.65217*	.21462	.014	-1.2087	-.0957
TEXTURE	375	421	.02041	.22975	1.000	-.5751	.6159
		650	-.25128	.23094	.697	-.8498	.3473
		724	.26531	.22975	.656	-.3302	.8608
	421	375	-.02041	.22975	1.000	-.6159	.5751
		650	-.27168	.23094	.642	-.8702	.3269
		724	.24490	.22975	.711	-.3506	.8404
	650	375	.25128	.23094	.697	-.3473	.8498
		421	.27168	.23094	.642	-.3269	.8702
		724	.51658	.23094	.117	-.0820	1.1151
	724	375	-.26531	.22975	.656	-.8608	.3302
		421	-.24490	.22975	.711	-.8404	.3506
		650	-.51658	.23094	.117	-1.1151	.0820
FIRMNESS	375	421	-.25185	.78230	.988	-2.2796	

		650	-1.16327	.77411	.438	-3.1698	1.7759
		724	-.01913	.77813	1.000	-2.0361	.8432
							1.9978
	421	375	.25185	.78230	.988	-1.7759	2.2796
		650	-.91142	.78230	.650	-2.9392	1.1163
		724	.23271	.78628	.991	-1.8054	2.2708
	650	375	1.16327	.77411	.438	-.8432	3.1698
		421	.91142	.78230	.650	-1.1163	2.9392
		724	1.14413	.77813	.457	-.8728	3.1611
	724	375	.01913	.77813	1.000	-1.9978	2.0361
		421	-.23271	.78628	.991	-2.2708	1.8054
		650	-1.14413	.77813	.457	-3.1611	.8728
AROMA	375	421	.18197	.22473	.850	-.4005	.7645
		650	-.08886	.22473	.979	-.6714	.4936
		724	.39031	.22473	.308	-.1922	.9728
	421	375	-.18197	.22473	.850	-.7645	.4005
		650	-.27083	.22589	.628	-.8563	.3147
		724	.20833	.22589	.793	-.3772	.7938
	650	375	.08886	.22473	.979	-.4936	.6714
		421	.27083	.22589	.628	-.3147	.8563
		724	.47917	.22589	.150	-.1063	1.0647
	724	375	-.39031	.22473	.308	-.9728	.1922
		421	-.20833	.22589	.793	-.7938	.3772
		650	-.47917	.22589	.150	-1.0647	.1063
COLOUR	375	421	-.12245	.19565	.924	-.6296	.3847
		650	-.27296	.19667	.508	-.7827	.2368
		724	.14371	.19667	.885	-.3660	.6534
	421	375	.12245	.19565	.924	-.3847	.6296

		650	-.15051	.19667	.870	-.6603	.3592
		724	.26616	.19667	.530	-.2436	.7759
	650	375	.27296	.19667	.508	-.2368	.7827
		421	.15051	.19667	.870	-.3592	.6603
		724	.41667	.19768	.154	-.0957	.9290
	724	375	-.14371	.19667	.885	-.6534	.3660
		421	-.26616	.19667	.530	-.7759	.2436
		650	-.41667	.19768	.154	-.9290	.0957
MOISTNESS	375	421	.00000	.21945	1.000	-.5687	.5687
		650	-.14286	.21945	.915	-.7116	.4259
		724	.57143*	.21945	.048	.0027	1.1402
	421	375	.00000	.21945	1.000	-.5687	.5687
		650	-.14286	.21945	.915	-.7116	.4259
		724	.57143*	.21945	.048	.0027	1.1402
	650	375	.14286	.21945	.915	-.4259	.7116
		421	.14286	.21945	.915	-.4259	.7116
		724	.71429*	.21945	.007	.1456	1.2830
	724	375	-.57143*	.21945	.048	-1.1402	-.0027
		421	-.57143*	.21945	.048	-1.1402	-.0027
		650	-.71429*	.21945	.007	-1.2830	-.1456

*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets SWEETNESS

TukeyHSD[a,b]

SAMPLE	N	Subset for alpha = 0.05

		1	2
724	46	3.6522	
421 650	47 46		4.2340 4.3043
375	47		4.3191
Sig.		1.000	.978

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 46.495.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

TEXTURE

TukeyHSD[a,b]

SAMPLE	N	Subset for alpha = 0.05 1
724	49	3.7959
421 375	49 49	4.0408 4.0612
650	48	4.3125
Sig.		.116

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 48.746.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

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FIRMNESS

TukeyHSD[a,b]

SAMPLE	N	Subset for alpha = 0.05 1
375	49	3.9184
724	48	3.9375
421	47	4.1702
650	49	5.0816
Sig.		.445

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 48.236.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

AROMA

TukeyHSD[a,b]

SAMPLE	N	Subset for alpha = 0.05 1
724	48	3.8750
421	48	4.0833
375	49	4.2653
650	48	4.3542
Sig.		.148

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 48.246.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

COLOUR

TukeyHSD[a,b]

SAMPLE	N	Subset for alpha = 0.05 1
724	48	3.9583

375	49	4.1020
421	49	4.2245
650	48	4.3750
Sig.		.151

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 48.495.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

MOISTNESS

TukeyHSD[a]

		Subset for alpha = 0.05	
SAMPLE	N	1	2
724	49	3.6735	
375	49		4.2449
421	49		4.2449
650	49		4.3878
Sig.		1.000	.915

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size =

49.000.

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7.4 Sensory Data Collection tool

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY DEPARTMENT OF FOOD SCIENCE INSTRUCTION: TICK (√) IN THE APPROPRIATE BOX WITH ITS ASSIGNED CRITERIA AND RESPONSE

CONSUMER SENSORY EVALUATION ON PREFERENCE TO RICH CAKE, REDUCED MARGARINE BUTTERNUT CAKE, REDUCED SUAGR BUTTERNUT CAKE AND REDUCED FLOUR BUTTERNUT SQUASH CAKE.

CRITERIA	ACCEPTANCES	02C	03S	04M	05F
SWEETNESS LEVEL	1. Disliked Very much	1			
	2. Disliked				
	3. Liked slightly				
	4. Liked moderately				
	5. Liked very much				
TEXTURE	1. Disliked very much				
	2. Disliked				
	3. Liked slightly				
	4. Liked moderately				
	5. Liked very much				
FIRMNESS	1. Disliked very much				

	2. Disliked				
	3. liked slightly				
	4. Liked moderately				
	5. Liked very much				
COLOUR	1. Disliked very much				
	2. Disliked				
	3. Liked slightly				
	4. Liked moderately				
	5. Liked very much				
MOISTNESS	1. Disliked very much				
	2. Disliked				
	3. Liked slightly				
	4. Liked moderately				
	5. Liked very much				
AROMA	1. Disliked very much				
	2. Disliked				
	3. Liked slightly				
	4. Liked moderately				
	5. Liked very much				

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