KOFORIDUA TECHNICAL UNIVERSITY

FACULTY OF APPLIED SCIENCE AND TECHNOLOGY

DEPARTMENT OF HOSPITALITY MANAGMENT

SENSORY QUALITIES AND PROXIMATE COMPOSITION OF COMPOSITE COOKIES FROM WHEAT FLOUR (*TRITICUM*), TIGER NUT FLOURS (*CYPERUS ESCULENTUS L.*) AND PINEAPPLE PUREE (*ANANA COMOSUS*)

BY

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DECLARATION

I declare that this project work is the result of my own original research work undertaken under the supervision of Professor John Owusu that all books consulted have been duly acknowledged and it has not been submitted to any other institution for the award of any certificate.

Abena Apreku Afari ..... 28/11/2023.

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SUPERVISOR CERTIFICATION

I hereby certify that the above students of BTECH in Hospitality Management of Koforidua Technical University is the writer of this project work and was duly supervised in accordance with the guidelines of supervision of project works laid down by the University.

Professor John Owusu	……**J. O**……	……**28/11/2023**……
(Supervisor)	Signature	Date

DEDICATION

I dedicate this project to God who gave me the strength to complete this work. My gratitude cannot be complete without mentioning the immense contribution of my parents Mr. and Mrs. Afari and Rev Daniel Twumasi who supported me in diverse ways. God richly bless you all.

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ABSTRACT

The main objective used for the study was to explore the feasibility of producing cookies with wheat flour, tiger nut flour and pineapple puree. The research design used for this study was experimental. A questionnaire was used to collect information from 50 sensory panelists from from DEREG Catering Services at the Shell Fuel Station, Highways, Koforidua. The results have shown that composite cookies of improved fibre content can be produced from wheat flour, tiger nut flour and pineapple puree. Also, cookie made from 80% wheat flour, 10% tiger nut flour, 10% pineapple puree is of comparable overall sensory acceptance as the control. The study recommends that wheat flour, tiger nut flour, and pineapple puree in the percentages of 80: 10: 10 should be used for cookies production and microbial studies on the cookies should be done to assess the safety of the products.

TABLE OF CONTENT

CONTENTS **PAGE**

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study

Cookies is a flat, crisp flour-based baked food product usually consumed as snacks. The main ingredients for cookies are flour, fat, sugar and water. The other ingredients include milk, salt, flavouring agent and aerating agent (Elizabeth and Tijesuni, 2020). In In Ghana, the readily availability, ready-to-eat, convenience and inexpensive nature of cookies makes it the second the most liked bakery product (Oladipo, 2022). Cookies are nutritive snacks made from unpalatable dough that is transformed into appetizing products through the application of heat in the oven in the process of baking (Ezeofor, 2022; Ukpong et al., 2021). The rich fat and carbohydrate content of biscuit make it an energy-giving food with rich source of protein and minerals (Ezeofor, 2022; Ukpong et al., 2021).

Consumption of biscuits and similar foods made from wheat has become so popular in Ghana that total elimination of wheat from the dietary pattern of cookies could have nutritional and socio economic implications (Baiano, 2020). There is a rapid growth in the consumption of ready-to-eat baked products in Ghana, and this has led to increased importation of wheat (Gustafson et al., 2022), since wheat is the main ingredient for baked products. In Ghana, staple crops such as cassava, yam or sweet potatoes, tiger nut bread fruits, rice and cereals can be used for baked foods (Gbenga-Fabusiwa, 2021). The inclusion of other crops such as pineapple puree and tiger nut which are locally grown and readily available in the production of baked foods such as biscuit will boost Ghana’s economy through job creation and reduction in wheat flour importation. Efforts are therefore, made to partially replace wheat flour with non-wheat flours in order to increase the

utilization of Ghana's indigenous crops as well as contribute to lowering cost of production of bakery products (Noort et al., 2022; Ani, 2021).

Pineapple is a tropical fruit with distinctive sweet and tangy flavour (Van-Tran et al., 2023). Being a popular fruit, pineapple may be consumed fresh, juiced or used in various culinary applications (Ali et al., 2020). Dehydrated or dried pineapple, is a preserved form of the tropical fruit produced through removal of water from fresh pineapple, to give a chewy and concentrated product (Sarkar et al., 2021). Pineapple puree is used in various culinary applications (Sarkar et al., 2021). Pineapple puree is a good source of vitamin C, an antioxidant that supports the immune system, skin health, and wound healing. It also contain vitamin B6 which play role in brain development and function, and it also helps the body convert food into energy (Sarkar et al., 2021).Pineapple puree contains dietary fiber, which aids in digestion and can help maintain healthy cholesterol levels. It also contain manganese which is essential for bone health, metabolism, and antioxidant defense (Sarkar et al., 2021).

Tiger-nut (Cyperus esculentus) is an underutilized crop which has been found to be cosmopolitan perennial crop of the same genus as the papyrus plant (Ntukidem et al., 2020). The high crude lipid, carbohydrate contents and its fairly good essential amino acid composition makes it a valuable source of food for man and can be consumed raw or processed into other valuable products. According to Yu et al. (2022) and Adejuyitan et al. (2009), tiger-nut produces high quality oil about 25% of its content and oil was implicated as lauric acid grade oil, non- acidic, stable and very low unsaturation. Cyperus esculentus has been reported to be "health" food since consuming it can prevent heart disease and thrombosis (blood clot formation in the blood vessel)

(Ene et al., 2023). It is considered a good flour additive for bakery industry since it contains high amount of natural sugar thereby avoiding the necessity of adding extra sugar and the tiger-nut Flour does not lose any of its nutritious properties in the milling process (Razola-Díaz et al., 2022). In recent years, there has been growing interest in developing innovative and healthier cookie products to cater to consumer preferences and nutritional needs. The use of alternative ingredients in cookie formulations has emerged as a promising approach to enhance their nutritional value and sensory appeal (Sielicka-Różyńska et al., 2021). Many researchers have delved into studying the physical and baking properties of composite biscuits from starchy staples like cassava, cocoyam and plantain (Adanse et al., 2021). Eke-Ejiofor et al. (2023) produced biscuit from various blends of bambara beans, cassava and wheat flours, Bello (2021) produced biscuit from wheat and tiger nut while Korese et al. (2021) produced biscuit from a blend of sweet potatoes and wheat flour. This study was aimed at finding out the possibility of producing cookies from a composite flour of wheat, pineapple, and tiger nut, and assessing its proximate composition and sensory qualities.

1.2 Problem statement

Traditional cookies made predominantly from wheat flour lack certain essential nutrients, particularly dietary fiber and essential amino acids such as lysine (Yousaf et al., 2013). The consumption of such cookies contributes to imbalanced diets, potentially leading to malnutrition and related health issues (Yousaf et al., 2013). Wheat which is a primary ingredient in cookie production, is often imported at a high cost, exerting pressure on a nation's foreign exchange reserves (Aizenman et al., 2015). This heavy reliance on imported wheat threatens the economic stability of the country. The incorporation of tiger nut flour and pineapple puree in cookie production provides an opportunity to enhance the nutritional quality of cookies (Agu et al., 2023).

Tiger nuts are a rich source of fiber, vitamins, and minerals (Madaki et al., 2018), while pineapple puree contains essential nutrients and natural sugars (Chaudhary et al., 2019). However, this opportunity remains underutilized. Hence, continuous wheat importation impacts the country's self-sufficiency and food security. Investing in alternative locally-sourced ingredients could help reduce the economic burden associated with wheat importation. Addressing these issues is vital for promoting healthier dietary habits, reducing dependency on imported wheat, and boosting the local agricultural and food processing sectors. The production of composite cookies using tiger nut flour, pineapple puree, and wheat presents an innovative approach to tackle these challenges, contributing to a more nutritious and sustainable alternative to traditional cookies.

1.3 Research objective

1.3.1 Main objective

The main objective used for the study was to explore the feasibility of producing cookies with wheat flour, tiger nut flour and pineapple puree.

1.3.2 Specific objectives

The specific objectives used for the study were to:

a) Determine the effect of different proportions of wheat flour, tigernut flour and pineapple puree on the proximate composition of cookies
b) Find out the effect of different proportions of wheat flour, tigernut flour and pineapple puree on the sensory qualities of cookies.
c) To assess the effect of different proportions of wheat flour, tigernut flour and pineapple puree on the overall acceptability of cookies.

1.4 Research questions

a) What are the effect of different proportions of wheat flour, tigernut flour and pineapple puree on the proximate composition of cookies
b) What is the effect of different proportions of wheat flour, tigernut flour and pineapple puree on the sensory qualities of cookies.
c) What is the effect of different proportions of wheat flour, tigernut flour and pineapple puree on the overall acceptability of cookies.

1.5 Significance of the study

The study on the production and sensory proximate analysis of cookies from composite wheat flour, tiger nut flour, and pineapple puree holds several significant implications for the food industry and consumers.

Firstly, the study explores the use of alternative ingredients such as tiger nut flour and pineapple puree in cookie production. This research will contribute to the development of innovative cookie recipes that offer unique flavours and nutritional benefits. Successful development of cookies from wheat, pineapple and tiger nut will expand the range of options available to consumers which will cater for their diverse dietary preferences and needs.

Again, pineapple and tiger nuts are rich in various essential nutrients such as fiber, vitamins, minerals, and natural sugars. The successful formulation of cookies from these food commodities will enhance the overall nutritional profile of the product, making it a healthier snack option. This development can positively impact consumers' diets by providing a more nutritious alternative to traditional cookies.

Also, the study has the potential to mitigate the economic burden associated with the importation of wheat. Wheat is a primary ingredient in cookie production and is often imported at a high cost, pressuring a nation's foreign exchange reserves. By developing cookies that rely less on wheat and incorporate locally sourced ingredients like tiger nut flour and pineapple puree, the study will potentially contribute to the reduction of wheat importation costs. This shift can enhance economic stability and promote the efficient utilization of local agricultural resources.

Furthermore, the successful production of cookies from wheat flour, tiger nut flour, and pineapple puree will bring about a diversification of the agricultural and food processing sectors. It will also encourage the cultivation of tiger nuts and pineapples, which may not have been extensively utilized in cookie production previously. This diversification can open up new economic opportunities for local farmers and reduce dependency on a single crop like wheat.

1.6 Scope of the study

Cookies are often produced using wheat as the main ingredient. This study made use of wheat flour, tiger nut flour and pineapple puree in cookies production. The study also evaluated the sensory properties, and the proximate composition, as well as the overall acceptability of the cookies produced.

1.7 Limitation of the study

Due to time and financial constraints, some aspects of the work which could help to make the study more comprehensive could not be done. The microbial load of the cookies could not be assessed, so their safety is not known. The number of sensory panelists was only fifty (50), and their views about the sensory qualities may not truly represent the views of large number of consumers of

cookies.

1.8 Organization of study

The study is organized into five chapters. Chapter one is the introduction which is made up of the background of the study, statement of the problem, objectives of the study, research questions, significance of the study, scope of the study, limitations of the study and organization of the study. Chapter two is about the review of relevant literature. Chapter three deals with the methodology that was used for the study. Chapter four is the results and discussion. The chapter five also focuses on the summary, conclusions and recommendations.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

The chapter two is basically about the review of existing literature as critical part of the study.

2.2 Cookies

Defined as a small, flat, and sweet baked or cooked food item, cookies are usually made with flour, sugar, and some form of oil or fat, and can also have additional ingredients such as raisins, oatmeal, chocolate chips, and nuts (Xu et al., 2020). Certain cookies may even be named based on their shapes, such as squares or bars (Joo and Choi, 2012). The increasing preference trend for cookies has been attributed to such factors as enhanced nutritional value and their convenience, and those who consume cookies of good nutritional qualities regularly enjoy better health and longevity (Noorfarahzilah et al., 2014).

2.3 Ingredients used for cookies production

The majority of the ingredients for making cookies are similar to those used for cakes, except that there is less liquid and more sugar and fat in the flour of cookies than cake (Luyts et al., 2013). Flour, sugar, and fat are the three basic components of each sort of cookie. In addition, fermenters, eggs, liquids, and flavours are employed in the making of cookies (Di-Cairano et al., 2018).

2.3.1 Sweeteners

There are many reasons why sweeteners are used in cookie production (Aidoo et al., 2013).

Sweeteners impart flavour, spreading, and softness to cookies (Ashokkumar, 2018). In most cookies, the recipe makes use of sweeteners such as granulated sugar, brown sugar, honey, molasses, and corn syrup (Carocho et al., 2017). The combination of different sweeteners can influence the overall taste of cookies. The type and quantity of sweetener used are important factors which influence the flavour and texture of biscuits, although the recipe itself plays the most critical role (Schiffman and Rother, 2013). The choice of sweetener significantly affects the texture of cookies. White sugar results in crisp cookies, because it does not attract much moisture from the atmosphere, preserving the cookie's crunchiness. On the other hand, brown sugar, which contains molasses, is hygroscopic and absorbs moisture from the surroundings, resulting in soft and chewy cookies (Nussinovitch, 2017).

For a chewy biscuit, liquid sweeteners like honey, corn syrup, or molasses are employed. These sweeteners act as humectants, retaining moisture over an extended period, keeping the cookie soft for several days, sometimes even longer (Nussinovitch, 2017). The use of honey can also impart a rich brown color to the cookie.

2.3.2 Fats

According to Mamat and Hill (2018), the role played by fat in cookie production is very important. They serve multiple functions such as coating gluten strands in flour, preventing excessive hardness when the cookie is exposed to moisture, and influencing the overall texture, taste, and flavour of the biscuit, as noted by Renzyaeva (2013).

The different types of fats used in cookies production include butter, margarine, shortening, and lard. Butter is known for imparting exceptional flavour and an average texture to the

cookies. Butter has a lower melting point (92°C - 98°C), and cookies made using butter tend to spread more, giving a crisper texture (Renzyaeva, 2013). Margarine yields cookies with a slightly different flavour profile, and vegetable oils produce cookies that are softer compared to those made with butter or margarine (Hwang et al., 2014).

2.3.3 Eggs

Yılmaz and Öğütcü (2015) have noted that eggs play a significant role in cookie production. The steam released by eggs becomes trapped in the dough, causing it to expand. Eggs contain lecithin, which acts as an emulsifier, harmonizing the water and fat components in the recipe and resulting in cookies with a creamy and smooth texture, as noted by Mouritsen and Styrbæk (2017). Additionally, the dry nature of eggs contributes to the overall structure and form of the biscuit (Ishwarya et al., 2015).

2.3.4 Liquids

Liquids play a crucial role in enhancing the texture and mouthfeel of baked items (Stokes et al., 2013). During baking, the vaporization of water creates steam, expanding air cells and boosting the final product's volume. Milk, besides providing essential water content, also contributes valuable nutrients to baked goods, enhancing their texture and flavour (Stokes et al., 2013).

2.3.5 Leaveners

Fermenters are important in cookie production because they provide carbon dioxide for leavening the cookies. Common leavening agents used in cookie making include sodium bicarbonate and baking powder (De Leyn, 2014).

2.3.6 Flavourings

Flavors either modify or enhance the taste of food or beverages by introducing specific ingredients, imparting a unique quality to the food. Moreover, aroma significantly influences the taste and overall sensory experience of cookies. Typical flavouring agents include extracts from cocoa, nuts, and vanilla (Vilela, 2019).

2.4 Wheat

Wheat is a cereal grain and staple food of the Triticum genus. It is a grass that is widely cultivated and used for various food products (Xiao et al., 2022). Wheat belongs to the family Poaceae (or Gramineae), which includes other important cereal crops like rice, maize (corn), and barley. There are several species and varieties of wheat, but the most commonly cultivated types include common wheat (*Triticum aestivum*) and durum wheat (*Triticum durum*). Common wheat is used to produce bread, while durum wheat is primarily used to make pasta (Hazard et al., 2020).

Wheat is grown in a variety of climates and regions, making it one of the most widely cultivated crops globally. It is a cool-season crop that typically thrives in temperate regions. It requires well-drained soil and receives irrigation in areas with insufficient rainfall. Wheat is a primary source of carbohydrates and is often consumed in the form of bread, pasta, and various cereal products. It also provides plant-based protein, fiber, vitamins (particularly B vitamins), and essential minerals like iron and magnesium (Xiao et al., 2022).

Wheat can be processed in various ways to produce different food products. Whole wheat contains the entire grain, including the bran, germ, and endosperm. Processed wheat, such

as white flour, has the bran and germ removed, leaving only the starchy endosperm (Saini et al., 2023; Ma et al., 2022). One important aspect of wheat is that it contains gluten, a protein complex that gives dough its elasticity and plays a crucial role in breadmaking. Gluten can cause health issues for some individuals, such as those with celiac disease or non-celiac gluten sensitivity, leading to the need for gluten-free alternatives (Xiao et al., 2022).

Wheat is used to produce a wide range of food products, including bread, pasta, pastries, cakes, biscuits, and breakfast cereals. It's a primary ingredient in many global cuisines, providing the foundation for various dishes (Hazard et al., 2020). Wheat is a staple crop and plays a significant role in the economies and cultures of many countries. It's often used as a symbol of nourishment and sustenance. Different regions cultivate wheat with varying characteristics, which can impact the texture and flavor of the food products made from it. For example, hard wheat is ideal for making bread due to its high protein content, while soft wheat is suitable for pastries and cakes (Hazard et al., 2020; Saini et al., 2023; Ma et al., 2022).

2.4.1 Nutritional value of wheat

Wheat is a staple grain with significant nutritional value. It provides essential nutrients and energy to individuals and populations worldwide (Saini et al., 2023; Ma et al., 2022). Wheat is primarily a carbohydrate-rich food. It contains complex carbohydrates, which are an excellent source of energy. These carbohydrates are gradually digested, providing a steady release of energy over time (Saini et al., 2023; Ma et al., 2022). Wheat is a good source of plant-based proteins. The protein content in wheat can vary depending on the

variety, but it typically contains around 10-15% protein (Saini et al., 2023; Ma et al., 2022). Wheat proteins are not considered a complete source of essential amino acids, so they are often consumed in combination with other protein-rich foods to ensure a balanced amino acid profile. Whole wheat, in particular, is high in dietary fiber. This fiber is essential for digestive health and helps regulate bowel movements. It also contributes to a feeling of fullness, which can aid in weight management (Saini et al., 2023; Ma et al., 2022). Wheat contains various vitamins, with the most notable being B vitamins. These include thiamin (B1), riboflavin (B2), niacin (B3), and folate (B9). These vitamins play crucial roles in metabolism, energy production, and overall health (Saini et al., 2023; Ma et al., 2022). Wheat is a source of important minerals, including iron, magnesium, and zinc. Iron is essential for oxygen transport in the body, magnesium is involved in various metabolic processes, and zinc is important for immune function and wound healing (Saini et al., 2023; Ma et al., 2022). Whole wheat contains various phytonutrients and antioxidants, such as lignans and phenolic acids. These compounds have potential health benefits, including reducing the risk of chronic diseases (Saini et al., 2023; Ma et al., 2022). Wheat is naturally low in fat, making it a good choice for those looking to reduce their fat intake. However, when wheat is processed into products like baked goods, fats are often added (Saini et al., 2023; Ma et al., 2022). Wheat is moderately calorie-dense. One cup of cooked wheat berries, for example, provides around 300 calories, making it a nutritious source of energy (Saini et al., 2023; Ma et al., 2022). It is important to note that wheat contains gluten, a protein that can cause health issues for individuals with celiac disease or non-celiac gluten sensitivity. For these individuals, gluten-free alternatives are necessary (Saini et al., 2023; Ma et al., 2022).

2.5 Tiger nut flour

Tiger nut flour is a type of gluten-free flour made from tiger nuts (Cyperus esculentus), which are not actually nuts but small, tuberous rhizomes (Nina et al., 2019). These small, wrinkled, and nutty-flavored tubers have been consumed for centuries in various parts of the world and are known by different names, including chufa, earth almonds, and yellow nutsedge. Tiger nut flour is a popular alternative to traditional wheat flour and offers several unique characteristics (Hussein et al., 2022; Kizzie-Hayford et al., 2023). Tiger nut flour is naturally gluten-free, making it an excellent choice for people with celiac disease, gluten sensitivity, or those following a gluten-free diet. Tiger nuts have a naturally sweet and nutty flavor, which imparts a pleasant taste to recipes that use tiger nut flour. This flavor can enhance the taste of baked goods, desserts, and various dishes. Tiger nuts are a good source of nutrients, including fiber, healthy fats (primarily oleic acid), vitamins (E and C), and minerals (such as iron, magnesium, and potassium). Tiger nut flour retains many of these nutrients (Hussein et al., 2022; Kizzie-Hayford et al., 2023).

Tiger nut flour can be used in a variety of culinary applications. It works well in baking, such as for making cookies, cakes, muffins, and bread. It can also be used as a thickening agent in sauces, soups, and stews or as a coating for frying foods. Tiger nut flour has a texture that is somewhat similar to almond flour. It can help provide a soft, moist, and slightly dense texture in baked goods. Tiger nut flour is rich in dietary fiber, which can be beneficial for digestive health and may help manage blood sugar levels. It can contribute to a feeling of fullness when consumed. Tiger nut flour is commonly used in paleo and vegan diets as an alternative to wheat and other grain-based flours. It aligns with these

dietary patterns due to its natural and unprocessed characteristics. The inherent sweetness of tiger nuts can reduce the need for additional sweeteners in recipes, making it an appealing option for those seeking to limit added sugars in their diets (Hussein et al., 2022; Kizzie-Hayford et al., 2023).

2.5.1 Nutritional value of tiger nut flour

Tiger nut flour made from the small tubers known as tiger nuts (*Cyperus esculentus*), is a nutritious and versatile ingredient that provides various essential nutrients (Sabah et al., 2019). Below are the nutritional value of tiger nut flour per 100 grams. Tiger nut flour is relatively energy-dense, providing around 385-400 calories per 100 grams. The calorie content is primarily due to the high fat content (Sabah et al., 2019). Tiger nut flour is rich in healthy fats, primarily oleic acid (a monounsaturated fat) and polyunsaturated fats. It contains about 25-30 grams of fat per 100 grams (Sabah et al., 2019). Tiger nut flour is a good source of carbohydrates, mainly dietary fiber and natural sugars. It provides roughly 60-65 grams of carbohydrates per 100 grams (Sabah et al., 2019). It is particularly high in dietary fiber, containing approximately 13-17 grams of fiber per 100 grams. Dietary fiber is beneficial for digestive health and may help with regulating blood sugar levels (Sabah et al., 2019). Tiger nut flour contains about 5-8 grams of protein per 100 grams, which contributes to overall protein intake (Sabah et al., 2019). Tiger nut flour is a source of several vitamins, such as vitamin E and vitamin C. These vitamins act as antioxidants and play a role in supporting overall health (Sabah et al., 2019). Tiger nut flour is a good source of essential minerals, including iron, magnesium, phosphorus, potassium, and zinc. These minerals are important for various bodily functions, including bone health and maintaining

electrolyte balance (Sabah et al., 2019). Tiger nuts, and consequently tiger nut flour, contain antioxidants that may help protect cells from oxidative damage (Sabah et al., 2019).

2.6 Pineapple puree

Pineapple belongs to the Bromeliaceae family, as one of the small representatives that bear fruit. It mainly grows in countries with tropical climates (Chaudhary et al., 2019). It is cone-shaped on the outside, and sweet on the inside. The dried pineapple has a sweet and crunchy texture. Pineapple puree is a smooth, thick, and homogeneous mixture made by processing fresh pineapples. It involves crushing, blending, or grinding ripe pineapples into a liquid or semi-liquid form, often without any additional ingredients (Khairina et al., 2023).

Dried pineapple can be eaten directly or used in muesli, oatmeal, smoothies, salads, or as an accompaniment to cakes and desserts. They can be soaked in hot water and then mashed into a puree. They can also be cooked in jam. Ready puree or jam can be added to pancakes or other favorite desserts (Khairina et al., 2023).

Pineapple puree starts with fresh, ripe pineapples. The pineapples are typically peeled, cored, and cut into small pieces. The goal is to remove the tough outer skin and the central core, leaving only the sweet and juicy flesh. The pineapple pieces are then processed using a blender, food processor, or specialized equipment. During processing, the fruit is broken down into a smooth and even consistency. No water or artificial additives are usually required in this process, as pineapples contain enough natural moisture (Khairina et al.,

2023).

Pineapple puree has a thick, smooth, and pourable texture. It is generally free from any large or solid particles, seeds, or fibers, making it easy to incorporate into various recipes. Pineapple puree retains the natural sweet and tangy flavor of fresh pineapples. It is known for its tropical, fruity, and refreshing taste, which is often used to add a burst of flavor to a wide range of dishes and beverages. Pineapple puree is a versatile ingredient used in both sweet and savoury dishes. It can be incorporated into smoothies, cocktails, sorbets, fruit salads, ice creams, desserts, and baked goods. In savoury cooking, it can be used as a glaze for meats, a sauce base, or a marinade ingredient (Khairina et al., 2023; Sohounhloué et al., 2022).

To extend the shelf life and convenience of pineapple puree, it can be preserved by canning, freezing, or converting it into dried pineapple puree. The preservation method chosen depends on the intended use and storage requirements (Sohounhloué et al., 2022). Pineapple puree retains the nutritional content of fresh pineapples. It is a good source of vitamin C, vitamin A, dietary fiber, and essential minerals like potassium and manganese. It provides natural sweetness and nutritional benefits to recipes (Khairina et al., 2023; Sohounhloué et al., 2022).

2.7 Composite flour in cookies

Composite flour refers to a blend of flours, starches, and various ingredients employed as partial or complete substitutes for wheat flour in bakery products (Noorfarahzilah et al., 2014). It can also be described as a mixture of two or three types of flours or crops

combined with wheat flour (Anggraeni et al., 2023).

The utilization of composite flour in baking offers substantial benefits, particularly for nations that do not cultivate wheat. These advantages encompass conserving foreign exchange, enhancing the nutritional content, and fostering local agricultural practices (Adejumo et al., 2023).

While wheat is recognized as a valuable source of energy and various nutrients, it lacks in protein, notably essential amino acids like lysine and threonine (Hansan and Malkanthi, 2023). The incorporation of different grains in combination with wheat results in bakery products with improved nutritional characteristics (Hansan and Malkanthi, 2023).

2.8 Cookies produced from other ingredients

Traditionally, cookies are produced using wheat flour (Bravo-Núñez and Gómez, 2021). Nonetheless, several studies have illustrated that incorporating alternative flours can augment the nutritional value of cookies. High-protein biscuits were formulated using wheat and soybean flour (Bravo-Núñez and Gómez, 2021), wheat combined with field peas and defatted peanut, as well as wheat blended with chickpeas and lapin. These experiments revealed the successful creation of biscuits by substituting wheat flour with up to 20% of a blend featuring wheat, cowpea, and peanut flour. The utilization of a blend comprising wheat flour, beans, and mung beans enhanced the protein content, starch resistance, and overall acceptability of the cookies, rendering it an appealing alternative (Krajewska and Dziki, 2023). Another notable substitution, replacing 10% of wheat flour with sweet potato flour, yielded biscuits with favorable physical and sensory attributes (Onabanjo and Ighere,

2014).

Jimoh (2021) focused on evaluating the quality of cookies made from wheat flour enriched with tiger nut flour and date palm fruit. The results of the microbial counts showed differences in cookies' storage conditions and their impact on microbial growth over time. In terms of sensory attributes, there were no significant differences at the 0.5% level of significance, and the cookies received high ratings for overall acceptability. This suggests that the cookies were of similar sensory qualities as the control.

The use of dates as a sugar substitute in cookie production gave flour of enhanced properties and cookies of improved properties like swelling index, oil absorption capacity, pH, and viscosity. Proximate composition increased with higher date palm pulp incorporation, except for carbohydrate and protein.

Akujobi (2018) assessed cookies made from blends of cocoyam and tiger nut flours, evaluating their chemical and sensory properties. The cookies were prepared using 100% cocoyam flour as the control and two variations: 30% and 50% substitution with tiger nut flour. Sample with 50% tiger nut flour substitution, showed the highest levels of moisture, protein, fat, ash, and crude fiber, while sample A had the highest carbohydrate content. Sample 50% tiger nut flour also exhibited the highest mineral and vitamin content, including magnesium, iron, zinc, vitamin E, vitamin A, and folic acid.

Ismail et al. (2014) studied the sensory properties of biscuits created by blending wheat

flour with defatted soy flour. The study utilized a 5-point hedonic scale to evaluate various sensory attributes of these biscuits. The findings revealed that the biscuits received positive sensory ratings, particularly in terms of taste, texture and overall liking or acceptability.

Abioye et al. (2019) conducted an evaluation of the sensory characteristics and consumer approval of biscuits that contained cashew nut shell liquid. The study employed a 5-point hedonic scale to gauge both sensory traits and consumer satisfaction. The results demonstrated that consumers positively received the sensory attributes of the biscuits, which encompassed aspects like taste, aroma, texture, and overall acceptability, as reflected by the favorable scores on the hedonic scale.

Colombo et al. (2019) concentrated on the sensory assessment of gluten-free biscuits prepared from a range of vegetable flours. Using a 5-point hedonic scale, the study evaluated the sensory qualities of gluten-free biscuits crafted from different vegetable flours. The outcomes revealed that the sensory features of the biscuits, including taste, texture, and overall acceptability, exhibited variations based on the specific type of vegetable flour utilized. Some variations received more favorable scores compared to others.

In a research on rice biscuit produced with different sweeteners sensory qualities taste, aroma, texture, and overall acceptability were found to be much influenced by the type of sweetener, with some receiving higher hedonic ratings than the others (Adeleke et al., 2017). The use of wheat flour, soya bean flour, and turmeric powder blend in biscuit production led to enhanced levels of dietary fibre and antioxidant activity (Singh et al.,

2018). In another study on proximate composition and sensory qualities of biscuit made with wheat, soy flour and turmeric powder it was revealed that there was improved protein and dietary fibre of the product (Yadav et al., 2016).

Obadina et al. (2016) conducted a study that centered on the assessment of biscuits produced from a blend of wheat and soybean flour. The research involved formulating biscuits with a combination of wheat flour and soya bean flour and examining their physicochemical characteristics, sensory attributes, and nutritional composition. The findings indicated that incorporating soya bean flour into the biscuit formulation enhanced their protein and dietary fiber content while preserving satisfactory sensory characteristics. Sultana et al. (2018) conducted research on creating and assessing the quality of biscuits enhanced with turmeric powder. The study involved enriching biscuits with turmeric powder and evaluating their quality features, encompassing physical traits, sensory properties, and nutritional composition. The results revealed that incorporating turmeric powder improved the biscuits' color, flavor, and antioxidant properties, all while preserving their overall quality.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Introduction

This chapter contains the ingredients used, the sources of the ingredients, recipe for wheat flour, tiger nut flour, and pineapple puree cookies, preparation of materials, production of cookies, proximate composition of cookies, sensory evaluation of cookies, and data analysis.

3.2 Materials used in the study

3.2.1 Ingredients used for the study

The ingredients used in the cookies production were wheat flour, tiger nut flour, pineapple puree, butter, sugar, salt, chocolate powder, baking powder and pineapple flavour.

3.2.2 Source of ingredients

Wheat flour, tiger nut, pineapple puree, butter, sugar, salt, chocolate powder, and baking powder were purchased from the Koforidua Central Market in the Eastern Region, Koforidua, Ghana.

3.2.3 Preparation of sample

3.2.3.1 Tiger nut flour preparation

After the raw tiger nut was brought from the market, it was washed with water until it became clean. The raw tiger nut was poured into a blender to blend to become rough. The blended tiger nut was poured into a muslin cloth to squeeze out the milk completely. The

baking tray was lined with aluminum foil and the oven was preheated to 150ºC. The tiger nut fibre was emptied on the baking tray and spread out evenly on the tray. The tiger nut fibre was put into the preheated oven and was checked after 15 mins. A wooden spoon was used to loosen the crumbs to prevent it from burning. After another 15 mins, the tiger nut fibre was completely dry. The dry tiger nut fibre was blended smoothly to become the tiger nut flour. The tiger nut flour was stored in an airtight container and was ready to be used.

3.2.3.2 Pineapple puree preparation

The pineapple was washed and peeled. After peeling, it was cut into pieces and blended without water to form the pineapple puree. The pineapple puree was kept in a container and was ready to be used.

3.3 Recipe for wheat flour, tiger nut flour, and pineapple puree cookies

The composite cookies of wheat flour, tiger nut flour, and pineapple puree was prepared with wheat, tiger nut flour and pineapple puree according to the recipe in Table 3.1. Each treatment was made up of different proportions of wheat flour, tiger nut flour and pineapple puree. The percentages of wheat flour, tiger nut flour, and pineapple puree for the treatments are shown in Table 3.2. The research design used for this study was experimental. In this design wheat flour alone was used to produce cookie, which formed the control experiment, but different proportions, of wheat flour, tiger nut flour and pineapple puree were used to produce composite cookies under the same condition. The proximate composition, sensory qualities and overall acceptability of the control were compared with those of the composite cookies.

Table 3.1: Recipe for the production of cookies

Ingredient (g)	Treatment				
	A	**B**	**C**	**D**	**E**
Wheat flour (g)	500	400	300	200	100
Tiger nut flour (g)	0	50	100	150	200
Pineapple puree (g)	0	50	100	150	200
Butter (g)	375	375	375	375	375
Sugar (g)	185.5	185.5	185.5	185.5	185.5
Baking powder (g)	2.25	2.25	2.25	2.25	2.25
Pineapple flavour (ml)	5	5	5	5	5

Table 3.2: Percentages of wheat flour, tiger nut flour, and pineapple puree in cookies

Ingredients	Treatment				
	A	**B**	**C**	**D**	**E**
Wheat flour	100	80	60	40	20
Tiger Nut Flour	0	10	20	30	40
Pineapple Puree	0	10	20	30	40

3.4 Production of cookies

Cookies were prepared according to the recipe used by Ogunjobi and Ogunwolu (2010) with some modifications in the amounts of shortening and sugar used. The recipe ingredients are shown in Table 3.1. The preparation followed six stages: weighing, mixing, shaping, cutting, baking and cooling. Butter and granulated sugar were mixed together with a hand mixer at a medium speed until a light and fluffy cream was formed. The composite

flour, baking powder, baking soda, chocolate powder, salt, and sugar were added and evenly mixed to form final dough. The dough was cut into pieces and rolled on a flat rolling board to a uniform thickness of about 0.4 cm using a wooden rolling pin and guiding sticks. Circular pieces of about 4.5 cm diameter was cut and placed on a baking tray. The baking of the cookies was done under a temperature of 100°C - 140°C for 10 min. in a kitchen oven. Afterwards, the cookies were cooled at room temperature and packaged in zip lock bags for sensory evaluation and proximate composition analysis.

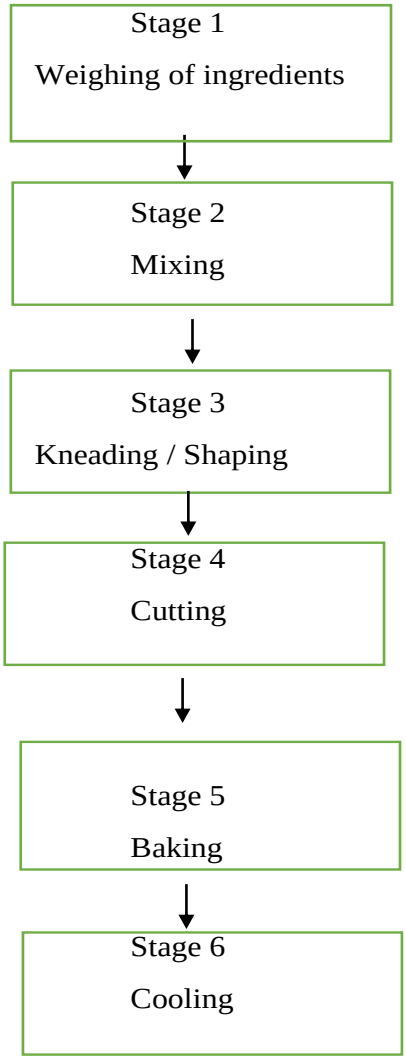

Figure 3.1: The six stages of preparing cookies (Ogunjobi and Ogunnolu, 2016)

3.5 Sensory evaluation of cookies

The five (5) treatments including the control were presented to fifty (50) sensory panelists from DEREG Catering Services at the Shell Fuel Station, Highways, Koforidua, Eastern Region, Ghana. The panel members were made up of both males and female adults. The attributes assessed were colour, aroma, taste, texture and overall acceptability. The panelists were requested to score their preference and general acceptability based on a five (5) point hedonic scale with 5- like very much, 4- like much, 3- neither like nor dislike, 2- dislike much and 1- dislike very much. The order of presentation of samples was done randomly.

3.6 Proximate composition of cookies

3.6.1 Moisture content determination

An amount of 2g of the sample was weighed using an analytical balance (Sartorius B120S, Germany). The weight of the petri dish and each sample were determined and recorded. The petri dish and its contents were placed in a drying oven (Fisher Isotemp® Oven, Senior model) at a temperature of 105^{o}C for three hours after which the differences in weight were determined using the appropriate formula for calculation of the moisture content. The procedure was repeated for each sample in triplicates (AOAC, 2000).

Moisture content (%) = $\frac{(W1-w2)}{w1}\ x\ 100$

W1= weight (g) of sample and crucible before drying

W2= weight (g) of sample and crucible after drying.

3.6.2 Crude fat determination

An amount of 3g of the composite cookie which the moisture content had been determined was used. The beakers were weighed using an analytical balance (Sartorius B120S, Germany). The samples were transferred 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 beakers. Cotton wool (asbestos) was placed on top of each sample in the thimble; the thimbles were then inserted in the gaskets of the apparatus 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 facilitate the condensing of the solvent. The apparatus was switched on and the sample extracted for 4 hours within a rate of 5 drops per seconds. The beakers and its contents dried in an oven (Fisher Isotemp® Oven, Senior Model) for 30 minutes, cooled in a desiccator for 30 minutes and weighed on an analytical balance (Sartorius B120S, Germany) to determine the difference in weight of the flasks. The procedure was repeated for each sample in triplicates (AOAC, 2000). The fat content was calculated using the formula:

.Crude fat (%) $\frac{W1}{W2}\ x\ 100$

W1 =Fat weight and W2 = Sample weight

3.6.3 Crude fibre 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% boiling H_2SO_4 were added and connected to a condenser and set on a hot plate. The flask boiled for thirty minutes, its content was filtered out and washed with

boiling water until the washings were no more acidic. The residues were put back into the flask, connected to the condenser and made to boil with 200ml 1.25% NaOH for thirty minutes. It was then filtered and washed with boiling water till filtrate was no longer basic and 15ml alcohol was used to do a final washing. Residues were transferred into silica crucibles and dried in an electric oven (Fisher Isotemp® Oven, Senior Model) for one hour at 100^{o}C. It was then cooled and the weight was taken. Crucibles and contents were ignited in a muffle furnace for 30 minutes, cooled in a desiccator and weighed and loss in weight was determined. The procedure was repeated for each sample in triplicates (AOAC, 1990). The crude fiber content was calculated using the formula:

$$\text{.Crude fiber (\%)} = \frac{C1-C2}{C3}\ x\ 100$$

C1= Weight of dried sample

C2 = Weight of ash sample

C3 = Weight of defatted sample

3.6.4 Ash content determination

An amount of 3g of the cookie sample was weighed using an analytical balance (Sartorius B120S, Germany). The weight of the crucible and each sample were determined and recorded. The crucible and its contents were placed in a muffle furnace (Thermo Scientific) at a temperature of 600 ^{O}C for two hours. The crucibles were removed and allowed to cool after which it was weighed. The procedure was repeated for each sample in triplicates (AOAC, 2000). The ash content was calculated using the formula:

$$\text{.Ash content (\%)} = \frac{C1-C2}{C3}\ x\ 100$$

C1= Weight of empty crucible

C2 = Weight of ash sample

C3 = Weight of sample

3.6.5 Crude protein content determination

An amount of 2g of composite cookie was weighed using an analytical balance (Sartorius B120S, Germany) and placed in a digesting flask. Twenty-five millilitres of concentrated H_2SO_4 and Kjeldahl catalysts were added. Digestion was carried out in a digestion chamber until a clear solution was obtained. The digested sample was filtered into a 100ml volumetric flask and made to the mark with sixty millilitres distilled water and mixed well. Seventeen millilitres of NaOH and 10 ml of sample were put into the Kjeldhal apparatus and heated for the distillation of ammonia. Twenty-five millilitres of 4% boric acid was measured into the conical flask to receive the liberated ammonia gas.

The nitrogen content was estimated by titrating the ammonium borate formed with standard 0.096N HCl using mixed indicator and titre values were recorded. The procedure was repeated for each sample in triplicates (AOAC, 2000). The protein content was calculated using the formula: $\text{Protein (\%)} = \frac{(A-B) \text{ x } 14.007 \text{ x } 6.25}{W}$

A= volume (ml) of 0.2N HCL used in sample titration

B= volume (ml) of 0.2N HCL used in blank titration

N= Normality of HCL

W= weight (g) of sample

14.007= atomic weight of nitrogen

6.25= the protein – nitrogen conversion factor

3.6.6 Carbohydrate / Nitrogen free extract

The total carbohydrate estimate was obtained by subtracting the sum of moisture, ash, protein, fat and crude fibre contents from hundred and expressed as a percentage (AOAC, 1990).

Carbohydrate content (%) = 100 – (M + A + P + F)

M = Moisture content (%)

A = Ash content (%)

P=Protein content (%)

F = Fat content (%)

3.6.7 Energy

The energy was determined by multiplying a factor of 17 to the protein, a factor of 37 to the fat and a factor of 16 to the carbohydrate and resultant summed up to obtain the energy of the product (AOAC, 1990). Energy was calculated using the formula:

Energy (kJ) = (17 x Protein) + (37 x Fat) + (16 x carbohydrate)

3.7 Analysis of data

The sensory evaluation data as well as the proximate composition data were analyzed using the software called Statistical Package for Social Scientists (SPSS), Version 26. The analytical tool used for the analysis was analysis of variance (ANOVA) and means were separated using the Duncan's multiple range test. Means were considered significant at $p < 0.05$.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Introduction

Data obtained using the methods described in the previous chapter are analyzed in this fourth chapter. Three (3) main sections are covered in this chapter of the study. The results of demographic characteristics is presented in the first section, the results of the sensory evaluation of the study are presented and discussed in the second section. The results of the proximate composition of the cookies are presented and discussed in the last section.

4.2 Socio-demographic characteristics of sensory panelists

The demographic background information captured in the study were panelists' gender, age, and status. The gender distribution of the sensory respondents showed that, 62% of them were females and 38% were males. Hence, majority of the respondents were females. The results from the study again revealed that, 90% of the sensory panelists were within 20-30 years and 10% were those within 31-40 years. The educational status of the respondents showed that 10% of them were JHS graduate, 78% were tertiary graduates, and 12% were those with primary educational background. Hence, majority of the panelists had tertiary education.

Table 4.1: Socio-demographic characteristics of panelists

Variable	Category	Frequency	Percentage
Gender	Female	31	62.0
	Male	19	38.0
	Total	50	100
Age range	21-30 years	45	90.0
	31-40 years	5	10.0
	Total	50	100
Educational status	Primary	6	12.0
	JHS	5	10.0
	Tertiary	39	78.0
	Total	50	100

4.3 Sensory attribute preference of composite cookie of wheat flour, tiger nut flour, and pineapple puree

The results on preference for the sensory qualities of the cookies produced (taste, colour, aroma, texture, and overall acceptability) by the sensory panelist are presented in Table 4.2. The preference were expressed by the panelists based on a 5-point hedonic scale with 1 as dislike very much and 5 as like very much.

4.3.1 Taste likeness of composite cookie

The results obtained on taste likeness for the various treatments of the composite cookies are shown in Table 4.2. The results indicate that most of the sensory panellists prefer or like the taste of Treatment B (80% wheat flour, 10% tiger nut flour, 10% pineapple puree) followed by those who like the taste of Treatment A (control sample). Treatment E which was made of 20% wheat flour, 40% tiger nut flour, 40% pineapple puree was least preferred in terms of taste. Thus, treatment B was generally preferred to treatment A in terms of its taste. However, treatment C, D and E were least preferred when compared to the control sample. Generally, cookies with tiger nut and pineapple were least preferred, in terms of

taste than the control. Madukwe et al. (2013) in a similar study found that, the control had significantly higher preference for taste than the other treatments.

Table 4.2: Taste likeness of composite cookies

Treatment	Mean preference
A (Control)	4.54 ± 0.71^{b}
B	4.64 ± 0.85^{a}
C	4.20 ± 0.88^{d}
D	4.40 ± 0.70^{c}
E	3.94 ± 1.24^{e}

Means with different alphabets are significant at $P<0.05$.

Treatment A - 100% wheat flour
Treatment B - 80% wheat flour, 10% tiger nut flour, 10% pineapple puree
Treatment C - 60% wheat flour, 20% tiger nut flour, 20% pineapple puree
Treatment D - 40% wheat flour, 30% tiger nut flour, 30% pineapple puree
Treatment E - 20% wheat flour, 40% tiger nut flour, 40% pineapple puree

4.3.2 Colour likeness of composite cookies

Colour of a food product is important because it can influence a consumer's choice. Colour likeness of composite cookie by the sensory panellists are indicated in Table 4.3. The results show that the colour preference for treatments C was not significantly different ($P>0.05$) from treatment A (control). However, treatment D and E were significantly lower ($P<0.05$), in terms of colour preference than the control. Treatment B was mostly preferred when compared to the control. Generally, treatments with tiger nuts and pineapple were of lower preference for colour than the control. Madukwe et al. (2013) found that the control had higher preference for colour than the other treatments.

Table 4.3: Colour likeness of composite cookies

Treatment	Mean preference
A (Control)	4.50±0.51[a]
B	4.72±0.45[d]
C	4.50±0.61[a]
D	4.14±0.78[b]
E	3.94±1.28[c]

Means with different alphabets are significant at P<0.05.

Treatment A - 100% wheat flour
Treatment B - 80% wheat flour, 10% tiger nut flour, 10% pineapple puree
Treatment C - 60% wheat flour, 20% tiger nut flour, 20% pineapple puree
Treatment D - 40% wheat flour, 30% tiger nut flour, 30% pineapple puree
Treatment E - 20% wheat flour, 40% tiger nut flour, 40% pineapple puree

4.3.3 Aroma/odour likeness of composite cookies

The sensory panellists' preference for the aroma of the cookies are shown in Table 4.4. The likeliness for the aroma of treatment C and D were not significantly different (P>0.05) from that of the control. The aroma preference for Treatment B was higher than all other treatments. The control was significantly higher than the other treatments interms of their aroma in prior study by Madukwe et al. (2013). The value for the control was 7.93 when compared to the others made of rice and groundnut (6.59), and rice and soya beans (7.05).

Table 4.4: Aroma/odour likeness of composite cookies

Treatment	Mean preference
A (Control)	4.40±0.76[b]
B	4.70±0.68[a]
C	4.44±0.58[b]
D	4.42±0.50[b]
E	4.28±0.67[c]

Means with different alphabets are significant at P<0.05.

Treatment A - 100% wheat flour
Treatment B - 80% wheat flour, 10% tiger nut flour, 10% pineapple puree
Treatment C - 60% wheat flour, 20% tiger nut flour, 20% pineapple puree
Treatment D - 40% wheat flour, 30% tiger nut flour, 30% pineapple puree
Treatment E - 20% wheat flour, 40% tiger nut flour, 40% pineapple puree

4.2.4 Texture likeness of composite cookies

The results on preference for texture of composite cookie as shown in Table 4.5 indicated that all the four treatment were significantly lower ($P<0.05$) than that of the control. The texture of composite cookies of the control was mostly preferred by the panellists. The results from the study are similar to Madukwe et al. (2013) who also found the control to be significantly higher than the other treatments. The value for the control in terms of texture was 8.0 when compared to the others made of rice and groundnut (6.92), and rice and soya beans (6.54).

Table 4.5: Texture likeness of composite cookies

Treatment	Mean preference
A (Control)	4.56 ± 0.50^{a}
B	4.48 ± 0.71^{b}
C	4.26 ± 0.83^{c}
D	4.22 ± 0.86^{c}
E	4.08 ± 1.12^{d}

Means with different alphabets are significant at $P<0.05$.

Treatment A - 100% wheat flour
Treatment B - 80% wheat flour, 10% tiger nut flour, 10% pineapple puree
Treatment C - 60% wheat flour, 20% tiger nut flour, 20% pineapple puree
Treatment D - 40% wheat flour, 30% tiger nut flour, 30% pineapple puree
Treatment E - 20% wheat flour, 40% tiger nut flour, 40% pineapple puree

4.2.5 Overall acceptability of composite cookies

The results on the overall acceptability of the composite cookies are shown in Table 4.6. The results clearly showed that the overall acceptability of treatment B was not significantly different from the Control. However, the overall acceptability of treatments C, D, and E was significantly lower than the control. Generally, treatments with tiger nut

flour and pineapple puree gave significantly lower overall acceptability than the Control. The variation in the likeness for taste, colour, aroma and texture may account for the differences in the overall acceptability of the various composite cookies. Treatment A and B were generally preferred than all the other treatments in terms of their overall acceptability by the panelists. In a similar study of Madukwe et al. (2013) the control had the highest overall acceptability compared to the other treatments.

Table 4.6: Overall acceptability of composite cookies

Treatment	Mean overall acceptability
A	4.74 ± 0.63^{a}
B	4.74 ± 0.66^{a}
C	4.19 ± 0.97^{d}
D	4.50 ± 0.74^{b}
E	4.28 ± 1.20^{c}

Means with different alphabets are significant at $P<0.05$.

Treatment A - 100% wheat flour
Treatment B - 80% wheat flour, 10% tiger nut flour, 10% pineapple puree
Treatment C - 60% wheat flour, 20% tiger nut flour, 20% pineapple puree
Treatment D - 40% wheat flour, 30% tiger nut flour, 30% pineapple puree
Treatment E - 20% wheat flour, 40% tiger nut flour, 40% pineapple puree

4.3 Proximate analysis of composite cookies

The proximate composition of the composite cookies are indicated in Table 4.7.

4.3.1 Moisture content of composite cookie

The moisture content of the composite cookies ranged from 2.055% to 5.287% with sample E having the highest moisture content while sample A had the lowest content. The moisture content of a product gives an idea about the shelf life of that product. The moisture content of the composite cookies studied was within the recommended range of 0-10% for storage

of cookies without degradation of its triglyceride by microorganism (Bravo-Núñez and Gómez, 2021).

4.3.2 Ash content of composite cookie

The results of the ash contents for the composite cookies are also shown in Table 4.7. The results indicate that, the ash contents ranged from 1.184% to 2.576%. The highest ash contents was recorded in sample B (2.576%) and the sample C had the lowest ash contents. There was no significant difference ($p < 0.05$) between the control and other samples in the experiment. The results are similar to the results of Ayo et al. (2018) who made composite cookies from wheat and turmeric flour blend. Their results found that, the range of values for the ash contents was from 1.79 to 2.11. Their results did not show any specific trend for the ash contents of the cookies produced as the turmeric flour increases. Similarly, it was observed from this study that the ash content of the cookies did not show any specific trend.

4.3.3 Fats content of composite cookie

The result of the fat content of the cookies is presented in Table 4.7. The results revealed that the fat content ranged from 2.122% to 4.545% with the control sample (100% wheat flour) having the lowest fat content while sample E had the highest fat content. The higher value recorded for sample B,C,D and E than the control could be attributed to the increase in tiger nut flour, as it has been reported that tiger nut has a high oil content (Yao et al., 2020). Prior study by Agu et al. (2023) found the control to be significantly lower, in terms of fat content when compared with the other treatments of cookies made from wheat, soybean and tigernut composite flour.

Table 4.7: Proximate analysis of composite cookies

Sample	Moisture (%)	Ash (%)	Fat (%)	Fibre (%)	Protein (%)	Carbohydrate	Energy (kJ)
A (Control)	2.06±0.0.08^{e}	1.38±0.07^{c}	2.12±0.03^{e}	2.16±0.10^{e}	8.42±0.10^{a}	77.66±0.39^{d}	363.32±1.43^{d}
B	3.58±0.09^{c}	2.58±0.09^{a}	2.31±0.01^{d}	2.34±0.05^{c}	7.24±0.15^{e}	77.36±0.36^{e}	359.19±1.33^{e}
C	3.01±0.04^{d}	1.18±0.18^{e}	2.67±0.06^{c}	2.28±0.14^{d}	7.45±0.10^{d}	77.99±0.39^{c}	365.76±2.09^{c}
D	4.06±0.06^{b}	1.32±0.06^{d}	4.14±0.13^{b}	2.50±0.14^{b}	8.15±0.15^{c}	79.20±0.26^{b}	386.66±0.48^{b}
E	5.29±0.15^{a}	2.06±0.09^{b}	4.55±0.12^{a}	2.57±0.12^{a}	8.39±0.13^{b}	79.86±0.22^{e}	393.91±1.12^{a}

Means with different alphabets are significant at P<0.05.

Treatment A (Control, 100% wheat flour)
Treatment B (80% wheat flour, 10% tiger nut flour, 10% pineapple puree)
Treatment C (60% wheat flour, 20% tiger nut flour, 20% pineapple puree)
Treatment D (40% wheat flour, 30% tiger nut flour, 30% pineapple puree)
Treatment E (20% wheat flour, 40% tiger nut flour, 40% pineapple puree)

4.3.4 Protein content of composite cookie

The protein content of the cookies ranged from 7.241% to 8.402%. The control sample had the highest value of 8.402% while the least value was recorded for treatment B. Generally, the protein content of the cookies made with tiger nut and pineapple puree was significantly lower than the control. It was observed from the study that the protein content of the cookies did not show any specific trend with increase in the replacement level of the wheat flour. Unlike in this study where the addition of tiger nut flour and pineapple puree led to a general reduction in protein content of the cookies, in a previous study by Ndife et al. (2014), composite cookie gave a higher protein content than the control.

4.3.5 Carbohydrate content of composite cookie

The results of the carbohydrate contents revealed that the carbohydrate contents of the composite cookies ranged from 77.36 to 79.86%. The carbohydrate content of the cookies generally increased with an increase in tiger nut flour and pineapple puree. The results are similar to prior study by Agu et al. (2023) who also found that the carbohydrate content of the control was significantly lower when compared with the others.

4.3.6 Energy content of composite cookie

The results of the energy contents of the composite cookies ranged from 359.19 to 393.91KJ. Generally, the cookies showed significantly higher ($P<0.05$) energy contents as the proportion of tiger nut flour and pineapple puree increased.

The results are similar to prior study by Agu et al. (2023) who found an increase in the energy contents of the cookies produced as the percentage of soybean and tigernut flour

increases. The reason for the increment in energy is that, tiger nut flour tends to have slightly more calories compared to wheat flour due to its higher fat contents, while pineapple puree is significantly lower due to its high water content.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the findings, conclusions drawn from the study as well as the recommendations based on the findings.

5.2 Summary of findings

This section of the study contains the summary of findings obtained from the study. The main aim of the study was to explore the production of cookies from wheat flour, tiger nut flour and pineapple puree. The specific objectives of the study were to determine the effect of different proportions of wheat flour, tigernut flour and pineapple puree on the proximate composition of cookies; to find out the effect of different proportions of wheat flour, tigernut flour and pineapple puree on the sensory qualities of cookies; and to assess the effect of different proportions of wheat flour, tigernut flour and pineapple puree on the overall acceptability of cookies. Standard methods were used in the determination of the proximate composition of the cookies. The contents of fat, fibre, and carbohydrate of the cookies improved with the increase in the tiger nut flour and pineapple puree. Consequently, the energy content also showed a similar trend as the fat, fibre, and carbohydrate contents of the cookies increased. The overall acceptability of the control and treatment B were not significantly different, but there was a general reduction in overall acceptability as the amount of tiger nut flour and pineapple puree in the cookies increased.

5.4 Conclusion

The results have shown that composite cookies of improved fibre content can be produced from wheat flour, tiger nut flour and pineapple puree. Also, cookie made from 80% wheat flour, 10% tiger nut flour, 10% pineapple puree is of comparable overall sensory acceptance as the control.

5.3 Recommendations

The following recommendations are made based on the findings obtained from this study.

1) Wheat flour, tiger nut flour, and pineapple puree in the percentages of 80: 10: 10 should be used for cookies production
2) There should be further studies to fine-tune the percentages of wheat flour, tiger nut flour, and pineapple puree to achieve the best sensory properties and nutritional composition.
3) Microbial studies on the cookies should be done to assess the safety of the products.

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APPENDIX I

RESEARCH QUESTIONNAIRES

SENSORY EVALUATION

SENSORY EVALUATION OF COOKIES FROM COMPOSITE WHEAT FLOUR, TIGER NUT FLOUR AND PINEAPPLE PUREE

This research work is about the sensory preference of cookies made with various percentages of wheat, tiger nut and pineapple puree. Please provide sufficient information as possible. The information provided shall be used for research purposes only, and kept confidential. Thank you.

Section A: Demographic Information

1. Gender:

a. Male [ ] b. Female [ ]

2. Age range:

a. Below 21years [ ] b. 21-30 years [ ] c. 31-40 years [ ] d. Above 40 years [ ]

3. Educational status:

a. Primary [ ] b. JHS [ ] c. Tertiary [ ] d. Other (specify)……

SECTION B: SENSORY EVALUATION

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

Sensory Attributes	**LEVEL OF LIKENESS OF THE PRODUCT**				
	1	**2**	**3**	**4**	**5**
	Dislike very much	**Dislike much**	**Neither like/dislike**	**Like much**	**Like very much**
Treatment A	--	--	--	--	--
Taste					
Colour					
Aroma/odour					
Texture					
Overall acceptability					
Treatment B	--	--	--	--	--
Taste					
Colour					
Aroma/odour					
Texture					
Overall Acceptability					
Treatment C	--	--	--	--	--
Taste					
Colour					
Aroma/odour					
Texture					
Overall Acceptability					
Treatment D	--	--	--	--	--
Taste					
Colour					
Aroma/odour					
Texture					
Overall Acceptability					
Treatment E	--	--	--	--	--
Taste					
Colour					
Aroma/odour					
Texture					
Overall Acceptability					

Which **one** of the cookies will you buy if sold on the market? (Tick only one)

Product	Which one to buy
Treatment A	
Treatment B	
Treatment C	
Treatment D	
Treatment E	

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SENSORY QUALITIES AND PROXIMATE COMPOSITION OF COMPOSITE COOKIES FROM WHEAT FLOUR (TRITICUM) TIGER NUT FLOURS (CYPERUS ESCULENTUS L.) AND PINEAPPLE PUREE (ANANAS COMOSUS)

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