AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

NUTRITIONAL AND SENSORY EVALUATION OF COMPOSITE BREAD FROM WHEAT FLOUR, TIGER NUT FLOUR AND CARROT FLOUR

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JANUARY, 2023

DECLARATION

STUDENT’S DECLARATION

I, GRACE SELORM AMETEFE, 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’S 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**

SIGNATURE: ……………………………………………

DATE:…………………..………………………………..

DEDICATION

I dedicate this project to my family, my son Daniel Yejiemo Tettey Feehi Nartey for sacrificing his time for me to pursue my education and Husband Ebenezer Narteh Nartey for his support and prayers.

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To God be the Glory great things He has done. For without him this study would not be a success. I am indebted to so many individuals for making this project successful. My deepest gratitude goes to my supervisor Dr. Gilbert Owiah Sampson for providing the necessary guidance for the successful completion of this work. My second thanks go to Mr. Emmanuel Tettey for the Laboratory works. To my husband Ebenezer Nartey for the support and finally the last but not the least goes to my wonderful family for the support throughout the course.

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ABSTRACT

This study was carried out to evaluate the quality of bread produced from composite blends of wheat, tiger nut and carrot flour. The objectives of the study were to determine the physicochemical properties of the bread, the proximate composition of the bread, microbial quality and sensory properties of the bread. Ingredients were obtained from markets around Koforidua central market and transported to the department of Hospitality studies of the University for the experiment. five composite blends of wheat, tiger nut and carrot flour were formulated at a ratio of 75:20:5, 60:35:5, 50:45:5, 45:55:5, 15:80:5 and a control (without the inclusion of tiger nut and carrot flour). All the parameters were measured and calculated following standard procedure. The result obtained was subjected to statistical analysis using ANOVA. The result of the experiment showed that sample treatment 4 (45:55:5) had the best proximate composition with the highest protein content (12.97±0.04), fat content (4.60±0.3) and crude fiber content (1.87±0.02). Sample treatment 2 also had the best sensory characteristics (overall acceptability) while sample treatment 5 and 1 had the best in term of total plate count and yeast and molds respectively for the microbial count. Following the result of the study, it was therefore concluded that bread of good nutritional and sensory qualities could be produced from composite flours of wheat, tiger nut and Carrot flour, at 45%, 55% and 5%, respectively. In terms of proximate composition, the crude protein increased with increased substitution of wheat flour with carrot and tiger nut. There was a general improvement in the quality of the bread as presented in the tables. It is therefore recommended that the test ingredients, tiger nut and carrot flour be used in the production of bread so as to improve nutritional quality and reduce cost of production.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Ghanaians of all ages now regularly consume wheat-based foods such as biscuits, bread, pizzas, noodles, pastries, cookies and other breakfast cereals (Albala, 2011; Tiimub, 2013). White bread variants: brown, sugar, whole wheat type and butter are found in the Ghanaian market (Ghana Statistical Service, 2019). In Ghana, bread is currently the food item with the highest cash cost. As a result, wheat imports have steadily increased (Taylor, 2019), resulting in a high foreign exchange import cost. Given that it can be found on all continents and is consumed in a variety of ways, bread in particular has become a basic food item that is consumed by the majority of people (Bordes et al., 2008). About 16 billion dollars' worth of wheat flour is being imported into Ghana each year thereby putting a lot of pressure on the country's revenues (Chikwati and Ziga, 2016). This highlights the necessity of promoting effective local flour alternatives or substitutes throughout the Continent (Alemayehu et al., 2006). Ghana imported over 595,000 MT of wheat flour in 2014 (Frazier, 2015), up from about 300,000 MT in 2011, of which 80% was used to make bread (USDA, 2014). This trend has been rising as a result of the country's growing population and rising bread consumption. It's not a novel concept to replace some of the wheat with other starchy, locally accessible crops. Several organizations, including FAO, have conducted studies to determine how to completely replace wheat or partially substitute wheat with other sources of flour (Olaoye et al, 2015). The composite flour initiative aims to save a sizable amount of foreign currency, supply more people with a traditional nutritious food at a lesser cost, and employ local crops more extensively (Wang et al., 2014).

In several nations, composite flour technology has been employed to extend the limited supplies of bread and other baked goods. A number of emerging countries have encouraged the start of creativities to evaluate the feasibility of using other, locally available flours in place of wheat flour. It has been suggested that mixing wheat flour with foods that are readily available in the area might be successful. The concept of composite flour is viewed as a bridge to maximizing the usage of regional food products (Arubayi & Ogbonyomi, 2019).

Tiger-nut (*Cyperus esculentus*), also identified as sedge, chufa, earth-almond, nut grass, and nut sedge, is a crop that is grown all over the world and belongs to the sedge family. It is known as "atadwe" by the Akans and “atangme” by the Gas in Ghana (Asare et al., 2020). Since ancient times, tiger nuts have been grown (mostly) in south Europe and West Africa for their minor rhizomes, which are consumed fresh or roasted, used as food, or juiced to prepare beverages. (Mordi et al., 2010) It can be crushed and the resulting white paste added to oatmeal or eaten raw as a snack. Since tigernut can reduce heart disease and thrombosis, they are considered to be "health" foods (Chukwuma et al., 2010).

According to Sanchez-Zapata et al. (2012), the tiger nut has roughly 26-30% starch and 21-25% fat, delivering 400-450 kcal per 100 g of calories. In addition to possessing significant amounts of vitamins E and C and some minerals, such as phosphorus (P), potassium (K), iron (Fe), and calcium (Ca), it also has 3-8% protein and 8–10% fiber (Adejuyitan, 2011; Sánchez Zapata et al., 2012; Chukwuma et al., 2010). Oleic acid makes up the majority of the fatty acids in the tuber (61% of all fatty acids), while linoleic, palmitic, and stearic acids are also present (Adel et al., 2015; Kim et al., 2015). According to Adeyeye et al. (2019), tiger nuts were discovered to be an excellent replacement for cereal grains. Tiger nuts were once a minor crop, but they are now regarded by many Ghanaians as having nutritional and health benefits, making them an increasingly significant crop in Ghana (Asare et al., 2020). Tiger nut is one of Ghana's neglected crops, yet it has a variety of uses in the culinary sector. Tiger nut flour is frequently used in Ghana to make ice cream, various alcoholic and nonalcoholic beverages, and pastries (Ayeh-Kumi et al., 2014). The crop is becoming vital for numerous low-income homes, who rely on it for revenue cohort and existence and can use it to become producers or merchants without having to make significant capital investments (Opiyo et al., 2015).

Carrot (*Daucus carota*) a root vegetable found all over the world, is very nutritious. The fact that the world produced 33.7 million tons of carrots in 2010 indicates the crop's importance to horticulture and the economy (Ulrich et al., 2015). In addition to being an important source of B-carotene and having a significant number of vitamins and minerals, carrots are also an essential vegetable for a balanced diet and are frequently used to make juice (Owolade et al., 2015 Demir et al., 2004). In recent years, a stable rise of carrot juice drinking has been reported in many countries due to cognizance about its use as a significant source of natural antioxidants (Owolade et al., 2017; Lourenço et al., 2019). Carrot juice provides healing properties that increase immunity, aid in the recovery of minor wounds and injuries, and lower blood pressure and heart disease risk. It helps to battle anaemia, enhances eye health, and lowers the risk of stroke, heart disease, high blood pressure, and some types of cancer. It also cleans the liver by excreting lipids and bile (Kaur & Aggarwal, 2016).

1.2 Problem Statement

Many consumers have resorted to fiber-enriched food products due to growing concerns about food safety and health risks. According to Akaln et al. (2018), there is a growing demand for foods with high fiber content. Aside the health implication associated with wheat free products, people allergic to gluten find it difficult to consume baked products due to their high content of gluten, a causative agent for celiac disease (Mumolo et al., 2020). Through local and international trade, tiger nuts have been used to diversify diets and reduce micronutrient deficiencies, especially in the poor and children. They have also helped to increase agricultural gross domestic product (GDP). Notwithstanding these latent profits of tiger nut, the crop is still not well recognized in Ghana. In most cases, it is consumed raw or with just the juice extracted. The crop has recently been provided in flour form to ensure availability. The use of tiger nuts in the production of bread would subsequently be economically advantageous to developing countries and farmers given the rise in bread demand. Obeng-Koranteng et al., (2017). This study aims to assess the nutritional value and sensory quality of composite bread made using wheat flour, carrot flour, and tiger nut flour.

1.3 Main Objective

The core objective of this study is to assess the proximate and sensory qualities of bread produce from tiger nut flour, carrot and wheat flour.

1.3.1 Specific objectives

2. To determine the proximate composition of the composite wheat flour, tiger nut flour and carrot flour.
3. To determine the Physicochemical composition and Microbial quality of the composite bread sample.

4. To determine the consumer acceptability of the composite product form tiger nut, carrot and wheat flour.

1.4 Significance of the Study

This work is to enrich wheat flour with tiger nut and carrot flour in the production of bread. The usage of tiger nut and carrot blend in the production of bread will improve the utilization of crops. Tiger nuts and carrot a highly rich in bioactive nutrients like phenols, saponins etc. and protein which ultimately improves the nutrient of the bread.

The study will also enable one to have a deeper understanding of how consuming foods high in fiber benefits one's health. As most people place their health at the top of their list of priorities, it will inform the food industry and a variety of people about how to produce and buy foods that are good for human health. The study will also advance our understanding of composite products, bring in varieties in products and money for the nation's farmers, and enlighten others about the availability and applications of regional produce crops in product creation.

CHAPTER TWO

LITERATURE REVIEW

2.0 Bread

Bread is a staple food in countless portions of the world. Despite the fact that people have been making and eating bread since antiquity and there are references in the Bible, the baking process is still not completely understood (Chopade et al., 2017). Bread is widely consumed around the world due to its inexpensive cost, easy preparation, versatility, sensory features, and nutritional value. In terms of human nutrition, in addition to giving energy, bread gives the body necessary components that cannot be substituted (Erbersdobler et al., 2017). However, because of the terrain and climate, it was not possible to produce wheat locally, thereafore the wheat flour required to create bread had to be trade in (Folalu and Okparavero, 2021). Consequently, in recent years, interest in composite bread research has increased due to the hunt for non-wheat bread substitutes to minimize the dependence of non-wheat making countries on imported wheat (Noorfarahzilah, et al., 2014). It is challenging to comprehend any one phenomenon on its own because several physical, chemical, and biological processes take place simultaneously throughout its evolution (Sevian, & Talanquer, 2014). The temperature gradient causes heat to be transferred toward the center of the dough when the finished product is put in the oven. The gas phase inside the dough expands as the temperature rises, indicating an increase in pressure. In addition, fermentation produces more gas (Bredariol & Vanin, 2021). The temperature causes the gases that are dissolved in water's liquid and solid phases to evaporate. Protein denaturation, starch gelatinization, and the Maillard reaction are examples of biological reactions that could occur at the crustal level when there is less water due to the system's increased temperature. The system subsequently develops as a result, altering the rheological properties of the dough. Gas pressure and volume increase within the alveoli until deformation stops, which causes volume expansion (Mildner-Szkudlarz et al., 2017). This concise justification makes it possible to make the broad remark that baking involves a lot of mechanisms and that their level of interaction is very high. Along with the complexity of baking components, there are a variety of bread recipes and production techniques. However, water, yeast, and wheat flour are the standard ingredients for baking bread (Amaral et al., 2016).

2.1 Ingredient used in Bread Production

2.1.1 Wheat flour

The most typical flour used in bread baking is wheat. It comprises of whole wheat flour, bread flour, and all-purpose flour. Gluten, a protein that gives dough its springiness and strength, is abundant in wheat. Gluten expands and spreads to form a network that traps the carbon dioxide bubbles the yeast releases when yeast and flour are mixed with liquid and then kneaded.

Loaves made with whole wheat flour are denser and contain less gluten. All-purpose flour is generally used in these recipes because it increases the gluten content and produces lighter, taller loaves.

- Flour is the major constituent for bread and other bakery foods.
- Flour gives the structure to the bread.
- Flour in good state should have a smooth white colour.
- Flour should have an enjoyable smell and slightly sugary taste.
- Conformation of flour: Both soluble and insoluble proteins are present in flour. For yeast to grow and reproduce throughout the fermentation process, soluble proteins are helpful in supplying nutrition (Anonymous,2021).

2.1.2 Sugar

The crust of bread gains flavor and color from sugar. You can also use jams, honey, brown sugar, and molasses.

- The key purpose of sugar in bread production is to offer food for yeast, which in turn, produces CO2 gas, that increases the dough fabric. It also helps in enhancing the flavour of bread.
- Sugar is a hygroscopic ingredient, helps in holding of moisture in bread.
- It gives golden brown crust colour of bread (Anonymous, 2021).

2.1.3 Yeast

Yeast is a vital component in the production of bread. It is an essential ingredient that makes the bread's amazing flavor and aroma are imparted by the dough as it rises. More components are required to ample the reactions that result in a fully cooked loaf of hot, crusty homemade bread. Each yeast bundle contains tens of thousands of live, plant-like microorganisms. When yeast is given sugar or starch and warm liquids, which activate and activate, minute foams of carbon dioxide gas are produced. This gas causes the bread to rise after baking and acquire its light texture.

After flour, yeast is next important ingredient for bread making.

The main purposes of fermenting bread dough are to produce carbon dioxide gas, which gives the finished product capacity, and to mature or condition the dough (gluten) so that it becomes sufficiently flexible to expand under the gas's weight and form the product's structure. Yeast is a tiny, one-celled plant. Its growth and reproduction are reliant on climate, moisture, and food (sugar).

- **Invertase:** transform sucrose or cane sugar into invert sugar, a straightforwar d type of sugar made up of dextrose and fructose.
- **Maltase:** changes maltose sugar into dextrose which is straight fermentable by yeast.
- **Zymase:** Actually, it's a specific enzyme for yeast fermentation. It consumes the dextrose and invert sugar that were previously produced. They are converted into alcohol and carbon dioxide, which gives out the flavour of fermentation.
- **Protease:** This enzyme has a smoothing effect on flour proteins, improving bread's capacity to stretch and take on volume and structure (Anonymous, 2021).

2.1.4 Water

Water performs two essential functions, making it the most significant liquid: The yeast is dissolved and made active. It mixes with the flour to produce a dough that is sticky and stretchy. For baking bread, any water that is safe to drink can be used. The gluten that is formed by the insoluble proteins in flour is bound together by water. Water in excess might affect how well all ingredients bond together (Anonymous, 2021).

2.1.5 Salt

Salt must be added when baking bread in order to help the flavour of the dough and improve the flavour of the finished produce. For the best results, we do not recommend ignoring the salt from a yeast recipe. Bread palates well with salt. On yeast, it has a regulating effect. The contraction outcome of salt on flour proteins improves the dough's capacity to recollect gas. It makes bread more wholesome and moister for a lengthier period of time. The amount of salt in a bread recipe may array from 1.25 to 2.5%, which makes the fermentation whole, liable on the forte of the flour, the distance of the fermentation, the hardness of the formula water, and the nearby of flavour desired in the ended product (Anonymous, 2021).

2.1.6 Fat/Oil

Butter provides flavor and make bread soft and humid. Because fat stops moisture loss, bread stays fresher for longer. When Rapid Rise Yeast is employed, liquid and fat are boiled simultaneously. Never use margarine or shortening in place of oil unless the recipe clearly calls for it. The bread's nutritional value is increased. It makes up 1% to 2% of the bread dough's dry ingredients. In small doses, it has a oiling effect on the gluten elements, improving their extensibility and contributing to the bread's good volume. It also aids with moisture absorption. If fat is added at the beginning of the mixing process, it will have a negative impact on how well the food absorbs water (Anonymous, 2021).

2.1.7 Milk

Milk may be added to enhance flavour or texture. Only warm liquids should be added to dry components in a formula since cold liquids will stifle or prevent the growth of yeast. It raises the bread's nutritional worth. It improves the physical characteristics of bread. It improves the dough's ability to retain gas by tightening the proteins in the flour. It enhances the taste and flavor of bread. Any type of milk, including fresh, condensed, milk powder, etc., can be used in bread (Anonymous,2021).

2.2 Wheat Flour

The key component in creating bread is flour because it controls the distinctive qualities of bakery goods (Avramenko et al., 2018). Protein (10–12%%), starch (70–75%), and other carbs make up its major constituents. It also contains ash, non-starch polysaccharides (2–3%), including arabinoxylans (AX), lipids (2%), and water (14%) in trace amounts (Severini et al., 2015). The flour that has been used most frequently is wheat flour. When turned into fermented dough, it yields a loaf of bread that is airy, tasty, and well-risen. Wheat flour has both starch and protein, which contribute to the bread's structure. The flour contains gliadin and glutenin, two different types of proteins. The very sticky and inelastic wheat prolamins (gliadin), which make about 40–50% of the proteins, are what give dough its cohesion. However, the glutelins, which were formerly known as glutamines, offer resistance to extension (Rai et al., 2018). Viscoelastic dough is produced when prolamins and glutelin's combine to form the elastic protein gluten multifaceted during mixing. The dough can be formed into thin sheets that can hold onto gas and result in a light baked good (Cauvain, 2012). Hard wheat has the capacity to absorb and hold onto carbon dioxide gas, increasing bread volume. Additionally, the flour has a lot of protein and powerful gluten (Ortolan & Steel, 2017).

2.3 Composite Flours

Totally non-wheat mixtures of flours or meals are also referred to as composite flours (Chandra et al., 2015). Therefore, it is a combination of flours, with flour denoting a powder made from grinding grain, most often wheat, and used to produce bread, cakes, and pastries. At the moment, this definition encompasses foods other than grains (seeds, roots, and tubers). Although the composite flours are designed for a variety of applications, breadmaking is the most prominent example since ancient (Oladunmoye et al., 2010). Local raw ingredients such cassava, maize, rice etc. have been used in composite flour trials in Africa (Noorfarahzilah et al., 2014).

2.3.1 Significant of Composite flour

Despite the fact that composite flours have attracted a lot of research, it is well recognized that no other crop flour can match the baking qualities of wheat. The usage of composite flours offers the following benefits for developing nations:

a) preserving hard money
b) b) promoting native plant species having high yields
c) Greater utilisation of domestic agricultural produce overall, increased availability of protein for human diets (Bugusu et al., 2010).

A quantity of lessons has also been shown with composite flours, particularly in Africa due to the region's consistently expanding population in places like Senegal, Niger, and Sudan (Saleh, et al., 2013).

According to Faparusi and Adewole (2019), when cereals and legumes are included, composite flour gives the added benefit of improving the nutritious value of biscuits and other baking goods. Because they make up for any inadequacies and minimize infant and adult malnutrition, composite flours are beneficial in countries where malnourishment is a solemn problem, particularly for children.

2.3.2 Composite flour production and its attributes

Combinations of wheat and non-wheat flour are used to make composite loaves. Because of the potential to decrease wheat imports and increase the use of locally grown grains, these flours are beneficial to developing nations (Abass et al., 2018).

The most common flours examined in the manufacturing of composite flour in breads are those from maize, barley, and cassava (Anonymous 2021). According to a study by Ragaee et al., (2006), the loaf volume and specific volume of pan breads made using composite flours (fababean, cottonseed, and sesame flour) were between 25 and 60 percent lower than those of the control loaf. Breadnut flour, which has a total essential amino acid content of 55.1% and high-quality protein, is comparable to soy flour and eggs. Researchers are paying rapt consideration to the creation of food products made using composite flour, mainly those used to make bakery goods and pastries, according to Banua et al., (2021). This article examines effects on the sensory quality, rheology features, nutritional values, and general acceptance after some changes. This review also discusses the mixing of diverse sources of tubers, legumes, cereals, and fruit flour (coconut) with wheat flour in order to create a variety of food products. It was shown that food products manufactured from composite flour can nevertheless have properties similar to those of goods made from full-wheat flour (Dewettinck et al., 2008). The functional, physicochemical, and well-being benefits of raw blended flour, together with percentage blending, can all be considered as favorable impacts of using composite flour in the finished product (Cayot, 2007).

2.4 Overview and Description of Tiger Nuts

Tiger nut, *Cyperus esculentus* belongs to the Division Magnoliophyte, Class-Liliopsida, Order-Cyperales and Family *Cyperacea*e (Bamishaiye et al., 2011).

Tiger nuts are actually tubers that can be discovered on the roots of sedge plants, not actual nuts. It has been around for 4,000 years and comes in many different forms. People in the Nile valley of ancient Egypt were the first to cultivate the tubers. Following then, its cultivation was spread to other regions with a moderate temperature and fertile soil. According to reports, tiger nuts arrived in Spain from Africa (Sanderson, 2012). Tiger nuts are edible tubers that taste sweet and nutty. These tubers are also known as “earth almond” and “yellow nut sedge” (Bamishaiye & Bamishaiye (2011). They are rather tough and are typically dipped in water before eating. Nut sedges were used as a source of food, medicine, and fragrances in Egypt and the Mediterranean. Nursing mothers would frequently roast and eat tigernut tubers. Coffee and chocolate beverages were made with the pulverized, dried tubers (Ezeh et al., 2014).

Oil extracted from the tubers was an ingredient in soap making as well as a lubricant for fine machinery. Animals were fed on the leafy plant sections of the nut sedge. The nut sedge was utilized quite effectively by the Egyptians. They started cultivating them circa 2400 BC. In a wall painting from an Egyptian tomb from the 15th century BC, a picture of tigernuts is shown as one such example (Samuel & Campus, 2016). Workers are depicted in the painting weighing the nuts as a scribe takes notes on their job. Instructions for eating the tubers as sweets after grinding and adding honey were recorded in another area of the same tomb. Tigernut tubers, which have been discovered in the tombs, are thought to have been domesticated locally in Egypt. This suggests that the tubers were highly regarded as a food by the Egyptian people.

Tigernut is a very versatile crop that thrives in a variety of soil and climatic situations. It can be found all across the tropics, subtropics, and warm climate zones. It is grown as a crop in Western Africa, but in 17 Eastern Africa, it is a severe weed of cotton, cereals, potatoes, and sisal. Additionally, it is grown throughout Asia, Europe, and South America. A tuber plant produces 50–250 tubers that weigh 2–26 g each

(Montes Osorio et al., 2016). Tiger nut is a 90 cm tall annual or perennial plant with single stems emerging from a tuber. The stems are trapezoidal in form and have thin leaves that range in size from 3 to 10 mm. Four hanging leaves that are positioned 90 degrees apart encircle a cluster of flat oval seeds in the plant's unusual blooms. The leaves of the plant are extremely stiff and fibrous, and is frequently mistaken for grass (Larridon et al., 2021). Delicious spikelets with 1 to 1.5 cm long, golden-yellow to brown petals are produced by tiger nut plants. The solitary, 5–20 mm long tubers have a thin, brown outer skin that gets darker over time. The rhizomes that make up the root system are yellowish. It resembles Cyperus rotundus, a non-flowering plant with blunt-tipped leaves without shoulders, dark brown, weakly perfumed, and foul-tasting tubers arranged in a chain (Larridon & colleagues, 2021).

The long, slender, shiny, light green leaves of the tiger nut (Cyperus esculentus leptostachyus) are grouped in three rows around the triangular stem and frequently have a distinctive pointy tip that is separated from the rest of the leaf by a distinct shoulder (Larridon et al., 2021). Tiger nut belongs to the Magnoliophyta division, class Liliopsida, order Cyperales, and family Cyperaceae. Cyperus esculentus belongs to the family Cyperaceae and the order Commelinales. The persistent linear brown spikelet's with tightly overlapping scales that set Cyperus esculentus apart from other New World nut sedge species. Yellow nut sedge has a triangular, light green-yellow colored stem. Although it does generate viable seed, the primary form of reproduction is by rhizomes that end in tubers (Larridon et al., 2021).

  

Plate 1: Brown variety   Plate 2: Black variety   Plate 3: yellow variety

2.4.1 Ecology of Tiger Nuts

Tiger nuts are widespread in irrigated crops, damp grassland, along banks, and seasonally wet grassland, but they are also thought to be quite drought resistant. Shade is not acceptable to it. The best yield is attained with evenly spaced rainfall and somewhat high temperatures during the growth season. Low nitrogen levels and a high temperature of 27 to 30 oC encourage the growth of tubers. Although it prefers light sandy loamy soils with a PH range of 5.5 to 6.5, it will grow in any soil as long as it is well-drained. High concentrations of calcium (Ca), sulfur (S), and manganese (Mn) can be found in some alluvial soils (Anderson et al., 2013). Particularly desirable elements are boron (Bo) and magnesium (Mg). Long photo durations of more than 16 hours stimulate vegetative development while short photo periods of 8 to 12 hours favor tuber formation (Liu, 2020). Sandy soil and a temperate environment are necessary for tiger nut farming. Prior to planting, either by hand or with a drill, tubers are submerged in water for 24 to 36 hours. In the United States of America, it was discovered that cold tubers germinated more effectively and produced more sprouts per tuber (Samuel & Campus, 2016). Tubers can be sown 2.5–4 cm deep along rows 60–90 cm apart, at intervals of 10-15 cm. One tuber per hole is utilized at closing spacing, and two per hole at wider spacing when seed rates are higher (Larridon et al., 2021Tiger nuts are rinsed with water as soon as they are harvested to get rid of any sand and small stones. After cleaning, the Tiger nuts are dried out to preserve them. This natural process takes one to three months to finish. During this time, temperature and humidity levels are closely watched. Every day, the Tiger nuts are rotated to achieve equal drying. Tiger nuts that are small or broken are removed before packaging and use (Larridon et al., 2021).

2.4.2 Cultivation of Tiger Nut

Tiger nuts thrive in conditions of fairly high temperatures and evenly dispersed, moderate rainfall. Though it has been seen to produce well in a variety of soil types, including sand, sandy loam, sandy gravel loam, muck, clay-loam, clay, and compost, it gives the highest yield in light sandy loams with a pH range between 5.5 and 6.5 (Dakogre, 2008). Before planting, the nuts are saturated in water for one to four days to encourage germination. It can either be soaked before planting or kept (for 7–12 days) until sprouting begins. Pre-sprouting before planting produces a flawless stand and uniform emergence.

2.5 Health Benefits of Tiger nut

According to Achoribo and Ong. (2017), nuts have a high concentration of dietary fiber. It may be useful for both treating and preventing a wide range of illnesses, such as colon cancer (Adejuyitan et al., 2009), coronary heart disease (Chukwuma et al., 2010), obesity, diabetes, and gastrointestinal problems. The usage of tiger nut milk for the treatment of gas, indigestion, diarrhea, and dysentery has been recorded, and its starch concentration is likely to have prebiotic characteristics for colon bacteria (kadam, 2017). Tiger nut milk has been discovered to be beneficial for reducing arteriosclerosis since it can promote blood circulation and prevent thrombosis and cardiac issues (Chukwuma et al., 2010). Due to its low-glycemic carbohydrates (mostly starch) and arginine, which releases hormones that make insulin, tiger nut milk is suitable for diabetics (Achoribo & Ong, 2017). Tiger nuts may prevent thrombosis, heart attacks, and stimulate blood flow. Tiger nuts' high soluble glucose content protects against cancer.

Researchers recently found that they lower the risk of developing colon cancer. Because they contain a significant amount of water-soluble flavonoid glycoside, tiger nuts have a relative antioxidant capacity (a phytochemical). Antioxidant consumption may safeguard the immune systems of populations who are undernourished (Brindha,2016). Tiger nuts are the perfect food for a balanced diet due to their high fiber content and tasty flavor. Tiger nuts' high fiber content has a positive impact on digestion. This is due to the fact that fiber stimulates the digestive system, prolongs the sense of fullness, and hastens intestinal transit, which avoids constipation. Because oligosaccharides, a type of short-chain carbohydrate, feed probiotic microorganisms and aid in the promotion of digestive health, tigers nuts may offer prebiotic properties. According to Yeboah (2020), oligosaccharide levels in tiger nuts have not been quantified, but they have been discovered in the milky beverage "horchata." Short chain carbohydrates called oligosaccharides have showed the most promise as potential prebiotics.

2.6 Utilization of Tiger Nut and its By-products

The crop tiger nut has a lot of potential. Due to its high dietary fiber content and pleasing, nutty flavour, it may be beneficial as a good source of dietary fiber in the food sector (Sánchez Zapata et al., 2010).

It has been discovered that tiger nut oil compares favorably to olive oil (Turesson et al., 2010; Muhammad et al., 2011). Given its fatty acid makeup and other physico-chemical characteristics, tiger nut oil may be used as an addition to or replacement for olive oil. Due to its low viscosity value, it could also be helpful as diesel fuel (Ofoefule et al., 2013). To thicken pudding, Martn-Esparza et al. (2018) combined tiger nut starch with sweet potato and corn starches. Tiger nut starch was utilized as an excipient in the pharmaceutical sector (Manek et al., 2012; Builders et al, 2013). According to Kenneth et al. (2014), tiger nuts can be utilized as animal feed and as an alternative to almonds in some forms of confectionary. The ground tubers are occasionally added to coffee and cocoa as an adulterant or replacement.

The food industry uses by-products of tiger nut processing, such as the fiber and liquid, for technological and practical objectives (Salau et al., 2012). According to Sanchez-Zapata et al. (2010), burgers with tiger nut fiber added were judged as having less meat flavor, being less juicy, oily, and grainier than the controls. Additionally, these burgers were discovered to have superior cooking qualities and to be healthier. According to Sanchez-Zapata et al. (2013), tiger nut liquid that is collected after the manufacturing of tiger nut milk has proved to have good qualities for the culture of probiotics.

2.7 Nutritional Composition of Tiger Nuts

Tiger nut tubers have tiny amounts of protein, which is about twice as much as cassava, but are rich in starch (20-30% of DW) and fat (20-28% DW). Tiger nuts compare better to nuts than cereals that are also members of the same Cyperales since they have a substantially higher fat content and gross energy. The oil obtained from the seeds of yellow nut sedge (Cyperus esculentus var. esculentus) has been studied as a non-traditional oilseed. Tiger nut oil has a good potential to replace imported olive oil because it is 80% unsaturated fatty acids, primarily oleic (64.2-68.8%) (Samuel & Campus, 2016). Low-fat diets are advised to help with weight control since they supply twice as much energy than diets high in carbohydrates or proteins. The impact of various fats (fatty acids) on health and the risk of developing conditions like coronary heart disease vary (CHD). Because they raise blood cholesterol levels, saturated fatty acids (SFA) should be avoided wherever possible.

The tiger nut is a good basis of potassium, iron, and phosphorus. Magnesium, calcium, zinc, copper, sodium, and manganese are also present (Gambo & Da'u, 2014). The majority of the time, the phosphorus in plants is bonded to a substance called phytate, which makes it difficult for the body to absorb from the stomach. Together with calcium, phosphorus (P) makes up the majority of the minerals that make up bones and teeth. It contributes to the production of ATP (an energy component necessary for "activating" glucose, fatty acids, etc.) and the enhancement of cognitive function. The body needs phosphate to function properly. As a buffer, it controls acidity and alkalinity (Ahmed et al., 2014). The most crucial neuronal component for intracellular function is potassium. It participates in a diversity of enzymatic reactions as well as key physiological procedures like heart rhythm, nerve conduction, and muscle contraction. Fe protects against anemia.

All human tissues contain zinc, which is used by the body for a variety of processes. It participates in a variety of enzyme processes, including those that produce energy from proteins, fats, and carbohydrates. Additionally, it plays a part in immunity, blood oxygen and carbon dioxide transport, and cell division. Because zinc plays so many different roles in the body, those who are deficient in it may have a variety of symptoms, such as slow wound healing, poor appetite, weakened immunity, and stunted growth (Ahmed et al., 2014). Magnesium is also a component of numerous enzyme systems, particularly those that deal with the body's energy currency. Magnesium is also necessary for muscle contraction, energy production, and protein synthesis (Ahmed et al., 2014). Low magnesium consumption may raise the risk of type 2 diabetes and coronary heart disease, according to research findings (Rosique-Esteban et al., 2018). With the exception of histidine, the essential amino acid content of tiger nuts was higher than that recommended in the protein standard for adults by the FAO/WHO. In comparison to the other 21 essential amino acids, arginine (1414.0 4.75 mg) is found to be relatively abundant, whereas tyrosine (50.0 0.13 mg Per g N) and methionine (58.1 0.62 mg) are found to be deficient. Tiger nuts' lysine content (307.5 0.30) may supplement lysine-deficient diets like maize. This may help in the creation of multi-mixes for newborn nourishment (Aljuhaimi et al., 2018).

2.8 Processing Techniques of Tiger Nut

Processing technology is widely used in the preparation of foods and drinks. Some possible objectives of food processing include separating food ingredients into solids and liquids, enhancing their natural flavors, stimulating the digestive system, adding variety to the menu, making them easily digestible and bioavailable, removing harmful microorganisms, boosting nutritional value, and preventing decomposition tiger nuts (Ndubuisi, 2009).

2.8.1 Heating (boiling or roasting)

Gelatinizes the starch granules, ruptures fat depots, and causes protein to coagulate. The conventional wisdom held that the finest heating outcomes could be achieved at the greatest temperatures conceivable. Tiger nuts, however, begin to caramelize as the temperature rises beyond 100 °C. Tiger nuts are typically roasted at temperatures between 95 and 120 °C for 15 to 20 minutes (Ndubuisi, 2015). The main method used during coffee production for its distinctive flavor is roasting at 120 °C and above. The softening of the tubers, which results in the breaking of the outer sheath coverings, is a sign of a successful cooking. Boiling the tuber for roughly 4-5 hours can soften it and make refrigerator storage easier and longer (Borthwick & Da Costa, 2017).

2.8.2 Steeping or soaking

Staples are a primary source of nutrition for big people in rural areas, and the soaking, fermenting, and steeping of these foods greatly increases the variety of raw materials that can be used to make edible goods. The amount of time spent steeping could have a big impact on extract recovery and enzyme development. Starch is transformed into lowering sugars during the process of steeping. During the first 24 hours of steeping, reducing sugars decrease, and then they start to grow as the process progresses. Small-scale food fermentation is quite poor, and the knowledge already available is not extensively disseminated. Additionally, as technology advances and populations turn away from conventional methods of food preservation, "tribal knowledge" on fruit and vegetable fermentations is being lost (Ijarotimi, 2012).

2.8.3 Fermentation

Food is fermented to produce new flavors and odors. Additionally, the microorganisms utilized in the fermentation process can be consumed alone or added to other foods as a food source (single cell-protein). Malting entails germination and steeping. Germination can begin after the steeping procedure has been carried out for approximately 24 hours in a manner that modifies or degrades tubers with a small loss in grain weight (Dahiya et al., 2018).

2.9 Overview of Carrot

The root vegetable known as the carrot, or Daucus carota, is a popular ingredient in juice manufacturing since it is incredibly nutrient-dense and a significant source of -carotene. Many countries have reported a steady rise in the use of carrot juice in recent years (Owolade, et al., 2017). Growing data from epidemiological research suggests that carotenoids and other antioxidants may shield people from developing certain types of cancer and cardiovascular conditions (Sánchez-Zapata et al., 2013). In recent years, research has shown that people can benefit from the part that carotenoids play in shielding plants and animals from excessive sunshine. Therefore, it is advised to consume at least five servings of fruits and vegetables each day, with a preference for citrus fruits and green and yellow vegetables. Healthy adults, according to (Baralic et al. 2015).

According to the USDA (2015), carrot root has 0.2% fat, 1% protein 88.3% water, 3% dietary fiber and 9.6% carbohydrate, The carbohydrate content is almost entirely made up of simple sugars, with the majority being sucrose, glucose, and fructose and a negligible percentage of starch. Through alpha- and betacarotene, carrots greatly increase dietary vitamin A consumption and marginally increase dietary intake of other nutrients (Furrer et al., 2018). In the majority of economically underdeveloped regions of the world, where inhabitants often rely exclusively on dietary sources of pro-vitamin A carotenoid to meet their vitamin A needs, vitamin A deficiency is still a significant nutritional problem (Palacios & Gonzalez, 2014). The only significant source of pro-vitamin A is carrots, which account for 14–17% of all vitamin A consumption (Saha et al., 2015). The B vitamins thiamin (B1), riboflavin (B2), and niacin (B3) are also present in carrots, though in much smaller amounts than in other regularly eaten vegetables. Fiber, vitamin K, potassium, folate, manganese, phosphorus, magnesium, vitamin E, and zinc are also present (Seal et al., 2018).

2.10 Nutritional Value of Carrot

One of the most widely consumed vegetable juices is carrot, which is a high natural source of D- and E-carotene. Therefore, it's crucial to create carrot goods that adhere to market standards while maintaining their nutritional value and high level of quality. In carrots, there is 84% water, 7% carbohydrate, 0.74 % protein, 1% fat, and 7% dietary fiber. Additionally, carrots are well known for their beneficial health benefits and their medicinal nature; for instance, they are beneficial for urogenital disorders and their dietary fibers aid in the prevention of cardiac ailments (Das et al., 2012). According to Prasad et al. (2017), carrot pulps include 4-5% protein, 8-9% reducing sugar, and 5-6% mineral. The main vegetable that contains the highest concentration of physiologically active carotenoids is carrots.

2.11 Health Benefits of Compounds in Carrots

Although beta- and -carotene are the primary pigments in orange carrots, some writers have also described other forms of carotenes (beta- and -carotene) and traces of lycopene (Schweiggert et al., 2017). Numerous studies have demonstrated that -carotene converts to vitamin A far more quickly than other carotenoids do (Harrison (2012). Recently, the antioxidant and free radical scavenger -carotene was shown to have anti-cancer properties. Alpha-carotene only has 50% of the theoretical vitamin A activity of beta-carotene, which makes it a significant biological molecule (Donhowe and Kong, 2014). The negative effects on health of eating fruits and vegetables high in carotenoids, and more specifically -carotene, have been documented by numerous writers.

Additionally, carrot contains additional substances that contribute to both its sensory qualities and its nutritional benefits for human health, such as phenolic compounds (mostly caffeoyl ester) and organic acids (primarily malate and citrate) (Okori, 2016). Recently, attention has been focused on them because numerous epidemiological studies suggest that consuming polyphenol-rich foods and beverages is linked to a lower risk of cardiovascular disease, stroke, and some types of cancer (Borowska et al., 2018). Carotenoids give carrots their yellow, orange, and red hues, while a group of polyphenolic substances called anthocyanins gives them their purple hue. Consumer interest in natural whole foods rich in these chemicals, frequently referred to as "functional foods," is rising as more research has been done on the health advantages of all of these pigments, including protection from various malignancies and cardiovascular disease (El-Sohaimy, 2012).

The potential usage of wheat-carrot-tiger nut flour in the bread sample will improve it nutrient profile, improves the health of consumers because of the carotenoids and phytochemical properties of the carrot and the tiger nut respectively.

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CHAPTER THREE

MATERIALS AND METHODS

3.1 Sources of Raw Materials

The wheat flour, tiger-nuts, carrot, sugar, milk, baking powder, Margarine, egg, salt and yeast for the study would be obtained from the Koforidua market, in the New-Juaben Municipal District, Ghana. Figure 3.1 below show some of the major ingredient used in the bread production. All ingredient used for the study would be purchase from Koforidua Agatha market in the Eastern Region of Ghana.

3.2 Equipment and Tools

The equipment and tools that was used for the study are measuring cup, measuring scale, mixing bowl, pallet knife, bread knife, sieve, pastry brush and loaf tin.

3.3 Sample Preparation

3.3.1 Preparation of tiger nut flour

To get rid of debris, stones, bad seeds, and foreign objects, the tiger nuts was sorted, cleaned and washed. The brown dried tiger nut was then freeze dried, milled into flour and sieved. Before the bread making, the sieved flour was packaged in a zip lock bag. The process flow diagram for making tiger nut flour is displayed below in (Figure 3.1).

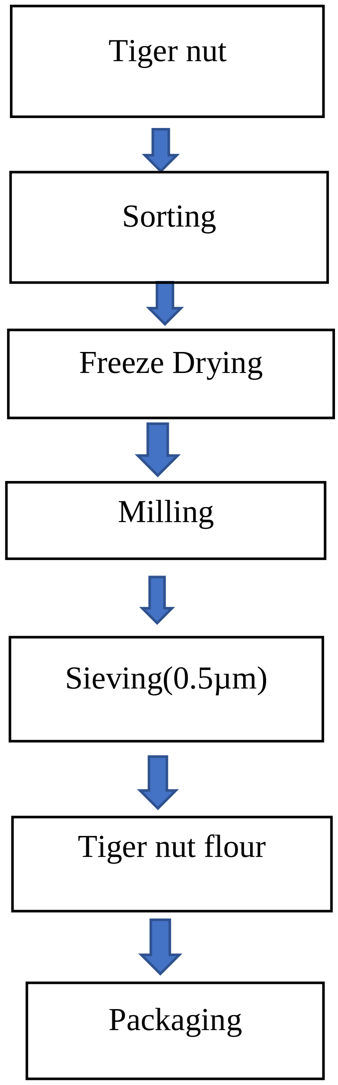

Figure 3.1: Flow Diagram for the Production of Tiger Nut Flour

3.3.2 Preparation of carrot flour

To get rid of debris, stones, mud and foreign objects, the purchased carrot was sorted, cleaned and washed. Before blending, the carrot was sliced, cut into pieces or cubes, and put to the blender for puree as shown in (Figure 3.2).

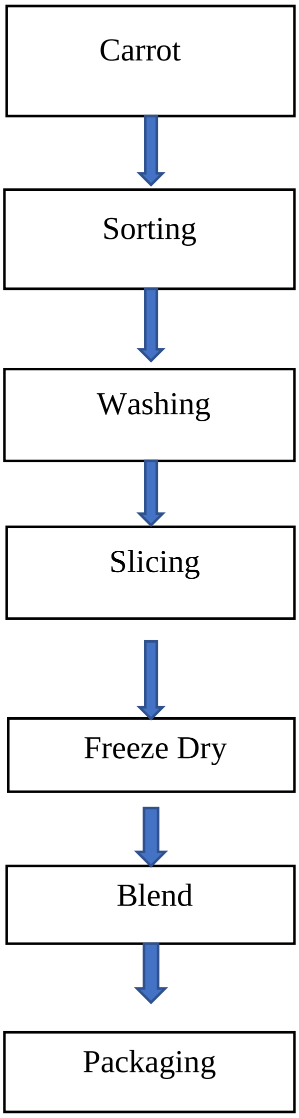

Figure 3.2: Flow Diagram for the Production of carrot Flour

3.4 Percentage Composition and Formulation of the Composite Bread

To make the bread, various amounts of tiger nut, carrot, and wheat flour was combined. All treatments, excluding the control, was produced with a combination of wheat, carrot, and tiger nut flour. Table 3.1 displays the composition for each type of bread treatment.

Table 3.1: Composition of various treatments of bread

Ingredients	Control	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
Wheat flour(g)	600(100%)	550(75%)	360(60%)	300(50%)	270(45%)	180(15%)
Tiger nut(g)	0	20	35	45	55	80
Carrot (g)	0	5	5	5	5	5
Yeast(g)	8	8	8	8	8	8
Fat/Margarine(g)	50	50	50	50	50	50
Sugar(g)	8	8	8	8	8	8
Milk powder(g)	24	24	24	24	24	24
Baking Soda(g)	6	6	6	6	6	6
Salt (g)	1	1	1	1	1	1

3.4.1 Production of the Composite Bread

The flour and all other ingredients were hand combined into dough after being weighed, the dough was then kneaded until the gluten was fully produced. Approximately twenty (20) minutes was spent resting the dough. The dough was then molded in a circular and rolled on the prepared crumbs after being cut to the desired weight of between 45 and 50 grams. To fit the aluminum container, the dough would be molded. According to the Oladunmoye et al. (2010) procedure, the dough was allowed to proof in pre-oiled baking pans for around 45 minutes to 1 hour before being placing it into the oven after reaching and maintaining baking temperature (about 130°C) for 35 minutes.

Pre heat oven to 350 degrees

Mix ingredient untill wet ingredients are evenly mixed.

Add tiger nut flour, wheat flour, baking powder, yeast and salt to the wet mixture and mix untill the dough is lump free

Allow the dough to proof

Portion the dough into a greased bread pan and allow to proof again .

Bake bread untill the top is golden brown

Remove, cool and package

Figure 3.3: Flow chart of the composite bread production

3.5 Physicochemical Properties

3.5.1 Determination of pH of the Bread

The digital bench top pH meter (Orion 2 tar PH meter,) was used in the determination. The electrode was cleaned in distilled water. It was then positioned into the dilute bread sample. The pH interpretation was read from the lead display screen of the pH meter (AOAC, 2000).

3.5.2 Titratable Acidity bread or flour

The titratable acidity, given as percent lactic acid, was calculated using the AACC (2000), which involved titrating 10 ml of mixture against 0.1 N NaOH with 1% phenolphthalein (2 - 3 drops) as an indicator until a light pink color appeared (endpoint). Triplicate determination per sample were made.

The following formula was used to compute the titratable acidity:

$$Titratable\ Acidity(\%\ Lactic\ acid) = (V\ \times N \times 9.08)/(W\ \times 10)$$

Where V = Titre value

N = Normality of the titrant

W = Sample weight

9.08 = Equivalent weight predominant Lactic acid

3.5.3 Determination of Total Soluble Solids of the bread.

A hand-held refractometer (REF-103, 0-32% Brix) was used. The refractometer was standardized by inserting a drop of distilled water on the prism and the sample drop on the prism of the instument. The eye-piece was used to observe the standardization after adjusting the coarse and fine adjustment properly. The procedure was repetitive for each sample and the suitable correction features made depending on the temperature of the sample (AOAC, 1990).

3.5.4 Colour measurement

The surface colour of *bread* was determined by using a digital handheld colorimeter (Digital handheld colorimeter-FRU® 10QC160226). CIE L* a* and b* colour values were used. L^* is the lightness (0-100), a^* is redness, and b^* is yellowness, and ΔE is colour difference which was calculated using the formular:

$\Delta E=\sqrt{(L_o{}^* - L^*) + (a_o{}^* - a^*) + (b_o{}^* - b^*)}$

The control bread sample was used as the reference point where Lo, a_o and b_o are the lightness, redness and yellowness respectively of a particular treatment of *bread*, and L* a* and b* are the lightness, redness and yellowness respectively of the control (Sumnu et al., 2005).

3.6 Proximate Analysis

3.6.1 Moisture content determination

An amount of 3 g *bread* was weighed using an analytical balance (SARTORIUS B120S, GERMANY). The weight of the petri dish and each sample was determined and recorded. The petri dish and its content were placed in a drying oven (FISHER Isotemp® Oven, SENIOR MODEL) at a temperature of 105^{o}C for 3 hrs. It was then removed and placed in a desiccator and then weighed. The procedure was repeated for each sample in triplicates (AOAC, 2000). The difference in weight were determined using formula for calculation of the moisture content:

Moisture (%) = $\frac{(W1-W2)X\ 100}{W2}$

Where: W1= weight (g) of sample and crucible before drying and W2= weight (g) of sample and crucible after drying.

3.6.2 Crude fat determination by goldfish apparatus method

An amount of 3 g *bread* which the moisture content had been determined was used. The moisture cans were weighed using an analytical balance (SARTORIUS B120S, GERMANY). The samples were transported into a thimble and placed in the holding chamber of the Goldfish apparatus. An amount of petroleum ether (25ml) was poured into each of the beaker. Cotton wool (asbestos) was placed on top of each sample in the thimble, the thimbles was then inserted in the gaskets of the gadget condenser. The beaker containing the solvents was also connected to the gaskets. The tap was then opened to allow free flow of water through the apparatus to enable the condensing of the solvent. The apparatus was switched on and the sample extracted for 4 h within a rate of 5 drops per seconds. The cans and its content were dried in an oven (FISHER Isotemp® Oven, SENIOR MODEL) for 30 min cooled in a desiccator for 30 min and weighed using an analytical balance (SARTORIUS B120S, GERMANY) to determine the difference in weight of the flask. The procedure was repeated for each sample in triplicates (AOAC, 2000). The fat content was calculated using the formula:

Crude fat (%) = $\frac{W1\ X\ 100}{W2}$

Where: W1=Fat weight and W2 = Sample weight

3.6.3 Ash content determination

An amount of 3 g *bread* was weighed using an analytical balance (SARTORIUS B120S, GERMANY). The weight of the crucible and each sample was determined and recorded. The crucible and its content were placed in a muffle furnace (THERMO SCIENTIFIC) at a temperature of 600^{o}C for 2 h. The crucibles were removed and allowed to cool in a desiccator after which was weighed. The procedure was repeated for each sample in triplicates (AOAC, 2000). The formula used to calculate ash content:

$$\%\text{ASH} = \frac{weight\ of\ ash\ sample - weight\ of\ empty\ crucible}{\text{sample weight}} \times 100$$

3.6.4 Crude fiber determination

The sample used for the fat determination was used for the crude fiber analysis. The defatted sample was transferred into a 500ml Erlenmeyer flask and 0.5g of asbestos and 200ml of 1.25% hot sulfuric acid was added and attached to a condenser and set on a hot plate. The flask was allowed to boil thirty minutes, filtered out and washed with hot water till the washings was no more be acidic. The residues were then placed back into the flask, attached to the condenser and made to boil with 200ml 1.25% NaOH for thirty minutes. It was then be filtered and washed with boiling water till deposit was no longer basic and 15ml alcohol was used to do a final washing. Residues were transported into silica crucibles and dried in an electric oven (FISHER Isotemp® Oven, SENIOR MODEL) for one hour at 100^{o}C. Crucibles and contents were ignited in a muffle furnace for 30 minutes, cooled in a desiccator and weighed and loss in weight will be determined. The procedure was repeated for each sample in triplicates (AOAC, 1990).

Crude fibre (%) = $\frac{(C1-C2\ )\ X\ 100}{C3}$

Where: C1= Weight of dried sample, C2 = Weight of ashed sample, and C3 = Weight of defatted sample

3.6.5 Crude protein content determination

An amount of 3 g *bread* was weighed using an analytical balance (SARTORIUS B120S, GERMANY) and placed in a digesting flask. Twenty-five millilitres of concentrated H_2SO_4 and Kjeldahal catalysts were added. Digestion was carried out until a clear solution was obtained. The digested sample was then filtered and neutralized with sixty millilitres distilled water. Seventeen millilitres of NaOH and 10 ml of sample was placed into the kjeldhal equipment and heated for the distillation of ammonia. Twenty-five millilitres of 4% boric acid were measured into the conical flask to receive the liberated ammonia gas.

The nitrogen was projected by titrating the ammonium borate formed with standard 0.096N HCl using mixed indicator and titre values recorded. (AOAC, 2000).

$$\text{Protein (\%)} = \frac{(A-B)\ x\ 14.007\ x\ 6.25}{W}$$

Where: A= volume (ml) of 0.2 N HCl used sample titration, B= volume (ml) of 0.2 N HCl used sample titration, N= Normality of HCl, W= weight (g) of sample, 14.007= atomic weight of nitrogen, and 6.25= the protein – nitrogen conversion factor.

3.6.6 Carbohydrate

The total carbohydrate estimate was obtained by subtracting the sum of moisture, ash, protein, fat and crude fiber from hundred and expressed as a percentage (AOAC, 2000).

3.6.7 Energy

The energy content of *bread* was determined by multiplying a factor of four (4) to the protein, a factor of nine (9) to the fat and a factor of four (4) to the carbohydrate and the results summed up (AOAC, 1990). The energy content of *bread* was calculated using the formula:

Energy (kJ) = (4 x protein content) + (9 x fat content) + (4 x carbohydrate content).

3.7 Sensory Evaluation

The composite bread samples were presented to thirty (50) panelists from Koforidua Technical University who were familiar with bread consumption. The panel comprised of both males and females who were adults. The attributes that were assessed were aroma, taste, texture, colour, and overall acceptability. Measures for recruiting included ensuring that panelists were frequent bread consumers. The panelists were given the bread in disposable plates that were randomly generated with three-digit codes. Panelists were asked to evaluate the samples based on the aroma, taste, texture, colour, and overall acceptability using a 5-point hedonic scale.1-Dislike very much, 5-Like very much (Peryam & Pilgrim 1957).

3.8 Data Analysis

Statistical Package for Social Sciences (SPSS) version 25.0 would be used to perform one-way Analysis of Variance (ANOVA) on all data received from various experiments. Means would be separated using the least significant difference (LSD). Differences in means would be regarded as significant at $p<0.05$. the result obtain from the study would be represented using graph and tables.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Physicochemical Properties of the Composite Bread (Wheat, Carrot and Tigernut flour)

Table 4.1: Physicochemical properties of the composite bread (Wheat, Carrot and Tigernut Bread)

Mean ± SD						
Sample /Parameters	**Control**	**T1**	**T2**	**T3**	**T4**	**T5**
PH	6.67± 0.12^{D}	6.25± 0.01^{E}	7.15± 0.01^{C}	7.65± 0.05^{A}	6.45± 0.07^{E}	7.36± 0.09^{B}
TSS (^{o}Brix)	1.70± 0.06^{C}	1.84± 0.06^{C}	2.40± 0.15^{B}	2.28 $\pm 0.09^{B}$	2.37 ± 0.12^{B}	3.53 ± 0.21^{A}
Acidity (%Lactic acid)	0.022± 0.001^{E}	0.022± 0.002^{E}	0.027± 0.001^{D}	0.057 $\pm 0.001^{B}$	0.050 ± 0.001^{C}	0.062 ± 0.001^{A}

****In each column, means that do not share a superscript are significantly different at α < 0.05;Control (100% wheat flour, 0% Tigernut flour & 0%Carrot flour);T1(75% wheat flour, 20% Tigernut flour & 5%Carrot flour);T2(60% wheat flour, 35% Tigernut flour & 5%Carrot flour);T3(50% wheat flour, 45% Tigernut flour & 5%Carrot flour);T4(45% wheat flour, 55% Tigernut flour & 5%Carrot flour);T5(15% wheat flour, 80% Tigernut flour & 5%Carrot flour);*

Supplementing Tigernut flour and carrot flour to bread sample caused energetic fluctuations in the titratable acidity (TA) and pH of the composite breads. pH basically measures the hydrogen ions concentration whereas Acidity measures the total hydrogen concentration (bound and unbound ions) of a sample. PH values for the bread sample treatments ranged between 6.67 to 7.36 with respect to Control sample and sample treatment 5 with a significant difference ($p\leq0.05$) between all the sample treatments. Also, there was no significant different ($p\geq0.05$) between the control sample treatment and sample treatment 1 but significant differences ($p\leq0.05$) between the rest of the sample treatment with respect to the acid content. The slight differences could be attributed to some degree of fermentation of the sugars used in the bread formulation processes.

It can also be assumed that, irrespective of the fraction of tigernut flour and carrot flour in the method, the acidity of the breads statistically significantly increased compared to the control. The upsurge in acidity was reliant on the number of organic acids contained in the added in the tigernut and carrot flour. Tigernut and carrot are rich in organic acids (Desava etal.,2022; Koltun et al.,2022) raised the acidity of the breads the most, especially in the case of 65% tigernut flour recipe additional.

Researches of pH and titratable acidity display that with the suitable addition of composite flour to the dough, these two parameters can be shaped in wheat bread. Consequently, this affects the organoleptic discernment of the bread.

This result therefore confirmed that Sample Treatment 2 bread sample will be more stable in terms of its shelf life than the rest of the treatments. Total soluble solids are an indication of an amount of sugar present in the bread sample. The T.S.S values obtained shows a significant difference ($p \leq 0.05$) between the sample treatments with the sample Treatment 5 with the highest mean value of 3.53 ^{o}Brix whereas control sample Treatment recorded the least mean value of 1.743 ^{o}Brix respectively. The differences in the mean of the T.S.S values as a result of the variations of sugar and added during the fermentation process and the degree of fermentation of the bread sample.

Table 4.2: Proximate composition of the composite bread (Carrot and Tigernut flour)

Mean ± SD						
Sample/ Parameters	**Control**	**T1**	**T2**	**T3**	**T4**	**T5**
Moisture (%)	33.18 ±0.17^{A}	27.28±0.65^{B}	26.81± 0.27^{B}	26.40±0.36^{B}	25.20±0.27^{C}	24.31± 0.60^{C}
Ash (%)	1.34 ±0.01^{C}	1.66±0.01^{B}	1.68± 0.1^{B}	1.68± 0.01^{B}	1.34±0.01^{C}	2.35± 0.02^{A}
Crude. Fat (%)	2.94 ±0.04^{D}	3.31±0.02^{C}	3.64± 0.04^{C}	4.10± 0.1^{B}	4.60±0.3^{A}	4.70± 0.04^{A}
Crude Fibre (%)	1.88 ±0.03^{BC}	1.67±0.02^{C}	1.73± 0.23^{A}	1.77± 0.02^{C}	1.87±0.02^{BC}	2.15± 0.13^{A}
Crude. Protein (%)	13.47 ±0.03^{C}	14.67±0.03^{A}	13.24± 0.10^{C}	13.54± 0.04^{B}	12.97±0.04^{D}	13.42± 0.02^{B}
Carbohydrate (%)	48.09 ±1.10^{C}	50.61±0.15^{B}	54.16± 0.04^{A}	54.16± 0.04^{A}	53.19±0.04^{A}	53.81± 0.17^{A}
Energy (Kcal)	269.00 ±0.70^{E}	292.00±1.83^{D}	303± 0.47^{C}	306.82± 0.61^{B}	303.92±0.03^{C}	309.87± 0.03^{A}

****In each column, means that do not share a superscript are significantly different at α < 0.05;Control (100% wheat flour, 0% Tigernut flour & 0%Carrot flour);T1(75% wheat flour, 20% Tigernut flour & 5%Carrot flour);T2(60% wheat flour, 35% Tigernut flour & 5%Carrot flour);T3(50% wheat flour, 45% Tigernut flour & 5%Carrot flour);T4(45% wheat flour, 55% Tigernut flour & 5%Carrot flour);T5(15% wheat flour, 80% Tigernut flour & 5%Carrot flour);*

4.1 Moisture Content

The moisture content of food goes a long way in signifying the shelf life of the produce. With this study, the moisture content ranged between 33.18% and 24.3%. The lowest level was found in samples treatment 5 and the higher moisture content in the control sample treatment. Although the sample treatments show a significant (P≤0.05) between all the samples but not significant(p≥0.05) between some individual sample treatments. The study suggests that the control sample which has a high moisture content possibly more vulnerable to decay by microbial attack particularly fungi and mould (Ihekoronye and Ngoddy, 1985) compare to the remaining sample treatment especially sample treatment 5 which recorded the least moisture content. A similar result was reported by Adebowale et al. (2009) on sweet potato-wheat bread.

Moisture is a very vital influence in the possession excellence of bread and high moisture can have an hostile result on storage stability. The bread sample having the highest moisture content may consequently have summary shelf life in contrast with other samples.

4.1.1 Crude. Protein Content

Crude Protein of the composite bread ranged between 13.42% to 13.47% with respect to control sample treatment and sample treatment 5. The results show a significant difference between ($P \leq 0.05$) between all the samples but not significant($p \geq 0.05$) between some individual sample treatments (T3 &T5). This is high than the range of 10.15% -12.44% obtained by Oluwalana et al. (2012) for sweet potato-wheat bread. This change may be due to addition of tiger nut in the composite flour. The protein content reduced as more sweet potato and tiger nut flours were merged into wheat flour, suggesting of low protein satisfied of the additives as associated to wheat. Ogunjobi and Ogunwolu (2010) also observed the same increase of protein content in their study. In general, a high protein content is a desired quality trait for producing food goods, this is so because protein is a necessary food that, via provide ng amino acids, is also involved in a diversity of biotic activities (Journel et al., 2012).

4.1.2 Fat Content

The percentage of fat varied from 2.94% to 4.70% with the control sample treatment with the least Sample A had the least and the sample treatment 5 with the highest fat content respectively. The composite bread was within range of fat contents 35.5 to 39.9% just as reported by Ratnayake et al., 2009). The study reveals an increase in fat content upon additional increase of the tigernut flour. The fat content was higher than that reported by Oluwamukomi *et al*, (2011). However, the current analysis suggests that the product's high fat content may be related to both the quantity of fat used in production and the high fat content of the raw materials used to create the flour. Fats are a major ingredient because they play crucial roles similar to making the completed product's texture more delicate. However, too much fat can also detract from the cookie's quality by giving it an especially soft texture and encouraging excessive fat consumption.

4.1.3 Ash Content

Ash content represent the total amount of minerals present in the sample. Bread ash contents varied between 1.34% and 2.35%. The study shows an increase in ash content as the tigernut flour is increase in the bread preparation process. This is evidence as tigernut is said to contain high amount of minerals Eke-Ejiofor and Deedam (2015).

4.1.4 Fibre Content

The percentage of crude fiber was from 1.88 % to 2.15, with control sample treatment least value of (1.88%) while sample T5 with the high fibre content of (2.15%) respectively which is similar to the range shown by Eke-Ejiofor and Deedam (2015) and Ogunjobi and Ogunwolu (2010), who reported values in the range of 1.3% to 2.5%. The crude fibre content was observed to increase with increasing tiger nut flour. All sample showed significant differences ($p \leq 0.05$) from each other except for sample treatment 5 and sample treatment 3 ($p \geq 0.05$) as shown in Table 4.2. High amount of tiger nut in the flour blend increased the fibre content. However, when compared to the recommended amounts of 20–35 g/day for adults and elders and 5 g/day for children, these numbers are still low for rich-fibre diets (Dhingra et al., 2012; Marlett et al., 2002). Consuming fiber reduces the chance of developing chronic diseases like diabetes and obesity and avoids constipation, making it crucial for good health (Marlett et al., 2002).

4.1.5 Carbohydrate Content

From Table 4.2 Carbohydrate contents ranged from 48.09% to 53.81%. The composite bread in accordance with Table 4.2 were all significantly different ($p \leq 0.05$) from the control. This result supported by similar results reported in separate studies by Alozie et al. (2009) and Abu-Salem and Abou-Arab (2011). The increase of carbohydrate content is as result of the high protein content, fat and mineral content in the composite bread sample.

4.1.6 Energy Level

Energy content range from 269.00Kcal/100g and 309.87Kcal/100g. The study reveals a significant ($p \leq 0.05$) difference between all the sample treatments. According to the study's findings, adding tiger nuts to baked goods can improve their energy content (Ezeocha & Nnenna, 2016).

Table 4.3: Bioactive analysis of the composite bread (Carrot and Tigernut flour)

Mean ± SD						
Sample/Parameters	**Control**	**T1**	**T2**	**T3**	**T4**	**T5**
Total phenolic compounds (GAE mg/ml)	15.42 $\pm 0.11^{E}$	17.633± 0.179^{D}	18.93 $\pm 0.02^{C}$	19.56 $\pm 0.56^{C}$	22.16± 0.18^{B}	24.12 $\pm 0.10^{A}$
Antioxidant Activity (% Inhibition)	81.66 $\pm 0.27^{E}$	82.30 $\pm 0.27^{E}$	86.18± 0.16^{D}	87.52 $\pm 0.025^{C}$	89.07± 0.12^{B}	90.83± 1.02^{A}

****In each column, means that do not share a superscript are significantly different at α < 0.05;Control (100% wheat flour, 0% Tigernut flour & 0%Carrot flour);T1(75% wheat flour, 20% Tigernut flour & 5%Carrot flour);T2(60% wheat flour, 35% Tigernut flour & 5%Carrot flour);T3(50% wheat flour, 45% Tigernut flour & 5%Carrot flour);T4(45% wheat flour, 55% Tigernut flour & 5%Carrot flour);T5(15% wheat flour, 80% Tigernut flour & 5%Carrot flour);*

Table 4.3 shows the results of the total phenolic compound and antioxidant activity of the composite bread sample (Tigernut and carrot flour). It is well identified that polyphenols are useful for health, due to their antioxidant possessions, which act as free radical scavengers and reduce oxidative stress in the human body (Abountiolas,2018; Zheng, 2017). But due to their (polyphenols) their collaboration with the food metric could affect mineral availability (Ferruzzi et al., 2020) and digestibility of protein and carbohydrate (Oghbaei & Prakash, 2016).

In this study, there was significant difference (P≤0.05) between the individual sample treatment with respect to the total phenolic compounds (TPC) but no difference between Sample treatment 2 and sample treatment 3. The increase in the TPC in ascending order is as a result of the increase of the Tigernut flour during the formulation process. Tigernut are generally known to have a high phenolic compound hence the high number of polyphenols recorded in the bread sample (Ferruzzi et al., 2020).

The antioxidant activity of the composite bread DPPH assays, displays the positive result of the baking procedure on this type of attribute. Antioxidant capacity increased in all bread variants tested associated to the control sample (81.66%) with no significant difference between the control sample and sample treatment 1. This study is in contract with the study conducted by Another study seems to confirm our finding (Tian, 2021). To check whether the increase in phenolic compounds by the rise of addition of Tigernut flour and continuous growth of the carrot flour had a direct outcome on the antioxidant activity of bread, a Pearson correlation was executed between TPC content and DPPH measurement values. Correlations of 0.797 and 0.893 (TPC-DPPH) were obtained, indicating an important but not limited effect of phenolic compounds on shaping the antioxidant capacity of the composite wheat bread. Therefore, it is concluded that along with the Tigernut and carrot flour, other biologically lively complexes seeing free radical scavenging skills were also supplied, as well as numerous other substances with antioxidant possible which were shaped during baking.

Table 4.4: Colour Analysis of the composite bread (Carrot and Tigernut flour)

Mean ± SD						
Sample/ Parameters	**Control**	**T1**	**T2**	**T3**	**T4**	**T5**
L*	18.14± 0.420^{C}	17.09 ±0.82^{C}	16.11 ±0.3^{B}	15.65± 0.30^{A}	13.56± 0.4^{B}	13.57 ±0.39^{B}
a *	0.50 ±0.04^{BC}	0.49±0.03^{BC}	0.46± 0.02^{C}	0.65± 0.02^{A}	0.44±0. 01^{C}	0.53± 0.03^{B}
b *	5.52±0.39^{CD}	4.68±0.04^{D}	5.55± 0.25^{CD}	5.59± 0.39^{C}	8.67±0. 29^{A}	7.61± 0.39^{B}
∆ E	-	4.77±0.48^{A}	4.04± 0.14^{B}	4.38± 0.24^{A}	4.48±0. 01^{BA}	5.1± 0.03^{C}

****In each column, means that do not share a superscript are significantly different at α < 0.05; Control (100% wheat flour, 0% Tigernut flour & 0%Carrot flour);T1(75% wheat flour, 20% Tigernut flour & 5%Carrot flour);T2(60% wheat flour, 35% Tigernut flour & 5%Carrot flour);T3(50% wheat flour, 45% Tigernut flour & 5%Carrot flour);T4(45% wheat flour, 55% Tigernut flour & 5%Carrot flour);T5(15% wheat flour, 80% Tigernut flour & 5%Carrot flour)*

The result of tiger nuts and carrot flour formulation on the bread colour is brief in Table 4.4. All colour values were expressed by Hunter L*, a*, and b* principles conforming to lightness, redness, and yellowness, respectively. The colour of samples was affected by the additional of wheat flour with Tigernut and carrot flour. In summary, as tiger nut flour level increased, the crust colour developed darker as measured by the colour instrument. The crust of the control was lighter and a lesser amount of yellow than any of the other samples. Though the exceptional colour of ingredients may have some adverse effect on the bread crust colour as effect to align to Millard and caramelization as suggested by Therdthai and Zhou (2003), but the colour change ΔE* on the bread crust improved with tiger nuts flour (taking the normal bread colour as standard) shows that there was no significant difference ($P \geq 0.05$) between control and the five treated samples. But a perilous look on the bread crust colour of the five samples found in plate 2 to plate 6 show that the samples containing the 45, 55 and 65 percent tiger nut flour were darker than the control and the 20 and 35 percent flour replacement.

Plate 4: Control

Plate5: Treatment 1

Plate 6: Treatment 2

Plate 7: Treatment 3

Plate 8: Treatment 4

Plate 9: Treatment 5

With respect to a* and b* crust colour values, breads with 0, 20 and 35 percent fibre replacement gave a higher value than breads with 45, 55 and 80 percent flour formulation, the a* and b* values differ significantly at ($p \leq 0.05$). This data outcome is in entire contract with what have been reported by Anil (2007) and Mohammed et al. (2012), however, the reported finding for the L* value for the control bread crust colour varies from the study conducted by Anil (2007).

From Table 4.5, the L results for the bread crumb colour in the samples, reduces as the level of substitution of wheat flour with tiger flour rise, this shows that the colour changes from white to grey. The a* and b* on the other hand increased as the level of replacement goes up. The obtained results are reliable with the findings of Hooda, (2005) and Miguel, (1999). The crumb colour difference, ΔE (taking the control bread colour as standard) shows the effect of tiger nut substitution on bread. The dimming of bread containing tiger nut flour may be ascribed to an increased Maillard reaction taking place during baking due to the occurrence of amino acid lysine and reducing sugar. In the Maillard reaction, reducing carbohydrates react with free amino protein and lead to amino acid sugar reaction foods. This reaction may affect the nutrient profile value of foods through the obstructive and destruction of essential amino nutrients as reported by Hurrell (1990). In a study conducted by Mohammed et al. (2012), they reported that colour of wheat flour bread was bright brown which increased significantly upon equal substitution and that typical loaves were gotten with substitution of wheat flour by chickpea flour at 10% levels.

Table 4.5: Sensory Analysis of the composite bread (Carrot and Tigernut flour)

Mean±SD						
Sample/ Parameters	**Control**	**T1**	**T2**	**T3**	**T4**	**T5**
Colour	3.70 ± 0.77^{A}	4.16 ± 0.68^{B}	3.98 ± 0.72^{B}	3.74 ± 0.94^{A}	3.54 ± 0.73^{AB}	3.34 ± 0.77^{C}
Taste	3.50 ± 0.77^{B}	3.24 ± 1.05^{C}	3.84 ± 0.95^{A}	3.46 ± 1.07^{B}	3.50 ± 0.82^{B}	3.34 ± 1.38^{C}
Aroma	3.70 ± 0.86^{A}	3.98 ± 0.74^{B}	3.86 ± 0.75^{B}	3.60 ± 1.01^{A}	3.32 ± 0.79^{C}	3.10 ± 1.25^{C}
Texture	4.04 ± 0.75^{A}	3.40 ± 1.09^{B}	3.82 ± 0.91^{A}	3.32 ± 0.97^{B}	3.08 ± 1.02^{C}	2.98 ± 1.33^{C}
Overall Acceptability	3.93 ± 0.89^{A}	3.76 ± 0.92^{B}	3.96 ± 0.83^{A}	3.58 ± 0.91^{C}	3.40 ± 0.86^{C}	3.93 ± 0.89^{A}

****In each column, means that do not share a superscript are significantly different at α < 0.05;Control (100% wheat flour, 0% Tigernut flour & 0%Carrot flour);T1(75% wheat flour, 20% Tigernut flour & 5%Carrot flour);T2(60% wheat flour, 35% Tigernut flour & 5%Carrot flour);T3(50% wheat flour, 45% Tigernut flour & 5%Carrot flour);T4(45% wheat flour, 55% Tigernut flour & 5%Carrot flour);T5(15% wheat flour, 80% Tigernut flour & 5%Carrot flour);*

4.2 Taste

Table 4.5 displays the average sensory rating for the flavour of samples of various bread recipes. A statistical analysis revealed a significant ($p \leq 0.05$) effect from the partial replacement of wheat flour with tigernut flour of the different bread formulation. Sample treatment 2 (35%tigernut replacement) recorded the highest score 3.84 for taste whiles sample treatment 1 (20% tigernut replacement) had the lowest value of 3.24. The taste ranking increased in proportion as the level of tigernut increased. There is clear evidence from the findings that, the bread sample with 15% replacement of wheat by tigernut flour enjoyed the highest preference with regards to taste as compare to the other composite product.

4.2.1 Colour

The bread crust's colour is an important sensory attribute that could improve appeal. Pale bread crusts are considered a sign of poor baking by the natives. Additionally, it is thought that the addition of nutrients, particularly iron, to the finished product is what gives it its brown hue. The fermented dough's temperature, baking time, moisture content, and the presence of reducing sugars and amino acids. Millard reactions during baking are a cause of the browning of bread crust (Dendy, 2013). From the results, colour ranged from 3.34 to 4.16. The sample with 20% and 65% tigernut replacement recorded the above values respectively with a significant difference ($p < 0.05$) from each other. The results indicated that colour preference decreased as the level of tigernut in the product increased.

4.2.2 Texture

When water is added to a dough during baking, the unique protein gluten, which is made up of the amino acid's gliadin and glutenin, causes the dough to form with good elasticity (Okaka, 2005). The samples analyzed show a significant ($p\leq 0.05$) different in texture. The score for texture ranged from 4.04 to 2.98. Control sample A (100% wheat) recorded the highest score of texture, whiles sample treatment 5 (80% tigernut incorporation) recorded the lowest. The texture score drops as the amount of tigernut flour rises, possibly as a result of the bread becoming firmer. Compared to fresh wheat bread, fresh composite bread was not as solid or stiff. This might be explained by the bread's reduced air cell structure and lack of gluten network creation as tigernut inclusion increased. The result shows a significant ($p\leq0.05$) difference from each other as the level of tigernut increase gradually in the composite bread product.

4.2.3 Aroma

Food aroma is a crucial aspect since it stimulates the taste receptors and gets the body ready to receive the product. Food that smells bad may be completely rejected before it is ever tasted. Taste is influenced by fragrance intensity at a healthy level (Iwe, 2008: Eddy et al., 2007). The statistical analysis revealed, based on the findings of the sensory evaluation of the five products under investigation, that replacing wheat flour with tigernut flour had a significant impact ($p \leq0.05$) on the aroma of the various bread formulations. The result for aroma ranges from 3.98 to 3.1 for 20% and 80% tigernut flour respectively. From the result, incorporation of wheat with tigernut has effect on aroma characteristics of bread (olaoye and Onilude, 2008). Product with 55 % tigernut flour replacement was rated second most preferred with respect to aroma. All samples showed a significant difference ($p\leq0.05$) from each other except some individual sample treatment($p\geq0.05$).

4.2.4 Overall Acceptability

The descriptive statistics was assessed for the overall satisfaction of all the products to the panelists. The overall acceptability of the samples ranged from 3.96 to 3.40. Maximum score value of overall acceptability from five-point hedonic scale was 3.96 recorded by Sample treatment 2 (35% tigernut flour), while minimum score value was 3.40scored by sample treatment 4 (55% tigernut). Significant disparities in the general acceptability of all the items were observed. The overall acceptability of samples was significantly different ($p \leq 0.05$). It was shown that the composite bread's overall acceptability dropped as tigernut replacement increased degrees of tigernut incorporation's appearance, texture, scent, and flavour, as well as the panelists' possible unfamiliarity with the product, may be to blame for the decline in overall approval. The findings on acceptance were consistent with earlier studies in the field, which discovered that adding wheat flour substitutes to bread reduces its overall appeal (Abdelghafor et al., 2011).

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.0 Conclusions

The composite bread was prepared from mixes of wheat flour, tiger nut flour, and carrot flour. The sensory characteristics and proximate composition were identified. The study found that the addition of tigernut increased the nutritional composition of t he mixture among the chemical parameters examined. Comparing it to the control, the composite bread had more nutrients. The preferred mean ratings for aroma, crispness, taste, and overall acceptability for wheat bread were higher. Consumers who gave the composite bread samples ratings between 1 and 2 on a 5-point hedonic scale accepted them all. where 1 is "Like very much" whereas 5 means "Dislike very much". The addition of the tiger nut and carrot influenced the consumer acceptability of the bread product based on the sensory results outcome with respect to higher mean value score for the various sensory attributes or parameters. The nutritional value such as protein, carbohydrate, fat etc. increased as the level of tiger nut increased in the product. The research also exposed that the proximate composition of breads produced from the composite blends are healthier compared with that made merely from wheat flour and hence bread prepared from such composite flour could help in battling protein-energy malnutrition since it has the potential as a functional food.

5.1 Recommendations

- Shelf-life study should be done in other to know the life span of the product.
- Also, a combine bread flour with defatted tiger nut meal to produce a more widely used low-fat product.

- Anti-nutritional and functional properties study should also be conducted.
- Textural Profile analysis should be study in order to get a detailed texture of the product.

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APPENDIX I

SENSORY QUESTIONAIRE

AKENTEN APPIAH-MENKA

UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

DEPARTMENT OF HOSPITALITY AND TOURISM EDUCATION

RESEARCH QUESTIONNAIRES

PRODUCT SENSORY AND EVALUATION

This research work seeks to determine consumer acceptability of bread made with various percentages of tiger nut flour, carrot flour and wheat flour. You have been provided with this form. Evaluate them and indicate your preference for them in terms of texture, aroma, taste, and appearance, and overall acceptability. Please tick your preference in the tables below.

Please provide sufficient information as possible. The information provided shall be used for research purposes only, and kept confidential.

Thank you.

Section A-Personal Details

Please tick the appropriate box.

1. Status: Administrators [ ] Lecturer [ ] other [ ]

2. Age: (20-25) [ ] (26-35) [ ] (36-45) [ ] (46 and Above) [ ]

3. Gender: Male [ ] Female [ ]

Section B- Product Information

Do you consume product made from wheat flour, tiger nut and carrot products?

1. Yes [ ] 2. No [ ]

Have you purchase/ or consumed bread products made from wheat flour, tiger nut, carrot and wheat? 1. Yes [ ] 2. No [ ]

What is the most important quality attribute that you /or would want in bread products? (Please tick only one) 1. Taste [ ] 2. odor/Aroma [ ] 3. Flavour [ ] 4. Appearance/color [ ] 5. Mouth feel [ ] 6. Texture[ ]

Section C: Sensory Evaluation

Please indicate each sample code before evaluating.

Quantify the degree of liking or disliking of the product before you and evaluate each given attribute one by one separately. Put a [√] in the box that best describes your opinion of the product.

Sample AA1					
SENSORY ATTRIBUTE	**LEVEL OF LIKENESS OF THE PRODUCT**				
	1	**2**	**3**	**4**	**5**
	Dislike very much	**Dislike much**	**Neither like/dislike**	**Like much**	**Like very much**
Taste					
Colour					
Flavour					
Aroma/odour					
Texture					
Overall acceptability					

Sample BB2					
SENSORY ATTRIBUTE	**LEVEL OF LIKENESS OF THE PRODUCT**				
	1	**2**	**3**	**4**	**5**
	Dislike very much	**Dislike much**	**Neither like/dislike**	**Like much**	**Like very much**
Taste					
Colour					
Flavour					
Aroma/odour					
Texture					
Overall acceptability					

Sample CC3					
SENSORY ATTRIBUTE	**LEVEL OF LIKENESS OF THE PRODUCT**				
	1	**2**	**3**	**4**	**5**
	Dislike very much	**Dislike much**	**Neither like/dislike**	**Like much**	**Like very much**
Taste					
Colour					
Flavour					
Aroma/odour					
Texture					
Overall acceptability					

Sample DD4					
SENSORY ATTRIBUTE	**LEVEL OF LIKENESS OF THE PRODUCT**				
	1	**2**	**3**	**4**	**5**
	Dislike very much	**Dislike much**	**Neither like/dislike**	**Like much**	**Like very much**
Taste					
Colour					
Flavour					
Aroma/odour					
Texture					
Overall acceptability					

Sample EE4					
SENSORY ATTRIBUTE	**LEVEL OF LIKENESS OF THE PRODUCT**				
	1	**2**	**3**	**4**	**5**
	Dislike very much	**Dislike much**	**Neither like/dislike**	**Like much**	**Like very much**
Taste					
Colour					
Flavour					
Aroma/odour					
Texture					
Overall acceptability					

Sample Control					
SENSORY ATTRIBUTE	**LEVEL OF LIKENESS OF THE PRODUCT**				
	1	**2**	**3**	**4**	**5**
	Dislike very much	**Dislike much**	**Neither like/dislike**	**Like much**	**Like very much**
Taste					
Colour					
Flavour					
Aroma/odour					
Texture					
Overall acceptability					

Which of the Sample will you buy if sold in the market? Please within a range of "1-5" kindly grade the products according to your preference.

Product	**Order of preference**
Sample AA1	
Sample BB2	
Sample CC3	
Sample DD4	
Sample EE5	

Which of the sample product you most prefer and why?

Which of sample product do you least prefer and why?

Would you buy bread product made from tiger nut and carrot? Yes/ No

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Additional comments:

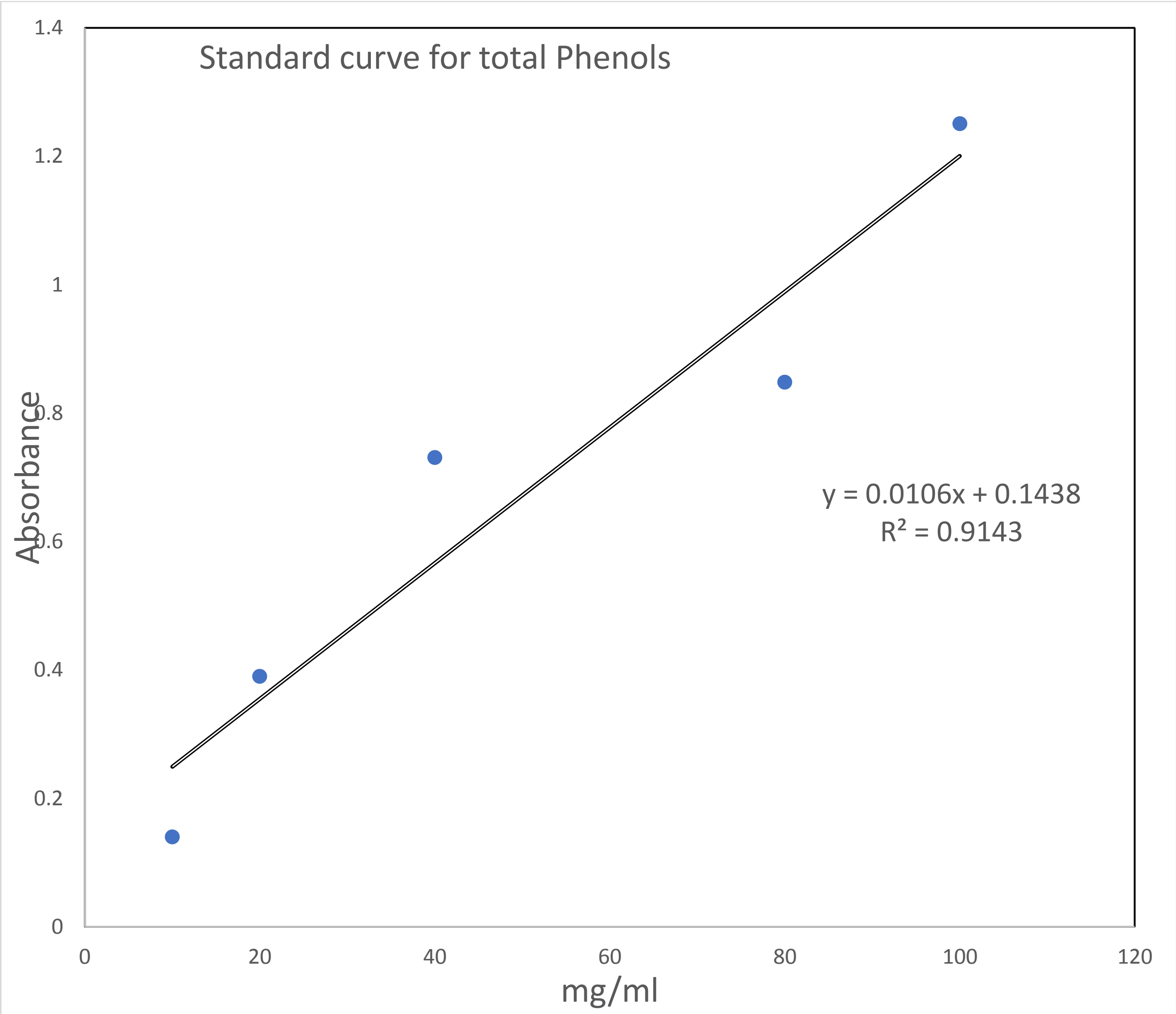
……………………………………………………………………………………..…

………………………………………………………………………………………

………………………………………………………………………………………

APPENDIX II

Gallic Acid Standard curve for Total phenolic compounds



APPENDIX III

VARIOUS STAGES OF CARROT AND TIGERNUT FREEZE DRYING PROCESSES

Plate 8: Freeze Drying Process of Carrot

Plate 9: Freeze - dried carrot

Plate 10: Packaged Freeze-dried carrot

Plate 11: Packaged Freeze-dried Tigernut flour