UNIVERSITY OF EDUCATION, WINNEBA

NUTRITIONAL, TEXTURAL AND SHELF-LIFE ANALYSIS OF VACUUM PACKAGED *WAGASHI* TREATED WITH GINGER (*ZINGIBER OFFICINALE*) AND AFRICAN NUTMEG (*MONODORA MYRISTICA*) EXTRACTS AS A FUNCTIONAL DAIRY FOOD

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A thesis in the Department of Food and Nutrition Education, Faculty of Home Economics Education, submitted to the School of Graduate Studies in partial fulfilment of the requirements for the award of the degree of Master of Philosophy (Home Economics) in the University of Education, Winneba

JUNE, 2021

DECLARATION

Student's Declaration

I, **El-Freda Korkor Ogli,** declares that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and that it has not been submitted, either in part or whole, for another degree elsewhere.

Signature: …………………………………

Date:………………………………………

Supervisor's Declaration

I hereby declare that the preparation of this work was supervised in accordance with the guidelines for supervisors of thesis as laid down by the University of Education, Winneba.

Name of Supervisor: MS. KUTUM COMFORT MADAH

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Date: ………………………………………

DEDICATION

This thesis is dedicated to the Ogli family and to all researchers in this field of study, as well as, all those who contributed in various ways to make this research come to a successful completion.

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ABSTRACT

Wagashi is a form of soft cheese made from coagulated cow's milk using fresh *Calotropis procera* juice extracts. It is a highly nutritious food with an excellent source of protein, fat, vitamins and minerals such as calcium, iron and phosphorus. *Wagashi* is highly perishable at ambient conditions with its shelf-life being very short. At high temperature, it is highly possible to develop a sour smell and bitter taste. For this reason, *wagashi* samples were treated with ginger and African Nutmeg extracts. Physicochemical, mineral, texture profile analysis and shelf-life testing were carried out. Proximate analysis showed moisture contents of 55.25% in the control sample, 52.12% in the *wagashi* samples that were treated with ginger extracts and 50.75% in *wagashi* samples treated with African Nutmeg extracts. Fat content ranged from 3.55% in the control sample to 2.18% in the *wagashi* samples treated with ginger extracts. Crude protein ranged from 20.18% in the control sample to 22.49% in *wagashi* samples which were treated with African Nutmeg extracts sample. Carbohydrate content ranged from 19.08% in control sample to 23.28% in *wagashi* samples treated with ginger extracts. Ash content ranged from 1.75% in the *wagashi* samples treated with ginger extracts to 2.50% in *wagashi* samples treated with African Nutmeg extracts. All samples had high contents of protein and carbohydrate. The product quality was judged by instrumental texture profile using hardness, adhesiveness, springiness, cohesiveness, resilience, gumminess and chewiness as the textural parameters. Texture of the samples was hard, gummy and chewy because of the high values recorded. The microbial analysis was done with reference to Yeast and Mould count. The result of the shelf-life study showed that preserving the *wagashi* samples with vacuum packaging extended the shelf life of the *wagashi* from 3 days to 15 days of storage under ambient conditions. Also, the vacuum packaged *wagashi* samples treated with ginger and African Nutmeg extracts had the lowest yeast and moulds count during the shelf-life study. Generally all samples were accepted. Based on the results from the sensory test it was concluded that *wagashi* treated with ginger and African Nutmeg extracts could be a viable alternative to the *wagashi*.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter covers the background to the study, statement of the problem, purpose of the study, research objectives and questions, significance of the study and the delimitation of the research. The contribution and the structure of the study are also described.

1.1 Background of the Study

Granting that a lot of people in developing countries are still incapable of affording good-quality foods because it is quite costly even though rising consumption of dairy and other livestock products is bringing significant nutritional benefits to majority of the population in developing countries. Milk contains numerous nutrients which make a substantial addition to meeting the body's needs for minerals such as magnesium, riboflavin, calcium, pantothenic acid, selenium, and vitamin B12 (Muehlhoff, Bennett & McMahon, 2013). Zannou, Agossou and Koca (2018) reported that, high consumption of milk and milk products will likewise fight against hunger and malnutrition.

Milk can be transformed into diverse dairy products for consumption such as; cheese, yogurt, ghee and butter. Cheese may be a foodstuff derived from milk that's developed during an extensive selection of tastes, qualities, and methods by clotting of the milk protein casein. It includes fat and proteins from the milk, typically goat milk, sheep milk, cow's milk or buffalo milk. Some well-known cheeses in the world include Blue (Bleu) cheese, Brie, Camembert, Cheddar cheese, Gouda, Mozzarella, Parmesan etc.

Cheese is a food product that is consumed throughout the world. It is mainly produced from differing kinds of milk and also, technologies permit people to get many varieties of the product. Furthermore, cheese has pleasing taste, good organic protein value, and because it is considered as a healthy food product, there has been an increase in the consumption recently (Gouvea, Santos, Rosenthal & Ferreira, 2017). Additionally, Cheese production may be a domestic process in a lot of developing countries. Animal farming generally and milk production still play a crucial socio-economic role in many developing countries (Ayanniran, 2014). According to Bamidele (2006), Cheese is a superb source of nutrients such as fat, protein and minerals like phosphorous, iron and calcium, vitamins and essential amino acids, thereby makes it a crucial food item in the dietary regime of the young and old.

Continuous research confirms that, Cheese offers a great nutritional value and is rich in amino acids, peptides, short-, medium- and long- chain fatty acids, proteins, vitamins, and essential minerals including calcium. A wide range of cheese variant has been developed in the world to meet the requirements of health need and taste of people (Kwak, Ganesan & Hong, 2011).

In Ghana, milk is developed into several forms such as condensed powdered milk, milk, yogurt, wagashi cheese among others. Milk can be consumed raw or added to breakfast and some snacks. Some snacks made with milk in Ghana include yogurt, ice-cream, “fura”, “nunu”, and “Burkina” among others. Also, milk is added to foods such as rice pudding, maize porridge (kooko), gari and many others.

According to The Milk Run (2005, April), one of the unique characteristics of Ghana’s dairy industry is the high demand for traditional soft cheese (*wagashi*) and other processed milk products as against fresh milk.

Wagashi is a local cottage cheese commonly found in most traditional West African communities. Some of the West African countries that produce *wagashi* are Benin, Ghana, Nigeria and Togo. The traditional soft cottage cheese is popularly known as woagachi in Benin, wara or warankashi in Nigeria and wagashi in Ghana.

It serves as a form of preservation of milk in the protein state and contains high proteins content. *Wagashi* is a form of cheese made from coagulated cow's milk using fresh *Calotropis procera* juice extracts. *Wagashi* is a highly nutritious food with an excellent source of protein, fat, vitamins and minerals such as calcium, iron and phosphorus.

Wagashi is a good source of animal protein and is used to replace meat or fish, or in combination with them, in various food recipes. Its low lactose content makes it an acceptable food to many people who suffer from lactose intolerance associated with milk consumption in Africa and Asia due to low levels of intestinal β-galactosidase (lactase) (Aworh, 2008).

Traditional production of *wagashi* cheese is usually the responsibility of the Fulani women. After the cow's milk has been collected by the assemblers (men), the processors (women) process the fresh milk by heating and coagulating with an extract of stems from the Sodom Apple plant (*Calotropis procera*). The resultant cheese curd is scooped into perforated calabashes to allow the whey to drain off. It can be eaten raw because it is already cooked, or fried, smoked or grilled and eaten with meals. *Wagashi* is a trademark and a popular delicacy of the Fulani tribe. Milking of the cow is done by hand and usually in the kraal by the herdsmen (assemblers). It usually has a salty taste due to the use of salt during the preparation method to preserve it.

Ritota and Manzi (2020) reported that, Cheese may be a food that's vulnerable to contamination by pathogenic and spoilage microorganisms, which may end in a reduced cheese shelf life, also as in risks to the consumers' health. This implies the possible use of preservatives within the cheese making process. At the same time, consumers are increasingly demanding for healthy food, free from synthetic preservatives. Just for this reason, natural ingredients are receiving increasing attention as substitutes for synthetic additives, also because they have bioactive compounds, which might provide health benefits in the prevention of several diseases. Furthermore, most of natural ingredients have shown antimicrobial activity, which could delay or inhibit the expansion of pathogenic microorganisms in food, also as minimize the incidence of foodborne diseases caused by food spoilage bacteria and fungi.

Consumers are looking for natural products which have less impact on the human health and environment and even containing less synthetic preservatives (Sessou et al., 2013). Since pre historical times, herbs are used not even as food flavouring but also for its medicinal properties. The antimicrobial and antioxidant constituents present in herbs enables them to be used as effective preservatives. Incorporation of herbs in foodstuff may results improvement the health and medical condition of person (Oraon, Jana, Prajapati & Suvera, 2017). The followings shed light on the health benefits of two spices interested in this research concerning their suitability for *wagashi* fortification.

Ginger (*Zingiber officinale*) is a member of the Zingiberaceace family that is within the tropical forests of many countries such as India, China, Fiji and Indonesia. Ginger is an excellent source of minerals like potassium, calcium, manganese, and magnesium (Yadav & Wadehra, 2016). Ginger has excellent antioxidant properties. Antioxidants are increasingly linked to the prevention of certain cancers. Studies include the role of components such as gingerol in inhibiting linoleic acid autoxidation, extending the shelf-life of meat, dehydrated pork and fermented meat sausage (Peter, 2012) *Monodora myristica* seed is a popular condiment used as a spicing agent in Africa. They are the most economically important part of *Monodora myristica* tree (Akinwunmi & Oyedapo, 2015). It does not have harmful effects when consumed, and therefore, the high availability of essential amino acids indicates its potential for future supplement/formulation of foods and as alternative source of protein for human consumption. (Ogungbenle & Adu, 2012). Agiriga and Siwela (2017) in a study reported that *Monodora myristica* possesses an impressive range of medicinal, nutritional properties and also different parts of this plant such as the seeds, bark and flowers contain important nutrients that are a good source of protein, vitamins, ß-carotene, amino acids and various phenolics.

1.2 Research Problem

A food, exposed to deterioration can have a decreasing in its sensory, nutritive and medicinal value (Barker & Bouguerra, 2012).

The microbiological quality of a food constitutes one of the essential bases of its ability to satisfy the safety of the consumer (Sessou, Farougou, & Sohounhloué, 2012). FAO (1990), reported that consumption of dairy products is low in the urban areas as a result of the perception that locally produced milk is not safe for consumption. *Wagashi* has quite a short shelf-life. In circumstances of poor manufacturing practices and storage conditions, spoilage of the *wagashi* occurs within a relatively short time.

Wagashi is sold in local markets on trays and sometimes soaked in sorghum water for coloration. But the cheese is stored into open air and the absence of a suitable packaging increase the risk of microbial and chemical contaminations, limiting the abilities for preservation and transportation (Sessou et al., 2016).

According to the Milk Run (2005), and a study reported by Osafo, Barton, Mensah, Aning, Gyiele (2004), observed that for lack of appropriate preservation technologies, *wagashi* sellers are forced to boil the cheese daily in order to preserve it. This practice negatively affects the quality of the cheese.

Arthur (2016) stated that, there is also the need to introduce a packaging material for *wagashi* in order to minimize post production contamination and extend its keeping quality.

In recent times, consumers have become more interested in consuming foods that are free of chemical preservatives, close to natural or natural and minimally processed (Buch, Pinto & Aparnathi, 2012). This has resulted in thorough investigations from food authorities and researchers to assess the feasibility of mild preservation techniques and to enhance the microbial quality and safety of products, while maintaining their good nutritional and organoleptic properties (Goñi, López, Sánchez, Gómez-Lus, Becerril & Nerín, 2009).

Thus, considering the above facts, the present research is designed to develop a vacuum packaged *wagashi* treated with ginger and African Nutmeg extracts and their effects on *wagashi*.

1.3 Purpose of the Study

The purpose of the study was nutritional, textural and shelf-life analysis of vacuum packaged *wagashi* treated with ginger (*Zingiber officinale*) and African nutmeg (*monodora myristica*) extracts as a functional dairy food.

1.4 Objectives of the Study

The specific objectives of the study were to:

1. determine the physicochemical properties of *wagashi* treated with Ginger and African Nutmeg extracts.
2. determine the mineral composition of *wagashi* treated with Ginger and African Nutmeg extracts.
3. analyze the texture profile of *wagashi* treated with Ginger and African Nutmeg extracts.
4. evaluate the shelf-life and sensory characteristics of wagashi treated with Ginger and African Nutmeg extracts.

1.5 Research Questions

1. What are the physicochemical properties of wagashi treated with Ginger and African Nutmeg extracts?
2. What is the mineral composition of wagashi treated with Ginger and African Nutmeg extracts?
3. What is the texture profile of wagashi treated with Ginger and African Nutmeg extracts?
4. What is the shelf-life and sensory characteristics of wagashi treated with Ginger and African Nutmeg extracts?

1.6 Significance of the Study

The study may contribute to:

- healthier options for processing milk.
- the addition of value to *wagashi*.

1.7 Delimitation of the Study

This study was delimited to the use of two spices that is ginger and African nutmeg. Analysis of the nutritional content of *wagashi* was delimited from cow's milk. Also, packaging of *wagashi* and obtaining market samples (cow milk) were delimited to specific areas in Greater Accra, specifically Nima market.

1.8 Limitation of the Study

The major limitation in this study was proximity to laboratory facilities.

- **Proximity to Laboratory Facilities:** Due to the fact that off campus laboratory facilities were used during the period of the entire research, it was quite challenging to easily walk in and undertake experiments easily. Also, it limited the number of experiments that could be done due to the high cost of testing
- **Only two herbs were used for study**
- **Change in sensory and chemical parameters could not be studied on daily basis**

1.8 Operational Definition of Terms

Adhesiveness – it is the rate at which a food product comes off from the probe or roof of the mouth.

African Nutmeg – it is a spice used for seasoning chicken, meat or in preparing soups and stews.

Aftertaste – this is the taste that remains in the mouth after eating food or drinking a beverage.

Aroma – it is often referred to an odor or a scent perceived from plants, spices and cooking.

Calotropis procera – it is the scientific or botanical name of the Sodom apple plant.

Cheese – it is a dairy product usually cow, goat or buffalo milk.

Chewiness – it is the energy needed to masticate or chew a solid food until ready to swallow.

Cohesiveness – it refers to the rate at which a deformed product reform.

Colony Count – it is the count of viable microbes based on counting the colonies in an agar plate.

Color – it is used to describe the visual perception of a food product or beverage.

Dairy Product – it is a type of food product developed or derived from milk.

Flavour – it is the sensory parameter of a food or a beverage usually determined by the senses of both smell and taste.

Gumminess – it is force needed to crumble or break a semi solid food until ready to swallow.

Hardness – it is measured by the primary compression of a food product used to attain deformation.

Hedonic Scale – it is a scale for measuring general overall opinion of a food product.

Milk – it is a liquid food rich in essential nutrients such as protein, calcium, magnesium and vitamins.

Milk Coagulant – it is an enzyme for cheese making that is used to convert milk to curds.

Mineral Analysis – it is the determination of the mineral composition and mineral structure of food products.

Monodora myristica – it is the scientific or botanical name for African Nutmeg.

Mould – it is a microscopic fungi which grow in the form of multicellular filaments called hyphae and causes discoloration of food products.

Mouthfeel - this is the way a food product or beverage is felt in the mouth, as different from its taste.

Organoleptic Properties – these include the sense of smell, sight, taste and touch of food.

Overall Acceptability – it is a sensory parameter that determines the how well a food product or beverage is accepted by consumers.

Physicochemical Composition – it is the physical and chemical properties of a product.

Proximate Analysis – it is the quantitative analysis of proximate analysis such as moisture, ash, crude protein, carbohydrate and crude fat.

Resilience – it is how well a food item regains its original height after compression.

Shelf-life – it is the period of time that a food product may be stored without deteriorating or becomes unsafe for consumption.

Sodom apple plant – it is a plant used as a vegetable rennet for coagulating milk.

Springiness – it is how well a product springs back during the first compression or holds itself together.

Texture Profile Analysis – it is the determination of the textural properties of food using a double compression test.

Vacuum Package – It is a type of packaging that removes air from the pack sealing the product.

Wagashi – it is a traditional delicacy of the Fulani which is a soft cheese usually made from cows' milk.

Yeasts – they are minute living single cell organisms whereby as they grow and multiply, converts food into carbon dioxide and alcohol.

Zingiber officinale - it is the scientific or botanical name of ginger.

1.9 Organization of the Study

Chapter One: Introduction

The introduction aspect of the study provides a description of the research work. It covers the background and general concepts; problem statement of the study, purpose; research objective of the study; questions, significance, delimitation of the study, operational definition of term and the general outline of the research report.

Chapter Two: Literature Review

This chapter critically reviews related literature on Herbs and Spices, packaging, *wagashi* and other related literature to the study under research. It establishes the premise or the theoretical and conceptual framework for production, evaluation and packaging of *wagashi* treated with local spices.

Chapter Three: Methodology

This part of the research report provides an overview of the materials and methods used in production, evaluation and packaging of the wagashi treated with Ginger and African Nutmeg. Recounts the format by which the research was conducted. This includes research approach, research design, the population, sample size, study area, instrument for data collection and data analysis.

Chapter Four: Results

This chapter presents the results of the study in tables and figures.

Chapter Five: Discussion

The objectives of the study are discussed in relation to the findings gathered from the information provided by the research.

Chapter Six: Findings, Conclusions and Recommendations

This chapter provides a summary of the results, the conclusions, recommendations and suggestions for further research. It draws conclusions from the findings, impact of the study and makes possible recommendations. It also includes suggestions for further research works on *wagashi*.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

Chapter two focuses on related literature regarding the subject under study. In order to conduct effective literature review, the chapter is presented in three parts. It begins by looking at functional foods; then milk, milk production and constituents and treatment of milk; types of dairy products and cheese. Proceeds to review previous researches conducted on wagashi; Spoilage and pathogenic microorganisms in soft cheese; Herbs and Spices. The last part reviews packaging and sensory evaluation.

2.1 Functional Foods

A foodstuff is normally referred to as functional as long as its health benefit has been shown within the consumption of a traditional daily dose of the ultimate product, or an efficient dose of the ingredient is employed and therefore the impact of the food matrix is known (Mattila-Sandholm & Saarela, 2003).

Generally, functional foods are divided into two (2) groups: modified and conventional. Conventional foods are whole, organic food ingredients that are good sources of nutrients like antioxidants, vitamins, wholesome fats, and minerals. However, modified foods are foods that have been fortified with additional ingredients, like minerals, fibre, probiotics, or vitamins, to extend a food’s health benefits (Link, 2020).

2.2 Milk

According to Muehlhoff, Bennett and McMahon (2013), milk is a main source of fat, energy and protein, and contributes on an average 8 g of protein/capita per day, 7.3 g of fat/capita per day in 2009 and 134 kcal of energy/capita per day Cow milk normally consist of high-quality protein and minerals, especially phosphorus and calcium as compared to that of human milk. Cow milk contains between 3 and 4 g of fat/100 g, with some reports of values as high as 5.5 g/100g in raw milk. Most milks consumed now contain a standardized fat content of around 3.5 g/100g (Muehlhoff, Bennett & McMahon, 2013).

2.2.1 World milk production

World milk production (81% cow milk, 15% buffalo milk, and a whole of 4% for goat, sheep and camel milk combined) grew by 1.6% in 2018 to about 838 Mt. In India, the largest milk producer in the world, production increased by 3.0% to 174 Mt, although this had little impact on the world dairy market as India trades only marginal quantities of milk and dairy products. The three major dairy product exporters achieved production increases during 2018, the European Union (0.8%), New Zealand (3.2%) and United States (1.1%), that were almost entirely driven by higher milk yields per cow; in New Zealand, favourable grass conditions also played a task (Food and Agriculture Organization of The United Nations, 2019).

2.2.2 Milk production in Ghana

Oppong-Asare (2016) reported that Importers play a major role in the milk value chain as the country has historically been a net importer of milk and dairy products (primarily powdered milk and processed milk products). They are, however, not involved in the traditional milk product markets. The gap between demand and local production of milk and dairy products keeps on widening year after year to the extent that the imported milk and dairy products increased by 2.268 percent from 2006 to 2012 (Oppong-Asare, 2016).

Ghana's dairy processors (including ice cream, baby foods, chocolate milk, yoghurt, and long-life milk producers) rely on combining and reconstituting milk powder imported mostly from the European Union countries. Dairy products such as infant formula, cheese, butter and ice cream are imported. A total of 34 local dairy processors had registered with the Ghana Food and Drugs Authority by 2009. Prominent among the producers were Nestles Ghana Ltd, Fan Milk, Promisidor and West Africa Distribution Ltd. Artisanal production of yogurt from locally produced milk is reducing in favour of industrial production that uses almost solely imported milk powder. The small-scale yoghurt manufactures use approximately 20 percent locally produced milk to 80 percent imported milk powder (Oppong-Asare, 2016).

2.2.3 Constituents of milk

Milk is mainly made up of water, minerals, fat, lactose and proteins which also contains some trace amounts of other substances such as vitamins, enzymes, gases, phospholipids, and pigments. Cows' milk is mainly 87 % liquid and just 13 % dry substance. This dry substance however, is suspended within the water (Hill, 2011).

Table 2.1: Typical gross composition (kg/100 kg) of milk of cow, sheep, buffalo and goat)

	Cow	Sheep	Buffalo	Goat
Fat	3.9	7.2	7.4	4.0
Total protein	3.3	4.6	3.8	3.2
Casein	2.6	3.9	3.2	2.6
Whey protein	0.7	0.7	0.6	0.6
Lactose	4.6	4.8	4.8	4.3
Ash	0.7	0.9	0.8	0.8

Source: Hill (2011)

2.2.3.1 Protein

Milk proteins is the most important source of bioactive peptides and have high nutritional value in comparison to other proteins due to the fact that they have good digestibility and relatively high essential amino acids content (Alshamiry & Abdelrahman, 2020).

2.2.3.2 Lipids

Lipids found in milk are a major source of energy for the newborn in all mammalian species. Lipids play an important role in the physical properties, Nutritive value, Flavour of milk and milk products. It causes dairy products to be very flavourful and gives it a smooth texture (Sanjay, 2018).

Milk lipids have beneficial properties which include antimicrobial, immunosuppression, anti-inflammatory, and anticancer properties (German & Dillard, 2006). Milk lipids are containing very distinctive organoleptic, textural and nutritional properties in products, such as cheese milk powder, butter and cream. Lipids consist of phospholipids, fats and oils, cholesterol and waxes. The role of milk fat is to carry fat-soluble vitamins viz., A, D, E and K as well yield roughly ~37 kJ per g (9 Kcal/g) aside from milk fat makes milk products very flavourful so therefore making them acceptable by consumers. Additionally, the texture and body of the milk products is influenced by milk lipids (Sarma, 2017).

2.2.3.3 Lactose

Lactose is a disaccharide found in milk, and is divided into galactose and glucose by the enzyme lactase. Lactose is a source of energy and sometimes it is known as milk sugar, due to its high percentages in dairy products. Furthermore, Lactose is also the primary source of carbohydrates during mammal growth (Gambelli, 2017).

Milk of mammals is the only source of lactose. It contributes to the nutritive value of milk and milk products and plays essential role within the body and texture and solubility of certain stored products. It has an important role in the color and flavour of heated products (Sarma, 2017).

2.2.4 Treatment of milk

2.2.4.1 Homogenization

Homogenization is the physical process of breaking down the milk fat globules into tiny droplets to discourage cream separation. As a result, the milk fat remains homogeneously distributed in the milk (Sagar, 2019). Milk and dairy products are homogenized to improve product properties such as color, consistency, taste, creaming stability, creaminess and mouth feel (Köhlera & Schuchmann, 2011).

2.2.4.2 Pasteurization

Pasteurization is a process in which certain packaged and non-packaged foods (such as milk and fruit juice) are treated with heat, usually less than 100^0C (217^0F), to eliminate pathogens and extend shelf life. Milk pasteurization as a process of heating milk (or mil product) to a predetermined temperature for a specified period without re-contamination during the whole process (Sagar, 2019).

By definition, 'milk pasteurization' refers to the process of heating every particle of milk to a specific temperature, holding it at the same temperature for specific duration (time) and followed by rapid chilling to less than 7°C. Pasteurization is considered as an optimized heat treatment as it kills all the pathogenic microorganisms and renders the milk safe for human consumption with minimum nutritional loss (Dhotre, 2019).

2.2.4.3 Thermization

Thermization is a treatment, in which milk is heated at 63°C for 15 Seconds. It is milder than pasteurization and usually adopted to improve keeping quality rather than to eliminate pathogens. Whereas, sterilization involves heating milk above 100°C. It is far more severe than pasteurization and it kills all the living cells in milk (Dhotre, 2019).

2.2.5 Types of dairy products

2.2.5.1 Yoghurt

Yoghurt is the best known of all fermented milk products, and the most popular worldwide.

The consistency, flavour and aroma vary from one district to another. Yoghurt can be produced in frozen form as a dessert, or as a drink. The flavour and aroma of yoghurt differ from those of other acidified products, and therefore the volatile aromatic substances include small quantities of acetic acid and acetaldehyde (Gerrard, 2015).

2.2.5.2 Butter

Gerrard (2015), categorized butter into two (2):

- Sweet cream butter
- Sour or cultured cream butter

Butter can be categorized in regards to its salt content: salted, extra salted and unsalted.

During the 19th century, butter was still developed from cream that had been allowed to ferment and become sour naturally. After which the cream was skimmed from the top of the milk and then into a wooden tub. Butter was then made using the hand in churns. Microorganism infection can result in causing the cream to go bad because during the natural souring process the cream is very sensitive.

2.3 Cheese

Cheese is known for its nutritional value as source of good quality fat, minerals, vitamins and proteins. For instance, cheese provides almost all essential amino acids with the exception of methionine and cysteine and it is an excellent source of phosphorous, magnesium, zinc and calcium. In addition, it is almost non-lactose making it a good choice for lactose intolerant consumers (Fernández-Recio, 2011).

2.3.1 Types of cheese

Fresh cheeses never go through an aging process and are only good for a few weeks. Often still containing some whey, they typically are soft with a mild flavor and may be coated in leaves, ash, or herbs. Examples: Feta, cottage and cream.

Natural Rind typically made with goat milk, natural rind cheeses can be described as chalky and moist when young. They develop a grayish blue, wrinkled rind without any added bacteria. Examples: Sancerre, Chabichou and Lancashire.

Soft ripened cheese retains some amount of its whey and may be recognized by their white “bloomy” rind. Having only slightly more flavour than fresh cheeses, they are buttery and almost runny in texture. Examples: Camembert, Brie and Chèvre.

Semi-soft Ripened cheeses are rubbery and elastic with a grey or brown rind. They even have a more pronounced flavor than softer cheeses. Examples: Edam, St. Nectaire and Pont L’Eveque.

Washed Rind these semi-soft cheeses are aged in a brine, beer, or wine wash to maintain their internal moisture. The wash attracts bacteria that produce an orange rind and causes a strong taste and odor known to many "stinky cheeses." Examples: Limburger and Muenster.

Hard cheeses are dense and heavy, having been cheddared early in their production. They may have been washed in brine or have an oiled or waxed rind to prevent them from drying out. Examples: Cheddar, Parmigiano-Reggiano and Gruyere.

Veined Cheeses are commonly known as blue cheese, veined cheese is recognized by its lines of blue-green mold spread throughout its interior. Its texture can differ, but then veined cheese tends to have a strong flavor. Examples: Gorgonzola, Maytag Blue and Stilton (Newendorp, 2018).

2.4 Origin of *Wagashi*

Historically, *Wagashi* originated from the Sahelian countries and spread widely to West Africa. It is also well known and a delicacy amongst nomadic tribes and has also been taken by Muslims in several countries (FAO, 1990).

2.5 Production of *Wagashi*

Wagashi cheese is characterized by the use of a vegetable coagulant extracted from the stem or leaves of the Sodom apple plant (*Calotropis procera*) which allows the milk to coagulate at temperatures above 70°C and over 90°C for approximately five (5) minutes until the curd is fully separated from whey. This olden way of making the *Wagashi* cheese makes the cheese's proteolytic activity very low, and allows the wagashi cheese to be boiled over and over again, every two (2) days, for about twenty (20) days from the time of production, without any apparent modification of the wagashi cheese structure (Mirabella, Belvedere, Marchese & La Terra, 2011).

Fellows and Axtell (2008) also described *Wagashi* as a fermented flavor, slightly sour and also can be coloured dark red using a type of dried leaf called sorghum leaves.

The process is described as been made by preheating slightly acidified milk (pH 5.6–6.0) to approximately about 40ºC, adding the juice from bark or leaves of the Sodom Apple plant (*Calotropis procera*) and heating it to 60–70ºC approximately for one (1) hour, whiles stirring continuously so as to prevent charring until it is partially solidified. The curd is worked by hand, washed to remove lactose, salted in boiled water and then boiled with the dried sorghum leaves in order to infuse the red color. After cooling, the curd is then dried and molded or cut into smaller pieces and fried in oil until it is slightly golden brown.

2.6 Safety of *Wagashi*

In a study conducted by Arthur (2016), 'Wagashie' is a type of fresh cheese and its production in Ghana has become quite a common sight without supervision or quality due to increase in population and consumption. 'Wagashie' is delivered to the market immediately after processing, under inadequate conditions, poor handling techniques, inappropriate packaging materials and lack of adequate storage facilities, however, dairy products including cheese must be safe, acceptable and meet consumer's satisfaction.

2.7 Milk Coagulation

The coagulation of milk proteins can be achieved in a number of different ways using rennet, an enzyme found in the fourth stomach of ruminant animals, or made synthetically fermenting to form lactic acid adding acid (e.g., lime juice or vinegar) boiling using plant extracts. Rennet causes the milk proteins to produce a semi-firm gel. Lactic acid production by bacterial cultures helps the whey to separate from the curd and also determines the final cheese flavour and texture. 'Fresh cheese' is produced by acid coagulation to pH 4.6–4.8 at 30–32ºC without added rennet. Fresh rennet cheese is produced without bacterial cultures. Milk proteins are coagulated in one of three ways: Coagulation of milk protein (casein) with rennet, and acid production by lactic acid bacteria. Coagulation of casein by acid produced using a natural fermentation at 20–35ºC. In this temperature range, a pH of less than 4.9 is needed to form the curd. Coagulation by lactic or citric acid added to hot milk at 75–100ºC, but no fermentation is involved. The whey proteins bind water in order for a firm cheese with a high moisture content (55–80%) to be produced. At high temperatures less acidification is needed, so the final cheese is much less acidic (pH 5.2–6.0) than fresh cheese (pH 4.4–4.8). The inclusion of whey proteins prevents cheeses from melting so that they can be used as frying/ cooking cheeses (Fellows & Axtell, 2008).

2.8 *Calotropis Procera*

Calotropis procera also named Sodom apple as one of the species of genus Calotropis from family Asclepiadaceae. *Calotropis procera* originates from Africa, India, and Middle East; and may thrive in an arid climate. This plant is used as a vegetable coagulant during *wagashi* cheese making. Its main active ingredient involving in cheese's coagulation is calotropin enzyme.

The *Calotropis procera* is a plant that is widely used in Benin by the Fulani people in traditional medicine to cure some sicknesses such as fever, cough, or even serves as protection. It has a very strong coagulation effect therefore it brings an added value to the constituents of milk into cheese (Tossou, 2018).

2.9 Salt

Sodium chloride is one of the most widely used additives in the food industry because of its low cost and varied properties. It has a preservative and antimicrobial effect; it acts as flavour enhancer and the salt has effects on microbial and biochemical processes (Engels & Burseg, 2011).

Kwak, Ganesan and Hong (2011) reported that, salt plays a very important role in cheese making process. It has various roles such as preservatives in cheese by preventing the growth of spoilage bacteria and also enhances the activity of both lipolytic and proteolytic enzymes, which promote the flavor of cheese. It also accelerates the whey expulsion and affects the rheology. Salt is very essential for life and it involves in various biochemical process for the normal function of our body. Some of the biological roles of salt include nutrient absorption and transport, nerve impulse transmissions for muscle and cardiac function. The minimal requirement of salt for body is about 0.5g/day. Among the main functions of salt in diet the maintenance of blood volume and blood pressure makes up more.

2.10 Spoilage and Pathogenic Microorganisms in Soft Cheese

The microbial quality of milk is crucial for the making of any high-quality dairy product. Spoilage is a term used to describe the deterioration of a foods' texture, colour, odour or flavour to the point where it is unappetizing or unsuitable for human consumption (Bamidele, 2006). The life forms that most commonly cause deterioration of food products or damage packaging materials are bacteria, moulds, insects, birds and rodents. Microbial attack requires the presence of moisture and heat. (Paine & Paine, 1992).

According to Dhotre (2019), milk being a complete food is a highly nutritious medium for microbial growth, which may include beneficial organisms (e.g., lactic acid bacteria) as well as numerous spoilage organisms (e.g., Gram-negative psychrotrophs) and bacterial pathogens (e.g., *Salmonella and Listeria*). Troublesome spoilage microorganisms include aerobic psychrotrophic Gram-negative bacteria, yeasts, molds, heterofermentative lactobacilli, and spore-forming bacteria. Psychrotrophic bacteria can produce large amounts of extracellular hydrolytic enzymes, and the extent of recontamination of pasteurized fluid milk products with these bacteria is a major determinant of their shelf life. Coliforms, yeasts, heterofermentative lactic acid bacteria, and spore-forming bacteria can all because gassing defects in cheeses. The rate of spoilage of several dairy foods is slowed by the usage of one or more of these treatments: reducing the pH by fermenting the lactose to lactic acid; adding acids or other approved preservatives; introducing desirable microflora that restricts the development of undesirable microorganisms; adding sugar or salt to decrease the water activity; removing water; packaging to limit available oxygen; and freezing. The type of spoilage microorganisms that cause spoilage differs widely among dairy foods because of the selective effects of practices followed in production, formulation, processing, packaging, storage, distribution, and handling (Seema, 2015).

2.10.1 Yeast and moulds

According to Coles and McDowell (2003), Yeasts are single-cell organisms of spherical, elliptical or cylindrical shape. Some yeasts can form spores, although these are part of the reproductive cycle and are quite different to bacterial spores where the spore is formed as means to survive adverse conditions. Therefore, yeast spores are relatively easy to kill within foods by mild heat or on packaging surfaces by mild heat or sterilising solutions.

Moulds belong to a large group of multi-celled threadlike fungi. One of the key sources of contamination of exposed packaging items is from mould spores. Due to the fact that, the spores are very tiny and light, they are produced in large numbers and are created to be carried by air to new environments. Moulds develop in a package as mould spores and are the usual source of post-process contamination of foods (Coles & McDowell, 2003).

2.11 Herbs and Spices

Herbs have multifarious roles like food flavourings, preservative and as medicinal ingredient. Various herbs are documented for their therapeutic properties viz., antioxidative, antihypertensive, anti-inflammatory, antidiabetic, antimicrobial, etc (Oraon, Jana, Prajapati & Suvera, 2017). Herbs may be defined as the dried leaves of aromatic plants used to impart flavour and odour to foods with, sometimes, the addition of colour. The leaves are commonly traded separately from the plant stems and leaf stalks. Spices may be defined as the dried parts of aromatic plants with the exception of the leaves (Peter, 2001).

UNIDO and FAO (2005), reported that spices are normally used for flavour, colour, aroma and preservation of food or beverages. Spices could also be derived from many parts of the plant: bark, buds, flower, fruits, leaves, rhizomes, roots, seeds, stigmas and styles or the whole plant tops. Herbs and spices are not just valuable in adding flavour to foods. Their antioxidant activity also helps to preserve foods from oxidative deterioration, increasing their shelf-life (Peter, 2001).

Herbs contain high amounts of phenolic compounds which possess potent antioxidant properties. The natural antioxidant properties of herbs have made their use within the formulation of functional foods specifically targeted for the people suffering from Cardio Vascular Diseases (CVDs) (Oraon, Jana, Prajapati & Suvera, 2017).

Herbs have found many uses in treating quantity of illnesses and their natural extracts can be used in pharmaceuticals, ayurvedic formulation, confectionery, nutritional foods, ready-to-drink mixes, on the spot foods, seasonings, dairy products, seasoning blends etc.

2.11.1 Ginger (*Zingiber officinale*)

The spice ginger is obtained from the underground stems or rhizomes of *Zingiber officinale* an herbaceous tropical perennial belonging to the family Zingiberaceae (Peter, 2001) (Plate 2.1 – Plate 2.3). Ginger is an underground stem (rhizome) of a perennial herb, which is used as a spice and as a preserve (FAO & WHO, 2001).

Ikivesi and Liu (2017) stated that, Ginger is commonly known as a spice, but it can also be used as an effective medicinal herb. Traditionally it has been used as remedy for different digestive problems, coughing, pain and general problems of metabolism.

Plate 2.1: Ginger plant

Source: How to grow ginger (*Zingiber officianale)* (2021)

Plate 2.2: Ginger rhizome

Source: Buckner (2019)

Plate 2.3: Ginger

Source: Ikivesi and Liu (2017)

Table 2.2: Nutritional composition of dry ginger (per 100 g)

Composition	Quantity
Water (g)	7.0
Food energy (k cal)	380
Protein (g)	8.5
Fat (g)	6.4
Carbohydrates (g)	72.4
Ash (g)	5.7
Calcium (g)	0.1
Phosphorus (mg)	150
Sodium (mg)	30
Potassium (mg)	1400
Iron (mg)	11.3
Thiamine (mg)	0.05
Riboflavin (mg)	0.13
Niacin (mg)	1.90
Vitamin activity (RE)	1.5

Source: Peter, (2001)

2.11.2 African Nutmeg (*Monodora myristica)*

African nutmeg (*Monodora myristica*) (Plate 2.4) is a spice and an edible plant belonging to the *Annonaceae* family (Ukachukwu, Odoemelam, Nwachukwu & Agbara, 2014).

It can make meaningful nutritional contribution in diet. Generally, it contributes to food cuisine nutritionally and imparts many health benefits. Conclusively, it should be noted that the seeds of *Monodora myristica* contained some important nutritional components (Nkwocha et al., 2018). According to Ukachukwu, Odoemelam, Nwachukwu and Agbara (2014) it is recommended that the use of *Monodora myristica* as feed additive should be encouraged since it can protect oil rich feed from early rancidity.

Table 2.3: Proximate composition of *Monodora myristica* seed flour

Proximate parameters	Composition (%)
Crude protein	12.09±0.52
Moisture	14.50±0.50
Total ash	2.50±0.50
Crude lipid	16.00±1.00
Crude fibre	19.00±1.00
Carbohydrate	35.92±0.50

Source: Nkwocha et al. (2018)

Plate 2.4: African nutmeg seeds

Source: Enwereuzoh, Okafor, Uzoukwu, Ukanwoke, Nwakaudu and Uyanwa (2015)

2.12 Packaging

The main focus in packaging was on covering and protection aspects of the item. The goods were placed in reliable, common materials usually from natural resources like wood pulp (paper, cardboard) or textiles (flour sacks) that enabled consumers to enjoy the contents of package at home (Sedlacekova, 2017). Packaging is an important part of product processing and preservation and has direct influence on the system in respect to physical and chemical changes (Prem, Vinnay, Abhay, Vipin, Eram & Barwa, 2017).

Food packaging can retard product deterioration, retain the beneficial effects of processing, extend shelf-life, and maintain or increase the quality and safety of food (Marsh & Bugusu, 2007). Four primary functions of packaging are: containment, protection, convenience and communication. These four functions are interconnected and every one must be assessed and measured simultaneously in the package development process (Robertson, 2013).

2.12.1 Containment

The role of containment is to conceal the product and its parts and prevent them from spillage and loss, starting from the packing line through transportation phases until it arrives to customer's home (Sedlacekova, 2017). The containment function of packaging makes an enormous contribution to protecting the environment from the myriad of products that are moved from one place to another on numerous occasions each day in any modern society (Robertson, 2013).

2.12.2 Protection

This is often considered as the first function of the package: to keep its contents from outside environmental influences like water, water vapor, gases, odors, microorganisms, dust, shocks, vibrations and compressive forces (Robertson, 2013).

Protecting the food from physical damage, physiochemical deterioration, microbial spoilage, and product tampering is perhaps the foremost important function of packaging. Without proper protection, the food may become unappetizing, less nutritious, and unsafe to consume (Lee, Yam & Piergiovanni, 2008).

2.12.3 Convenience

Based on a fact that package is a tool which helps goods remain in desired condition when reaching consumers, it also should be convenient for them to carry, transport and open the package while maintain safe (Lee, Kit, Yam & Piergiovanni, 2008). Two other aspects of convenience are important in package design. One of these can best be described as the apportionment function of packaging. In this context, the package functions by reducing the output from industrial production to a manageable, desirable "consumer" size (Robertson, 2013).

For a product that is not entirely consumed when the package is first opened, the package should be resealable and retain the standard of the product until completely used. Furthermore, the package should contain a portion size that is convenient for the intended consumers; a package that contains so many products that it would deteriorate before being completely consumed clearly contains too large a portion (Robertson, 2013).

2.12.4 Communication

Packaging is a crucial aspect in promoting sales. It is a communication interface between consumers and producers. It guarantees that the product will be safely delivered and that its message will be carried to consumers. Also, the unit load and the shipping container must inform the carrier about its destination, provide instructions about the handling and storage of the food and inform the retailer about the method of opening the package and possibly even of the best way to display the product (Paine & Paine, 1992).

2.12.5 Materials used in food packaging

Glass has several advantages for food packaging applications due to the fact that it is odourless and chemically inert with virtually all food products. Also, it is impermeable to gases and vapors, so therefore, it maintains product freshness for a long period of time without diminishing taste or flavor. The capability to resist high processing temperatures makes glass functional for heat sterilization of both low- acid and high-acid foods.

2.12.5.1 Glass

Glass is inflexible, provides good insulation, and is malleable; can be produced in numerous different shapes. The glass is see-through which allows consumers to see the product, yet variants in glass color can protect light-reactive contents. Finally, glass packaging is environmentally friendly because it is reusable and transformable (Marsh & Bugusu, 2007).

2.12.5.2 Metal

Metal is the most adaptable of all packaging forms. It offers a blend of excellent physical protection and barrier properties, formability and decorative potential, recyclability, and consumer acceptance (Marsh & Bugusu, 2007).

2.12.5.3 Tinplate

Tinplate has excellent barrier properties to gases, water vapor, light, and odors, and can be heat-treated and sealed hermetically, making it suitable for sterile products. Because it has good adaptability and formability, tinplate can be used for containers of many different shapes. Therefore, tinplate is extensively used to form cans for drinks, processed foods, and aerosols; containers for powdered foods and sugar- or flour-based confections; and as package closures (Marsh & Bugusu, 2007).

2.12.5.4 Plastics

There are various advantages to using plastics for food packaging. Fluid and pliable, they can be made into sheets, shapes, and structures, offering considerable flexibility. Furthermore, many plastics are heat sealable, easy to print, and can be integrated into production processes where the package is formed, filled, and sealed in the same production line (Marsh & Bugusu, 2007).

2.12.5.5 Vacuum packaging

Vacuum packaging, which is also known as the skin packaging involves the redraw of air inside the container completely and maintaining food material under vacuum conditions, so that oxygen available for the oxidation and growth of microbes will be limited (Mohan, 2017). A combination of vacuum packaging and cold storage act synergistically to retard the development of microbes that find their way into the product before packaging, thereby, retarding the chemical composition and sensory changes of the food; this extends the keeping quality (Tohibu et al., 2013).

2.13 Shelf Life

Shelf life is referred to as the period a food product may be stored before a specific element of the product makes it unfit for consumption or usage. This element could be physicochemical or biological in nature (Valero, Carrasco & García-Gimeno, 2012).

Furthermore, Shelf-life of liquid milk products, for instance, depends on various factors, namely temperature control, quality of the incoming milk, packaging technologies, filling conditions quality of the milk, heat treatment and additional processes like micro-filtration. However, heat treatment remains the main factor that determines the span of the shelf-life (IDF, 2012).

2.14 Sensory Evaluation

Food Sensory Evaluation is a scientific method of evaluation of food that evokes, measures, analyzes and interprets results obtained by using the senses of smell, taste, sight and touch (Stone, 2018).

Sensory appraisal is referred to as a discipline of measurements strongly connected with accuracy, precision and sensitivity so as to avoid wrong inputting of results. Sensory Evaluation is comprised of methods that involve food science, psychology, physics, mathematics, humanities, and various other biological sciences. Furthermore, sensory evaluation is categorized into two; namely: objective and subjective testing (Sharif, Butt, Sharif & Nasir, 2017).

Also, for all sensory assessment methods, human beings are the measuring tool. It is therefore necessary to present reliable and valid results for a sensory assessment and this is achieved when the sensory panel is treated as a scientific instrument. Meaning, the panelists must go through screening, calibration and validation (Singh-Ackbarali, & Maharaj, 2014).

According to Sharif, Butt, Sharif and Nasir (2017), sensory analysis involves the examination of an item or product by the five (5) senses which are the smell, touch, sight, hearing and taste for various quality parameters like aroma, flavor, appearance, sound and texture. These characteristics of a food product are described below:

- **Appearance**

Appearance normally happens to be the first characteristics perceived by the human senses thereby playing a crucial role in identifying and making the final selection of a food product. Appearance is the pictorial observation of a food item comprised of shape, colour, size, transparency, dullness and gloss. The appearance of a food item has been observed to show to an impact on appetite excitement or displeasure. Even before the food is eaten, the look of a food informs a person's decision as to whether the food is appetizing before the person decides to accept and consume it.

• **Flavour**

Flavour is a sensory parameter which is used to symbolize the sensations of odor, taste and mouthfeel. Flavouring substances are aromatic compounds which are conceived by the mixture of taste and odour and perceived by the mouth and nose. Odour improves the delight of eating e.g., aroma of freshly cooked rice and most of the baked products. Taste helps in identification, acceptance and appreciation of food. It is perceived by the taste buds on the tongue. There are four types of taste perception: sweet, salty, sour and bitter. Sour and bitter are often confused for instance, lemon juice has a sour taste whereas coffee has a bitter taste. In case of mouthfeel, nerves present inside the mouth are enthused by chemical or thermal responses e.g., coldness of ice cream or the fiery impression of pepper.

• **Aroma**

Aroma is a volatile compound which is always perceived in the nasal cavity by the olfactory receptors. The release of aromatic compounds occurs during the mastication process. Perceiving a pleasant smell from food makes the food delicious. To provoke a sensation of smell, the product must be in a gaseous state. Furthermore, aroma is valuable in order to perceive freshness, rancidity or intermittently poisonous food.

• **Texture**

Texture is perceived by different sensory parameters blended together such as sight, mouth feel, hearing and touch. For instance, if a consumer bites a very hard gum or eats a dessert with grainy texture, it is highly possible they are not going to be back for that same texture. Texture is an important requirement to consider in the overall acceptability of several foodstuffs such as, tenderization of meat or the softness of boiled rice. It also includes the thickness, chewiness, consistency, shape and size and fragility of food product. However, the use of a Texture analyzer is useful effective in ensuring the required texture from the food laboratory to the consumer's kitchen.

- **Sound**

Hearing deliberates the sounds made by food during preparation and ingesting e.g., the cracking of hard cookies, the fizziness of carbonated drinks and the sizzling of frying food. So, in sensory analysis, the five (5) senses are often used in measuring, analyzing and interpreting the organoleptic properties of food products.

2.14.1 Descriptive sensory analysis

Descriptive analysis is a sensory method which requires the use of very qualified panels. Procedures used for descriptive analysis records both the qualitative and quantitative sensory characteristics of a product. The qualitative features of products usually include flavor, aroma, appearance or texture, called parameters or attributes. Whiles the quantitative characteristic focuses on the intensity or strength of each of the parameters (Christodoulaki, 2016).

Descriptive testing is useful in evaluating variances among samples, their perceived sensory parameters and the impact of differences in the processing, packaging and storage conditions on the sensory attributes of the particular product. This testing is appropriate for overseeing development of food products and research, assessing attributes important to shelf-life studies or quality control, analyzing the impact of changes in a recipe or process on the organoleptic parameters and understanding the basis of overall acceptability of a product (Sharif, Butt, Sharif & Nasir, 2017).

2.15 Theoretical Framework

2.15.1 The total food quality model

Food Quality represents properties and attributes of a food product such as colour, texture, nutritional content, safety, flavour and appearance.

Total Food Quality Model consist of three categories namely;

- ✔ Product-oriented Quality
- ✔ Process-oriented Quality
- ✔ Quality Control

2.15.1.1 Product-oriented quality

Deals with all the details of the physical product that together give an accurate account of the specific food item. Examples of product-oriented quality may be fat percentage of pork, protein content in soft cheese, starch content in cassava, and alcohol content in wine.

2.15.1.2 Process-oriented quality

Deals with food production and preparation, this includes safety, with or without chemicals, without growth inhibition, by organic production, etc.

2.15.1.3 Quality control

This deals with adherence to specific Standardized food procedures and approved quality by Food and Drugs Authority (FDA) or Ghana Standards Board (GSA) used to make or develop food product. Descriptions established on these aspects provide information about the methods used to make the product, and these aspects may not necessarily have any effect on the product’s physical properties (Brunsø, Fjord & Grunert, 2002).

2.15.2 Permeation theory

Numerous factors can influence the barrier attributes of a packaging material, like environmental conditions like temperature and relative humidity and food contact. Permeates diffusion across a film is thereby influenced by the concentration gradient across the film, thickness, difference in pressure, area film, structure, film permeability to specific vapour or gases, or temperature. Permeability, as reported in the literature, is defined as the quantity of permeate gas or vapour, transmission through a resisting packaging material (Siracusa, 2012).

Permeation significantly affects the keeping quality of these food products this is because the loss or gain of aromas, odors, oxygen and carbon dioxide and water vapor can rob the product of nutrition, flavor, texture, color, and taste (Stevens, 2012). In permeation food packaging, food must be packaged with the appropriate food material so there is no gas or liquid transferred to the food for it to become spoiled. This will also increase the shelf-life of the food when purchasing or consuming. Permeation is an extremely important topic into what we consume. It enables the sustainability of our food and must be at top conditions of our food packaging.

2.15.3 Theory of attractive quality

Kano's theory of attractive quality is a theory of product development and consumer satisfaction.

This theory was developed by Professor Noriaki Kano and his team in 1984 to:

- Categorize and prioritize customer needs
- Guide product development
- Enhance customer satisfaction

This model envisioned to comprehend diverse aspects of how consumers assess and observe quality attributes well.

The Theory of Attractive Quality explains the relationship between the degree of sufficiency and customer satisfaction with a quality attribute that may be grouped into five categories of perceived quality: ‘reverse quality’, ‘indifferent quality’, ‘attractive quality’, ‘one-dimensional quality’, and ‘must-be quality’. Kano explains the importance of categorizing and prioritizing customer needs as the primary step to food product development. In view of this, it serves as a guide to what quality attributes must be featured in a product.

Based on these theories, the quality of a food product is important in the acceptance and consumption of the product by consumers. Having standardized procedures, following of food safety measures, adhering to regulations by authorities relating to specifications, appropriate, informative and attractive food packaging infers wholesomeness of a food product.

2.15 Conceptual Framework

The conceptual framework gives a pictorial overview of the study. It was developed based on literature reviews of existing studies and theories about the topic.

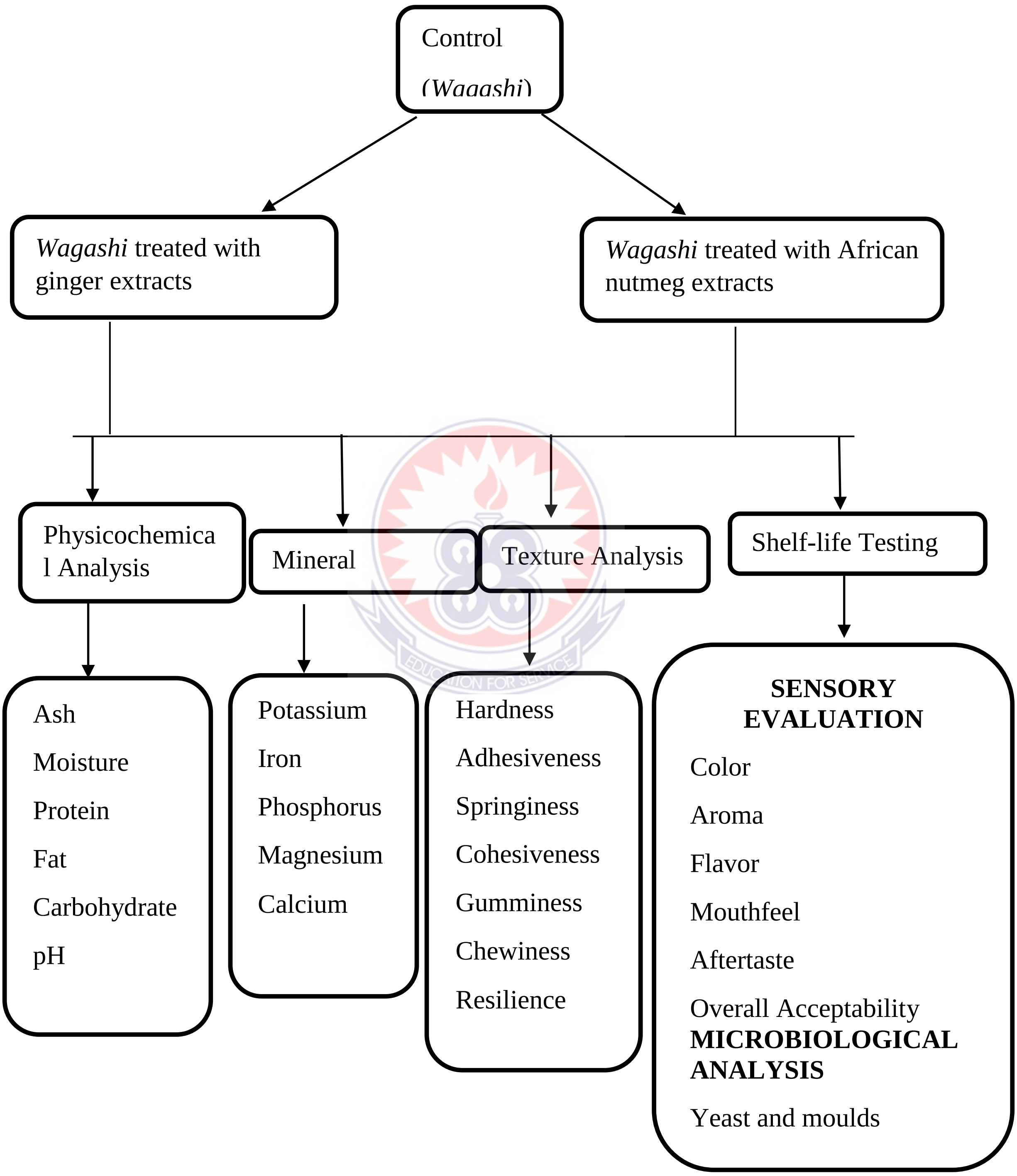

Figure 2.1: Conceptual framework

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter describes in detail the procedures employed in achieving the aims and objectives of this research. A justification of the research approach is given, followed by a comprehensive explanation of the quantitative research design.

3.1 Research Approach

Experimental research is any research conducted with a scientific approach, where a set of variables are kept constant while the other set of variables are being measured as the subject of experiment. This method typically yields quantitative data, as they are concerned with measuring things (McLeod, 2012)

3.2 Procedure for Data Collection

A test can be considered an experiment that determines one or more characteristics of a given sample, product or services. The laboratory tests were done by the researcher. All samples were made available, labelled and aseptically carried on ice in a sterile ice chest and sent to the laboratory for proximate and mineral analysis, pH determination and texture profile analysis immediately on arrival. All samples were done in duplicate to ensure reliability of the result and to reduce the margin of error as much as possible. All laboratory equipment to carry out the test were washed, dried in an oven and cooled in a desiccator before used. Chemicals to be used were carefully collected. Samples were collected and laboratory procedures were carefully followed during the process. Samples for minerals were prepared, labelled and sent to the laboratory for the analysis.

3.3 Instrumentation for Data Generation

Conventioneer oven was used for moisture determination, muffle furnace for ash determination, Kjeldahl apparatus for crude protein determination, soxhlet apparatus for crude fat determination, Erlenmeyer flask. For minerals, PerkinElmer Atomic Absorption Spectrophotometer (AAS; Model AAnalyst 400, Minneapolis, U.S.A.) was used to determine the various mineral components. Texture analyser TA-XT2 (Stable Micro Systems, Godalming, England) equipped to determine the texture profiling. Yeasts and molds were enumerated on acidified potato dextrose agar (Oxoid).

3.4 Study Area

This study was conducted in the University of Ghana, Legon; Food Science Department in the Greater Accra region, Accra, which is Ghana‘s capital town. The choice of Accra is mainly due to the populous and cosmopolitan nature of the city.

3.5 Materials and Equipment

The materials and equipment used for the preparation of the *wagashi* samples included colander, perforated spoon, tablespoon and teaspoon, scale cheese cloth, plastic bowl, stainless steel knife, chopping board, table top burner, cooking pot, food saver bag, vacuum packaging sealer and thermometer.

3.6 Sampling of Fresh Cow Milk

Fresh cow milk was obtained from the Nima market. Samples were packaged in clean gallons, kept in an ice chest which contained ice packs, prepared and transported to laboratory for analysis.

3.6.1 Sampling of ginger and African nutmeg

Ginger and African Nutmeg were obtained from the Nima market.

3.7 Packaging Material

Transparent nylon bags and vacuum packaging were used for packaging of samples during shelf-life study.

3.8 Preparation of Traditional *Wagashi*

Wagashi was prepared by the coagulation of cow fresh milk using vegetable rennet extract of sodom plant (*Calotropis procera*).

3.8.1 Vegetable rennet extraction (coagulant)

The stems of the *Calotropis procera* plant were washed and cut into smaller sizes. They were then pounded using a mortar with a pestle. About 500ml of water was added to the crushed stems and a weighed amount of salt was added. The mixture was allowed to rest for a total of 10minutes and filtered. Figure 3.1 shows the flow diagram of the vegetable rennet extraction.

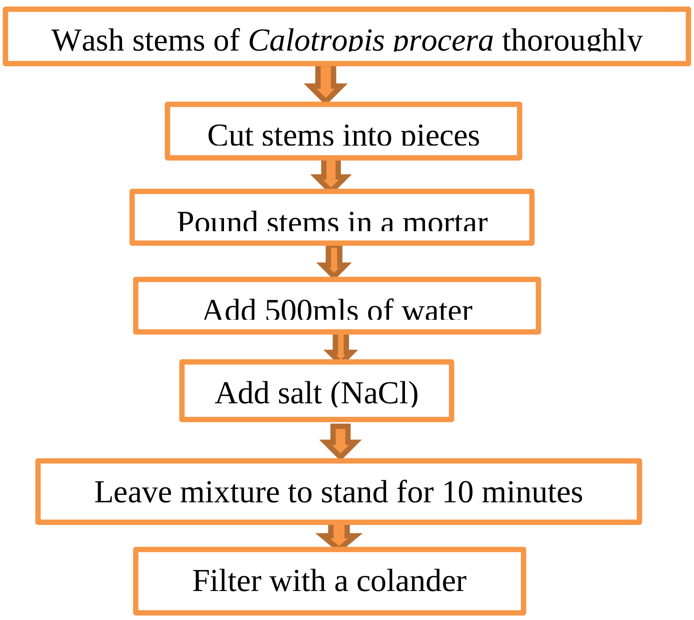

Figure 3.1: Flow diagram for plant extract preparation (coagulant)

3.8.2 *Wagashi* production

Wagashi was prepared using fresh cow milk. Milk was pasteurized at 80^{o} C for thirty (30) minutes. Vegetable rennet extract was added to the warm milk with constant stirring. Coagulation started within 15-20 minutes after adding the coagulant. The curd was strained through a cheese cloth and a sieve. A volume of 1.5litres was placed on the cheese for 3hours to help drain off excess moisture. Figure 3.2 Flow diagram of *wagashi* production process (Traditional method).

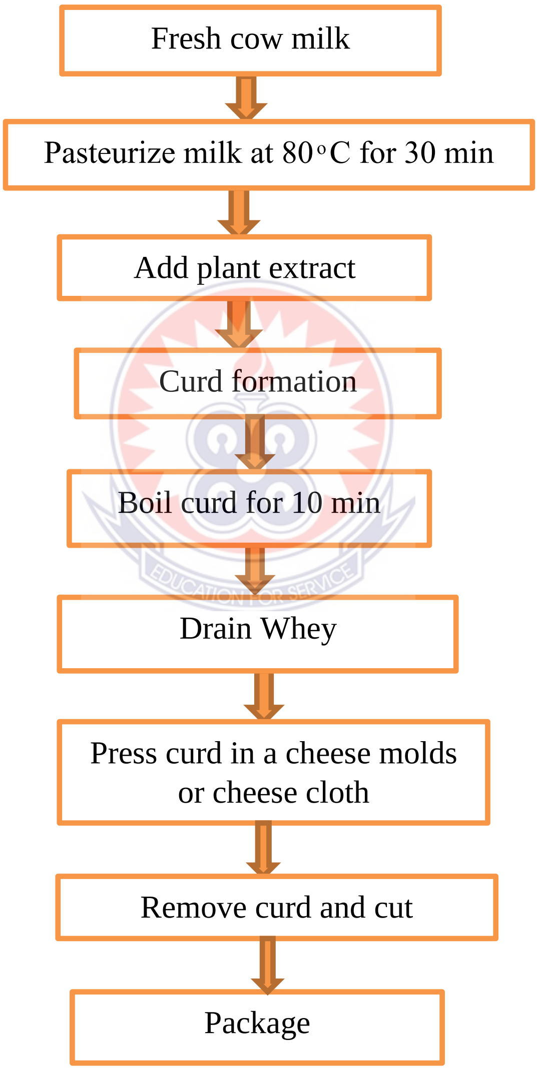

Figure 3.2: Flow diagram of wagashi production (Traditional method)

Source: Arthur (2016)

3.8.2.1 *Wagashi* treated with ginger extract production

Wagashi treated with ginger extract was obtained by adding ginger extracts to *wagashi* after the curd was sieved and stirred. Ginger extraction was done by washing and peeling ginger which was then blended into a puree. Water was added and the mixture allowed to sit for 10 minutes and the juice was drained into a clean jar using a cheese cloth and a sieve. A volume of 1.5litres was placed on *wagashi* treated with ginger extract for 3hours to help drain off excess moisture. Figure 3.3 Flow diagram of *wagashi* treated with ginger extract.

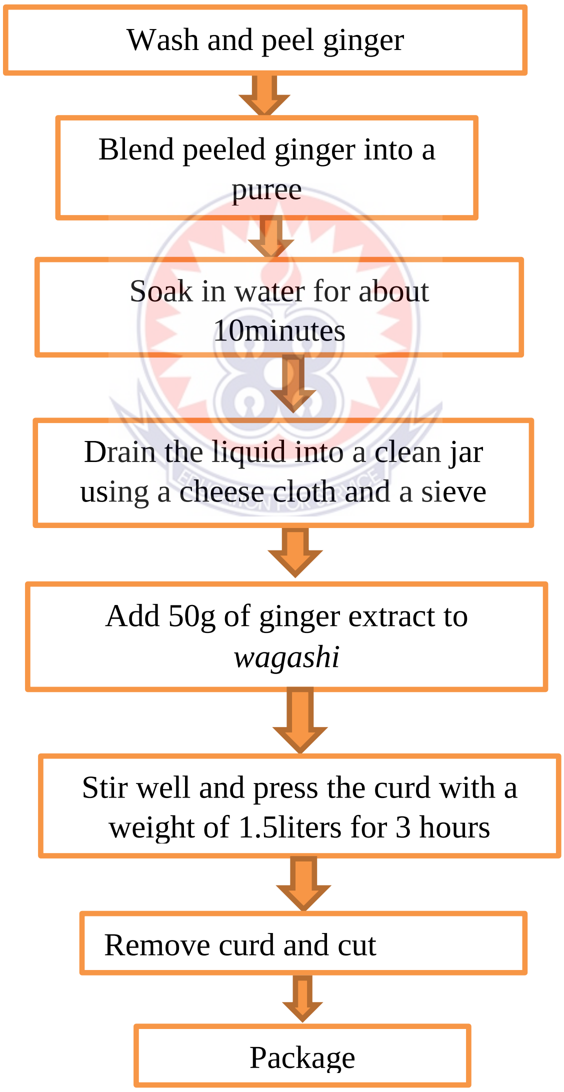

Figure 3.3: Flow diagram of wagashi treated with ginger extract

3.8.2.2 *Wagashi* treated with African Nutmeg extract production

Wagashi treated with African nutmeg extract was obtained by adding African nutmeg extracts to *wagashi* after the curd was sieved and stirred. African nutmeg extraction was done by blending African nutmeg in a powdered form. Water was added and the mixture allowed to sit for 10 minutes and the juice was drained into a clean jar using a cheese cloth and a sieve. A volume of 1.5liters was placed on *wagashi* treated with African Nutmeg extract for 3hours to help drain off excess moisture. Figure 3.4 Flow diagram of *wagashi* treated with African nutmeg extract.

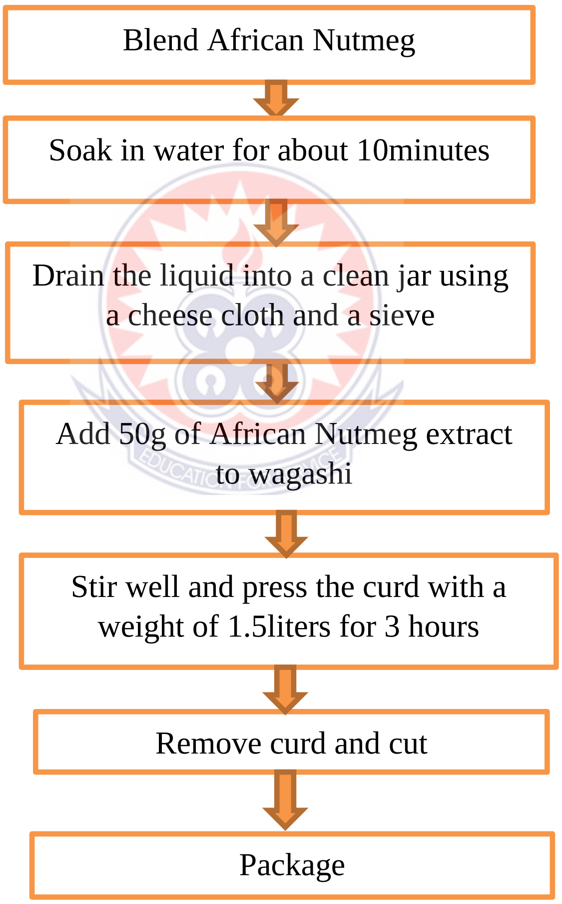

Figure 3.4: Flow diagram of *wagashi* treated with African nutmeg extract

3.9 Physicochemical Analysis

The following physical and chemical properties were determined in the *wagashi* samples.

3.9.1 Proximate composition

The samples were weighed using a digital weighing scale to obtain the individual weight from each market. The sample was blended and homogenized and samples kept for analysis.

3.9.1.1 Moisture content

The moisture content of the samples was determined by measuring the initial mass ($M_{INITIAL}$) of the sample using a digital weighing scale. The samples were then placed in an oven to dry at 105°C overnight until they reached constant mass and the mass recorded as dried mass(M_{DRIED}). The percentage moisture content was then determined by the equation below:

$$\%Moisture = \frac{M_{INITIAL} - M_{DRIED}}{M_{INITIAL}} \times 100$$

3.9.1.2 Ash content

The ash content of a sample is the residue left after ashing in a muffle furnace at about 550-600°C till the residue become white. Ash content was determined by incineration of two grams of each sample in a muffle furnace at 600°C for 2 hours. The percentage residue weighed was expressed as ash content.

Calculation:

$$\%Ash = \frac{(wt\ of\ crucible + ash) - wt\ of\ empty\ crucible}{(wt\ of\ crucible + sample) - wt\ of\ empty\ crucible} \times 100$$

3.9.1.3 Crude protein

Crude protein of the sample was determined using the Kjeldahl method, which evaluates the total crude nitrogen content of the sample after it has been digested in sulphuric acid with a catalyst. Two grams (2.0g) of the sample was digested with 15mls of concentrated Sulphuric acid (H_2SO_4) in the presence of a catalyst (mixture of potassium sulphate and copper sulphate) for about one and half hours and allowed to cool for about 15 min. The resulting digestate were distilled in the presence of strong alkali, sodium hydroxide (NaOH). The ammonia released was collected in aqueous solution of boric acid and titrated against 0.01M HCl. Blank determination was administered in a similar manner. Based on the determined ammonia, equivalent nitrogen was calculated. The percentage crude protein was estimated by multiplying the sample percentage nitrogen by a factor 6.25 (AOAC, 2005).

Calculation:

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

Va- volume in ml of standard acid used in titration
Vb- volume in ml of standard acid used in blank
NA- normality of acid
Wt- Weight of sample taken

3.9.1.4 Fat content

A previously dried (air oven at 100°C) 250 ml round bottom flask was accurately weighed. Dried *wagashi* samples of 5.0g was weighed into a folded filter paper. Small amount of cotton wool was placed into the thimble to prevent loss of the sample. One hundred and fifty milliliters (150ml) of petroleum spirit (B.P 40-60°C) was added to the round bottom flask and the apparatus assembled. The condenser was connected to the soxhlet extractor (Cat number EME60250/CEB and Serial number M521590) and refluxed for 6 hours on the heating mantle. After extraction, the thimble was removed and solvent was recovered by distillation. The flask and fat were heated in oven at about 103°C to evaporate the solvent. The flask and contents were cooled to room temperature in a desiccator. The flash was later weighed to determine the weight of fat collected.

Calculation:

$$\%Fat = \frac{(wt\ of\ flask + fat) - wt\ of\ flask}{wt\ of\ sample} \times 100$$

3.9.1.5 Carbohydrate

The carbohydrate was determined by the actual difference between the sum total of moisture, ash, protein, crude fat, fibre and 100% according to AOAC (1990) method. In calculating the percentage carbohydrate, the formula below was used;

Calculation:

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

3. 9.1.6 Determination of pH

The pH of 10% solution of homogenize sample was measured using a pH meter by taking three (3) replicate readings (pH meter, Hanna Instruments, model HI 9321, USA), periodically calibrated with buffered solutions (pH 4.0 and 7.0) (AOAC, 1995).

3.10 Mineral Analysis

3.10.1 Determination of magnesium, calcium, potassium and iron

Wet digestion method was used to eliminate all organic matter from the sample before sample was analysed for the various minerals. About 1g of sample was measured into a 250ml beaker. Twenty-five millimeters (25ml) concentrated HNO_3 was added and the beaker was covered with a watch glass. The sample was digested with care on a hot plate in a fume chamber until all the organic matter had been oxidized (20-30mins). The pale- yellow solution was cooled and 1ml 70% $HClO_4$, was added with care. Digestion was continued until the solution was almost colourless (until all the HNO_3 was removed) The solution was then cooled slightly after the digestion process, and about 30 ml distilled water was added and allowed to boil for about 10 minutes then filtered when hot through No. 4 Whatman filter paper into a 100ml volumetric flask. The beaker was well washed with distilled water and filtered. The flask was then cooled and made up to the 100 ml mark. This solution was used for all the mineral analyses. The following minerals;

Magnesium (Mg), Calcium (Ca), Potassium (K), and Iron (Fe) were all determined using the PerkinElmer Atomic Absorption Spectrophotometer (AAS; Model AAnalyst 400, Minneapolis, U.S.A.) and results recorded in milligram (mg).

3.10.2 Determination of phosphorus

Phosphorous (P) was then determined by using spectrophotometric-colorimetric method and result recorded in milligram (mg) per 100g.

3.11 Texture Profile Analysis (TPA) of *Wagashi*

Texture Profile Analysis (TPA) including the measurement of hardness, gumminess, chewiness, springiness and cohesiveness was performed on cheese samples at room temperature using a texture analyser TA-XT2 (Stable Micro Systems, Godalming, England). The hardness of a sample indicates the amount of force required to attain a given deformation, or in sensory terms, the force necessary to compress cheese between the molar teeth. The gumminess is the ability of a cheese to regain its original position during the first deformation test, while the chewiness is a measure of the energy required to masticate cheese into a uniform state before swallowing. The springiness is a measure of the recovery of the original undeformed condition after the first compression force is removed and the cohesiveness is a measure of the extent to which a cheese can be deformed before it ruptures (Chevanan, Muthukumarappan, Upreti & Metzger, 2006). The probe used was a 5 cm cylindrical flat probe. Each sample (1.5 cm × 1.5 cm × 1.5 cm in size) was cut from the central part of the cheese using a sharp knife and held at room temperature for 1 h in a closed container preceding analysis to avoid moisture loss. A test using 50% sample compression was applied to the cheese using two compression cycles at a constant crosshead speed of 2mms^{-1} (Pollard, Sherkat, Seuret, & Halmos, 2003). The texture analyses were performed twice for two (2) independent samples from each batch of cheese. A total of 6 readings were taken for each treatment.

3.12 Shelf-Life Determination

The shelf-life of the *wagashi* samples was determined. The end of the shelf-life of cheese has frequently been associated with microbiological counts and/or values of physicochemical parameters in different products categories. Therefore, in this study, yeast and moulds were chosen as the alteration component determining the shelf-life of the *wagashi* samples. For this exact purpose, *wagashi* samples were stored for fifteen (15) days at 4^{0}C. The determination of yeast and mould counts of every sample were determined each and every five (5) days of the indicated temperature.

3.12.1 Vacuum packaging of *wagashi*

Wagashi samples were divided into 10 pieces of 10g each and divided into two groups. One group was inserted into a food saver bag and sealed with a vacuum machine. The other group was inserted into nylon bags which were not vacuum packaged. This served as the control at each storage temperature.

3.12.2 Storage of wagashi

The vacuum and transparent nylon packaged *wagashi* samples were stored under 4^{o}C storage temperature. Physical observation was carried out until spoilage was observed in the samples.

3.12.3 Physical observation of *wagashi*

The physical observation was done to look for any quality changes that could impact on the shelf stability of the product. Some parameters considered texture changes through the sense of touch and aroma changes through the sense of smell.

3.12.4 Microbiological characteristics of *wagashi* samples

3.12.4.1 Yeasts and moulds

Yeasts and molds were enumerated on acidified potato dextrose agar. Plates were incubated aerobically upright at 25°C for 5 days.

3.12.5 Sensory test

Sensory test was carried out using ten (10) trained panel members. The objective of the test was to obtain hedonic responses towards the *wagashi* samples. Consumer selection was conducted based on their familiarity with cheese or *wagashi* and were regular consumers of the product. Samples were removed from the refrigerator at (4◦C) for one hour (1hr) prior to sensory evaluation, and kept at room temperature (22 ± 2◦C). Samples were coded and served in randomized order (Krumov, Ivanov, Slavchev & Nenov, 2010). Ten (10) grams of *wagashi* was served to each panel member. By the use of a 9-point hedonic scale (1 = 'dislike extremely', 2 = 'dislike very much', 3 = 'dislike moderately', 4 = 'dislike slightly', 5 = 'neither like nor dislike', 6 = 'like slightly', 7 = 'like moderately', 8 = 'like very much', 9 = 'like extremely'), consumers were trained to rate wagashi samples based on the following sensory attributes; colour, aroma, flavor, texture and overall acceptability. Water and tissues were served for the exact purpose of mouth rinsing and hand cleansing after every assessment. Questionnaire for sensory evaluation can be found in appendix 16.

3.12.6 Training of panelists

The training for the sensory evaluation was done for one hour. A brief introduction about the origin, process, consumption of *wagashi* and the purpose for the gathering was given. The panelists developed words which described the sensory attributes; flavor, aroma, aftertaste, colour, mouthfeel and overall acceptability of *wagashi* samples.

3.13 Statistical Analysis

Illustrations with tables and descriptive statistical analysis were done and determined using the Microsoft Excel 2013. Results were presented using tables and graphs for easy interpretation. Research questions were analyzed using means and standard deviations (SPSS version 23).

3.14 Ethical Consideration

The consideration of some ethical issues is very necessary for the completion of study as well as to make a reliable research report. According to Saunders et al. (2009), in order to ensure the reliability, validity and quality of the research report, the researcher must follow and maintain significant ethical issues during the completion of research project. The researcher has to follow and maintain relevant ethical issues. All ethical issues were followed and maintained by the researcher included - honesty, integrity, acknowledgment, confidentiality, objectivity and fairness. The researcher has acknowledged all previous works that have been used in this research report. In similar ways, the researcher followed and maintained other relevant ethical during the collection of primary and secondary data and information from the parties involved in this study.

CHAPTER FOUR

RESULTS

4.0 Overview

This Chapter presents the results of the analysis of the proximate composition, pH, mineral composition, texture profile and shelf-life testing of *wagashi* samples.

4.1 What is the Physicochemical Composition of *wagashi* treated with Ginger and African Nutmeg Extracts?

Table 4.1: Proximate chemical composition of *wagashi* samples (N=2)

Sample	%moisture/100 g	%ash/100 g	%protein/100 g	%fat/100 g	%carbohydrate/100 g
Control	55.25±0.25	1.95±0.06	20.18±0.57	3.55±0.01	19.08±0.74
wagashi treated with ginger	52.12±0.38	1.75±0.25	20.67±0.63	2.18±0.05	23.28±0.55
wagashi treated with African nutmeg	50.75±0.75	2.50±0.00	22.49±0.35	1.96±0.02	22.30±0.38

Values are means ± range/2 of duplicate determination

The chemical evaluation of the *wagashi* samples were carried out to determine the nutritive values of the *wagashi* samples which covered moisture, ash, protein, fat and carbohydrate. The results are presented in Table 4.1.

From Table 4.1, the values for ash were the lowest ranging from 1.95 g to 2.50 g with the *wagashi* treated with African nutmeg sample rating highest and the control (*wagashi*) sample rating the lowest. This was followed by values for fat which ranged from 1.96 g to 3.55 g with the control (*wagashi*) sample rating the highest and African nutmeg sample rating lowest. The values for carbohydrate ranged from 19.08 to 23.28 with the *wagashi* treated with ginger sample rating highest and the control (*wagashi*) sample rating the lowest. Furthermore, the values of crude protein ranged from 20.18 to 22.49 with the *wagashi* treated with African nutmeg sample rating significantly higher the control (*wagashi*) sample rating the lowest. Moisture content rated the highest. The values for moisture ranged from 50.75 to 55.25 with the control (*wagashi*) sample rating highest and African nutmeg sample rating lowest.

4.1.1 Determination of pH

Table 4.2: pH of *wagashi* samples

SAMPLE ID	PH
Control	6.27±0.06
wagashi treated with ginger	6.67±0.045
wagashi treated with African nutmeg	6.61±0.50

Values are mean ± range/2 duplicate determinations

From Table 4.2, the pH of the *wagashi* samples were slightly acidic ranging from 6.27 to 6.67 the control sample recorded the lowest in pH value with a 6.27 whiles *wagashi* treated with ginger recorded the highest pH value with 6.67.

4.2 What is the Mineral Composition of *wagashi* treated with Ginger and African Nutmeg Extracts?

The mineral composition of the *wagashi* samples determined included Phosphorous (P), Iron (Fe), Potassium (K), Magnesium (Mg) and Calcium (Ca). Table 4.3 shows the results obtained from the analyses.

Table 4.3: Mineral composition of *wagashi* samples

sample ID	potassium mg/100g	iron mg/100g	phosphorous mg/100g	magnesium mg/100g	calcium mg/100g
Control	115.75±4.45	0.79±0.00	302.00±0.00	35.94±0.00	444.40±2.5
wagashi treated with ginger	122.10±0.00	1.51±0.00	144.00±0.00	63.61±0.00	661.00±0.00
wagashi treated with African nutmeg	112.30±0.00	2.29±0.00	353.00±0.00	56.65±0.00	708.30±0.00

Values are means ± range/2 of duplicate determination

From Table 4.3, it was observed that, the values for Iron (Fe) were the lowest ranging from 0.79mg to 2.29mg/100g with the *wagashi* treated with African nutmeg sample rating highest and the control (*wagashi*) sample rating the lowest. This was followed by values for Magnesium (Mg) which ranged from 35.94mg to 56.65mg/100g with the *wagashi* treated with ginger sample rating the highest and control (*wagashi*) sample rating lowest. The values for Potassium (K) ranged from 112.30mg to 122.10mg/100g with the *wagashi* treated with ginger sample rating highest and the African nutmeg sample rating the lowest. Furthermore, the values of Phosphorous (P) ranged from 144.00mg to 353.00mg/100g with the *wagashi* treated with African nutmeg sample rating highest and the *wagashi* treated with ginger sample rating the lowest. With Calcium (Ca) content been the highest, the values for Calcium (Ca) ranged from 444.40mg to 708.30mg/100g with the African nutmeg sample rating highest and control (*wagashi*) sample rating lowest.

4.3 What is the Texture Profile of *wagashi* treated with Ginger and African Nutmeg Extracts?

Evaluation of texture by instrumental analysis is important to new product development. The results for Texture Profile Analysis (TPA) for *wagashi* are presented in Table 4.4. Seven (7) parameters were measured; hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness and Resilience.

Table 4.4: Texture profile analysis of *wagashi* samples

sample id	Hardness	Adhesiveness	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
control	3231.57±3814.52	-19.66±12.39	0.76±0.08	0.40±0.08	1442.11±1841.90	9886.28±2196.39	0.12±0.03
wagashi treated with ginger	12409.98±4897.37	-24.53±8.88	0.82±0.03	0.42±0.03	5056.88±1854.70	4145.23±1569.61	0.17±0.03
wagashi treated with African orchid nutmeg	17594.92±1810.87	-8.54±4.40	0.87±0.03	0.42±0.08	7454.64±1747.32	6526.98±1648.77	0.17±0.04

Values are means range/2 of duplicate analysis

Hardness, g = Maximum force of first compression

Adhesiveness, g/sec = Negative area in the graph.

Springiness = $\frac{length\ one}{length\ two}$

Cohesiveness=$\frac{Area\ under\ 1st\ compression}{Area\ under\ 2nd\ compression}$

Gumminess=$\frac{\boldsymbol{Area\ 2}}{\boldsymbol{Area\ 1}}$

Chewiness=$\frac{Distance\ 2}{Distance\ 1}$

Resilience=$\frac{Area\ 4}{Area\ 3}$

From Table 4.4, the values for hardness ranged from 3231.57 to 17594.92. The values for adhesiveness ranged from -8.54 to -24.53. The value for springiness ranged from 0.76 to 0.87. The values for cohesiveness ranged from 0.40 to 0.42. The values for gumminess ranged from 1442.11 to 7454.64. The values for chewiness ranged from 4145.23 to 9886.28. The values for resilience ranged from 0.12 to 0.17. The *wagashi* treated with African nutmeg sample recorded the highest value for hardness while the control sample recorded the lowest value. The *wagashi* treated with ginger sample recorded the highest value for adhesiveness while the control sample recorded the lowest value for adhesive texture. The *wagashi* treated with African nutmeg sample recorded the highest value for springiness while the control sample recorded the lowest value for spring texture. The *wagashi* treated with ginger and *wagashi* treated with African nutmeg sample recorded the highest value for cohesiveness while the control sample recorded the lowest value for cohesive texture. The *wagashi* treated with African nutmeg sample recorded the highest value for gumminess while the control sample recorded the lowest value for gummy texture. The control sample recorded the highest value for chewiness while the *wagashi* treated with ginger sample recorded the lowest value for chewy texture. The *wagashi* treated with ginger and *wagashi* treated with African nutmeg sample recorded the highest value for resilience while the control sample recorded the lowest mean value.

4.4 What is the Shelf-Life of *wagashi* treated with Ginger and African Nutmeg Extracts?

The shelf life of the product was determined using microbiological and sensory parameters. Changes in microbiological counts (yeasts and moulds) of *wagashi* samples during storage of the samples under refrigeration condition (4^0C) were observed at five days interval up to 15 days storage period, and results are presented in Table 4.5 and Table 4.6.

Table 4.5: Yeasts count (log cfu/gm) changes in *wagashi* samples during storage refrigeration (4^0C)

Sample	day 0	day 5	day 10	day 15
WTNB	ND	$3.6x10^1$	$4x10^2$	$2x10^4$
WGTNB	ND	<10	$1.1x10^1$	$1.9x10^1$
WATNB	ND	<10	$1x10^1$	$1.6x10^1$
VPW	ND	ND	ND	<10
VPWG	ND	ND	ND	<10
VPWA	ND	ND	ND	<10
Specification	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$	$1.0x10^2$

,[1] LOD: Limit of Detection; *Guidelines for specification based on [2]Ghana Standards Authority Standards GS955:2013. ND: Not detected

LOD: Limit of Detection<10.

WTNB = wagashi packaged with Transparent nylon bag (control), WGTNB = wagashi with ginger packaged with Transparent nylon bag, WATNB= wagashi with African Nutmeg packaged with Transparent nylon bag, VPW = Vacuum Packaged wagashi, VPWG = Vacuum Packaged wagashi with ginger, VPWA =Vacuum Packaged wagashi with African Nutmeg

S: Spoiled

From Table 4.5, on day 0 of storage of the *wagashi* samples, yeast was not detected (ND) in any of the samples. On day 5 however, there was a detection of yeast in the *wagashi* samples packaged with nylon bag with a count of $3.6x10^1$ cfu/g. *Wagashi* treated with ginger and African Nutmeg extracts, packaged with Transparent nylon bag recorded a slight growth for yeast. Yeast continued to gradually increase up to the level of $4.0x10^2$ cfu/g in *wagashi* packaged with Transparent nylon bag as the highest count and *wagashi* treated with African Nutmeg extracts packaged with Transparent nylon bag recorded the lowest count of $1.0x10^1$ cfu/g on the 10th day of storage. Furthermore, on the 15^{th} day of storage, *wagashi* samples packaged with nylon bag recorded the highest count of $2x10^4$ cfu/g whiles all of the Vacuum Packaged samples had a count of not more than 10 cfu/g.

Table 4.6: Mould count (log cfu/gm) changes in *wagashi* samples during storage refrigeration (4^0C)

Sample	day 0	day 5	day 10	day 15
WTNB	ND	<10	$1.35x10^1$	$1.2x10^2$
WGTNB	ND	ND	<10	$1x10^1$
WATNB	ND	ND	<10	$1x10^1$
VPW	ND	ND	ND	<10
VPWG	ND	ND	ND	<10
VPWA	ND	ND	ND	<10
Specification	$1.0x10^1$	$1.0x10^1$	$1.0x10^1$	$1.0x10^1$

,[1]LOD: Limit of Detection; *Guidelines for specification based on [2]Ghana Standards Authority Standards GS955:2013. ND: Not detected

LOD: Limit of Detection<10.

WTNB = wagashi packaged with Transparent nylon bag (control), WGTNB = wagashi with ginger packaged with Transparent nylon bag, WATNB= wagashi with African Nutmeg packaged with Transparent nylon bag, VPW = Vacuum Packaged wagashi, VPWG = Vacuum Packaged wagashi with ginger, VPWA =Vacuum Packaged wagashi with African Nutmeg

S: Spoiled

From Table 4.6, on day 0 of storage of the *wagashi* samples, moulds were not detected (ND) in any of the samples. On day 5, moulds were not detected in all the samples with the exception of *wagashi* packaged with nylon bag with a colony count not more than 10. On the 10th day, moulds continued to gradually increase up to the level of $1.35x10^1$ cfu/g in *wagashi* packaged with nylon bag. *Wagashi* treated with ginger and African Nutmeg extracts, packaged with transparent nylon bag samples had mould not more than 10 cfu/g colony count on the 10th day of storage. Furthermore, on the 15th day of storage, *wagashi* samples packaged with nylon bag recorded the highest count of $1.2x10^2$ cfu/g whiles all of the vacuum packaged samples had a count of not more than 10 cfu/g.

4.4.2.1 Affective sensory attributes of *wagashi* samples during refrigeration storage at (4^0C)

Parameters such as colour, aroma, flavour, mouth feel, aftertaste and overall acceptability were assessed. Changes in ratings of Sensory attributes of *wagashi* samples during storage of the samples under refrigeration condition at 4^oC were observed at five days interval up to 15 days storage period and results are presented. The *wagashi* samples were prepared and processed, and an affective sensory test was carried out.

4.4.2.2 Sensory score for color

Table 4.7: Sensory score for color

SAMPLE NO. = 6	DAY 0	DAY 5	DAY 10	DAY 15
300	8.1	7.1	5	0
175	8.0	7.2	6.2	6.4
561	7.9	7.1	6.6	6.3
780	8.2	7.9	7.2	6.6
202	8.2	7.7	7.3	6.5
986	8.1	7.5	7.1	6.3

Key

300: *wagashi* packaged with transparent nylon bag

175: *wagashi* treated with ginger packaged with transparent nylon bag

561: *wagashi* treated with African Nutmeg packaged with transparent nylon bag

780: Vacuum Packaged *wagashi*

202: Vacuum Packaged *wagashi* treated with ginger

986: Vacuum Packaged *wagashi* treated with African Nutmeg

Colour is the primary focus of attraction for every product. Therefore, colour happens to be a very important sensory attribute during a sensory assessment test (Anaglih, 2015). From Table 4.7, on day 0, samples graded by panelists were between 7.90 and 8.20 which corresponds to "like moderately" and "like very much" on the hedonic scale. Panelists graded *wagashi* treated with African Nutmeg packaged with transparent nylon bag with a score of 7.90 and Vacuum Packaged *wagashi* and Vacuum Packaged *wagashi* treated with ginger extracts samples received the highest grading of 8.20. Subsequent days saw a steady decline in grading of samples. At the end of the study, the results showed that vacuum packaging and treatment with ginger and African Nutmeg extracts had a positive impact on the colour of the *wagashi* samples. Panelists graded the vacuum packaged *wagashi* sample with a score of 6.6 which corresponds to "like slightly" on the hedonic scale. The control sample packaged in a nylon bag without treatment was not graded due to the fact that the sample had gone bad.

4.4.2.3 Sensory Score for Aroma

Table 4.8: Sensory Score for Aroma

SAMPLE NO. = 6	DAY 0	DAY 5	DAY 10	DAY 15
300	8.0	7.2	6.2	0
175	8.2	7.3	6.9	6.0
561	8.2	7.3	6.6	5.0
780	8.1	7.7	7.3	6.1
202	7.6	7.5	7.4	6.4
986	8.2	7.6	7.2	6.2

Key

300: *wagashi* packaged with transparent nylon bag

175: *wagashi* treated with ginger packaged with transparent nylon bag

561: *wagashi* treated with African Orchid Nutmeg packaged with transparent nylon bag

780: Vacuum Packaged *wagashi*

202: Vacuum Packaged *wagashi* treated with ginger

986: Vacuum Packaged *wagashi* treated with African Nutmeg

From Table 4.8, on day 0, samples graded by panelists were between 7.60 and 8.20 which corresponds to "like moderately" and "like very much" on the hedonic scale. Panelists graded Vacuum Packaged *wagashi* treated with ginger with a score of 7.90 whiles *wagashi* treated with ginger and African Nutmeg extracts packaged with Transparent nylon bag and Vacuum Packaged *wagashi* treated with African Nutmeg extracts samples received the highest grading of 8.20. Subsequent days saw a steady decline in grading of samples. At the end of the study, the results showed that vacuum packaging and treatment with ginger and African Nutmeg extracts had a positive impact on the aroma of the *wagashi* samples. Panelists graded samples between 6 and 6.40 which corresponds to "like slightly" on the hedonic scale. *Wagashi* treated with African Nutmeg extracts packaged with transparent nylon bag was graded with a score of 5.0 representing "neither liked nor disliked" on the hedonic scale.

4.4.2.4 Sensory score for flavour

Table 4.9: Sensory score for flavour

SAMPLE NO. = 6	DAY 0	DAY 5	DAY 10	DAY 15
300	8.3	7.0	6.4	0
175	8.0	7.4	7.1	6.0
561	8.1	7.3	6.7	6.1
780	8.5	7.5	7.1	6.2
202	8.1	7.6	7.2	6.6
986	8.3	7.3	7.2	6.2

Key

300: *wagashi* packaged with transparent nylon bag

175: *wagashi* treated with ginger packaged with transparent nylon bag

561: *wagashi* treated with African Nutmeg packaged with transparent nylon bag

780: Vacuum Packaged *wagashi*

202: Vacuum Packaged *wagashi* treated with ginger

986: Vacuum Packaged *wagashi* treated with African Nutmeg

From Table 4.9, on day 0, samples graded by panelists were between 8.50 and 8.0 which corresponds to "like very much" on the hedonic scale. Panelists graded *wagashi* treated with ginger extracts packaged with transparent nylon bag with a score of 8.0. Vacuum Packaged *wagashi* samples received the highest grading of 8.50. Subsequent days saw a steady decline in grading of samples. At the end of the study, the results showed that vacuum packaging as well as treatment with ginger and African Nutmeg extracts had a positive impact on the flavour of the *wagashi* samples. Panelists graded samples between 6 and 6.60 which corresponds to "like slightly" on the hedonic scale.

4.4.2.5 Sensory score for mouth feel

Table 4.10: Sensory score for mouth feel

SAMPLE NO. = 6	DAY 0	DAY 5	DAY 10	DAY 15
300	8.1	6.8	6.3	0
175	7.4	7.5	6.7	6.3
561	7.8	7.5	6.5	6.2
780	8.1	7.8	6.9	6.9
202	7.7	7.7	7.3	6.6
986	8.0	7.6	7.0	6.4

Key

300: *wagashi* packaged with transparent nylon bag

175: *wagashi* treated with ginger packaged with transparent nylon bag

561: *wagashi* treated with African Nutmeg packaged with transparent nylon bag

780: Vacuum Packaged *wagashi*

202: Vacuum Packaged *wagashi* treated with ginger

986: Vacuum Packaged *wagashi* treated with African Nutmeg

From Table 4.10, on day 0, samples graded by panelists were between 7.40 and 8.10 which corresponds to "like moderately" and "like very much" on the hedonic scale. Panelists graded wagashi treated with ginger extracts packaged with transparent nylon bag with a score of 7.40. *Wagashi* packaged with transparent nylon bag and Vacuum Packaged *wagashi* samples received the highest grading of 8.10. Subsequent days saw a steady decline in grading of samples. At the end of the study, the results showed that vacuum packaging as well as treatment with ginger and African Nutmeg extracts had a positive impact on the mouthfeel of the *wagashi* samples. Panelists graded samples between 6.20 and 6.90 which corresponds to "like slightly" on the hedonic scale.

4.4.2.6 Sensory score for aftertaste

Table 4.11: Sensory score for aftertaste

SAMPLE NO. = 6	DAY 0	DAY 5	DAY 10	DAY 15
300	8.1	6.9	6.1	0
175	8.1	7.6	6.8	6.3
561	7.7	7.5	6.5	6.5
780	7.8	7.7	7.3	6.9
202	8.3	7.6	7.3	6.7
986	8.0	7.5	7.0	6.3

Key

300: *wagashi* packaged with transparent nylon bag

175: *wagashi* treated with ginger packaged with transparent nylon bag

561: *wagashi* treated with African Nutmeg packaged with transparent nylon bag

780: Vacuum Packaged *wagashi*

202: Vacuum Packaged *wagashi* treated with ginger

986: Vacuum Packaged *wagashi* treated with African Nutmeg

From Table 4.11, on day 0, samples graded by panelists were between 7.70 and 8.30 which corresponds to "like moderately" and "like very much" on the hedonic scale.

Panelists graded *wagashi* treated with African Nutmeg packaged with transparent nylon bag with a score of 7.40 whiles Vacuum Packaged *wagashi* treated with ginger extracts sample received the highest grading of 8.30. Subsequent days saw a steady decline in grading of samples. At the end of the study, the results showed that vacuum packaging and treatment with ginger and African Nutmeg extracts had a positive impact on the aftertaste of the *wagashi* samples. Panelists graded samples between 6.30 and 6.90 which corresponds to "like slightly" on the hedonic scale.

4.4.2.7 Sensory score for overall acceptability

Table 4.12: Sensory score for overall acceptability

SAMPLE NO. = 6	DAY 0	DAY 5	DAY 10	DAY 15
300	8.1	7.0	6.3	0
175	7.8	7.4	6.8	6.4
561	8.1	7.2	6.6	6.2
780	8.4	7.8	7.0	7.0
202	8.1	7.4	7.2	6.5
986	8.2	7.1	7.1	6.5

Key

300: *wagashi* packaged with transparent nylon bag

175: *wagashi* treated with ginger packaged with transparent nylon bag

561: *wagashi* treated with African Nutmeg packaged with transparent nylon bag

780: Vacuum Packaged *wagashi*

202: Vacuum Packaged *wagashi* treated with ginger

986: Vacuum Packaged *wagashi* treated with African Nutmeg

From Table 4.12, on day 0, samples graded by panelists were between 7.80 and 8.40 which corresponds to "like moderately" and "like very much" on the hedonic scale. Panelists graded *wagashi* treated with ginger extracts packaged with transparent nylon bag with a score of 7.80. However, Vacuum Packaged *wagashi* sample received the highest grading of 8.40. Subsequent days saw a steady decline in grading of samples. At the end of the study, the results showed that vacuum packaged *wagashi* was the most preferred sample with a 7.0 score which corresponds "like moderately" on the hedonic scale.

CHAPTER FIVE

DISCUSSION

5.0 Overview

This chapter discusses and evaluates the findings of the proximate composition, mineral composition, texture profile analysis and shelf life of *wagashi*, treated with ginger and African nutmeg extracts and sensory test.

5.1 What is the Physicochemical Composition of *wagashi* treated with Ginger and African Nutmeg Extracts?

The Proximate Composition of food comprises of proteins, moisture, ash, fat and carbohydrate. The present study investigated the proximate composition of *wagashi*, treated with ginger and African Nutmeg extracts.

5.1.1 Ash content

Ash content refers to the inorganic residues which remained after either ignition or complete oxidation of organic matter within the sample, and provides a summary of mineral content of the product (Nkwocha, Nworah, Okagu, Nwagwe, Uchendu, Paul-Onyia, & Obeta, 2018). The ash content of the control (*wagashi*) sample was 1.95% which was similar to that obtained by Okon and Ojimelukwe (2017), Arthur (2016) and Badmos et al. (2017) who found the ash content of wagashi to be 1.80%, 1.95% and 1.57% respectively. The ash content of the *wagashi* treated with ginger extracts sample was 1.85% which was slightly higher than that obtained by Oladipo and Jadesimi, 2012) who found the ash content of *wagashi* treated with ginger extracts to be 1.75%. The ash content of wagashi treated with African Nutmeg extracts sample was 2.50% which was observed to be the highest which corresponds to the ash content observed in African nutmeg seed studied by Nkwocha et al. (2018).

Nutritionally, ash helps in the metabolism of carbohydrate, fat and protein (Nkwocha et al., 2018). A high amount of ash implies high mineral contents. African Nutmeg is high in calcium, phosphorus, iron and potassium which would contribute to the high levels of ash.

5.1.2 Moisture content

Moisture content is the quantity of water contained within a food material. The moisture content was determined by measuring the mass of a food before and after the water was removed by evaporation. The moisture content of the control (*wagashi*) sample was 55.25%, which was similar to that obtained by Okon, and Ojimelukwe, (2017), Ajayi, Balogun, Oriowo-Olaleye and Faturoti (2018) and Badmos et al. (2017), who found the moisture content to be 54.75%, 55.32% and 56.87% respectively. The moisture content of *wagashi* treated with ginger extracts sample was 52.12%, which was lower than the moisture content obtained by Belewu et al. (2005), who found the moisture content to be 60.27%. The moisture content of the *wagashi* treated with African Nutmeg extracts sample was 50.75%. The control (*wagashi*) and *wagash*i treated with ginger extracts sample however possessed higher moisture contents than *wagashi* treated with African Nutmeg sample. Therefore, the low moisture content in *wagashi* treated with African Nutmeg extracts sample compared to other samples is an indication of the fact that it can be stored for a longer period of time without deterioration in quality as compared to the other samples because microbial activity may be reduced to a minimum as reported by (Onimawo, Esekheigbe & Okoh, 2019).

5.1.3 Crude protein content

Protein is required for body building and the repair of worn-out tissues. Crude protein of the sample was determined using the Kjeldahl method, which evaluates the total nitrogen content of the sample after it has been digested in sulphuric acid with a catalyst.

The protein content of the control (*wagashi*) sample was 20.18%, which was similar to that obtained by Adetunji and Chen (2011), who reported 20.78%. Crude protein content however obtained was higher than the value recorded by Arthur (2016), who found the protein content of the control (*wagashi*) sample to be 23.20%. Also, Dauda, Abiodun, Oyeyinka and Afolabi (2018), found the protein content of *wagashi* sourced from some selective towns in Nigeria to be in the range 19.80% - 22.20%. Therefore, the protein content of the control (*wagashi*) sample studied is in accordance with previous reports. The protein content of the *wagashi* treated with ginger extracts sample (20.67%), similar to that obtained by Oladipo and Jadesimi (2012), who found the protein content of *wagashi* treated with ginger extracts sample to be 20.88%. The protein content of the *wagashi* treated with African Nutmeg extracts sample was 22.49%. It is commonly known that any plant food that offers more than 12% of their caloric value from protein is measured to be a good source of protein (Onimawo, Esekheigbe & Okoh, 2019). This implies that *wagashi* is a good source of protein and a good indication that *wagashi* treated with African Nutmeg extracts contains a fairly high amount of protein as compared to the other samples.

5.1.4 Fat content

The fat content of the control (*wagashi*) sample was 3.55% which was similar to that obtained by Oladipo and Jadesimi (2012), who found the fat content of *wagashi* to be

3.02%. The fat content of the *wagashi* treated with ginger extracts sample was 2.18%, which was higher than that obtained by Oladipo and Jadesimi (2012), who found the fat content of *wagashi* treated with ginger extracts sample to be 1.25%. The fat content of the *wagashi* treated with African Nutmeg extracts sample was 1.96%. The high fat content of the control (*wagashi*) sample may potentially make it a good flavour retainer.

5.1.5 Carbohydrate

Carbohydrates were determined by difference and results recorded in grams (g). Onimawo et al. (2019) stated that, carbohydrate gives energy to the cells in the body. It is therefore essential for maintenance of the plasma glucose level and carbohydrate spares the body's protein from being used for energy.

The carbohydrates content of the control (*wagashi*) sample was 19.08%, which is comparable to that obtained by Ajayi, Balogun, Oriowo-Olaleye and Faturoti (2018) who found the carbohydrate content of *wagashi* to be 21.33%. The carbohydrates content of the *wagashi* treated with ginger extracts was 23.28% and the carbohydrates content of the *wagashi* treated with African Nutmeg extracts was 22.30%. Ogungbenle and Adu (2012), found the carbohydrate content of African Nutmeg to be 44.85%. This is an indication that African Nutmeg has a high carbohydrate content which resulted in the *wagashi* sample containing African Nutmeg to have the highest percentage of carbohydrate.

5.1.6 pH Content

The pH of the control (*wagashi*) sample was 6.27, which was comparable to that obtained by Adesokan (2009), Belewu et al. (2005), and Abiola, Adewumi, Oyawale, and Takunbe (2017), who found the pH of *wagashi* sample to be 6.07, 6.50 and 6.36

respectively. The pH content of the *wagashi* treated with ginger extracts sample was 6.67, which was comparable to that obtained by Adesokan (2009) and Belewu et al. (2005), who found the pH of *wagashi* treated with ginger extracts sample to be in the range of 6.35 – 6.45 and 6.10 respectively. The pH of the *wagashi* treated with African Nutmeg extracts sample was 6.61. *Wagashi* treated with ginger extracts sample recorded the highest pH value. Fresh cheeses have high pH which creates a suitable condition in the cheese for the growth of spoilage organisms like *Bacillus cereus*, yeast and moulds etc.

5.2 What is the Mineral Composition of *wagashi* treated with Ginger and African Nutmeg Extracts?

5.2.1 Potassium (K) content

The potassium content of the control (*wagashi*) sample was 115.75mg per 100g. The potassium content of the *wagashi* treated with ginger extracts sample was 122.10mg per 100g. The potassium content of the *wagashi* treated with African Nutmeg extracts sample was 112.30mg per 100g. Potassium is an important nutrient required for maintaining the normal cell function, acid and total body fluid volume, and electrolyte balance (World Health Organization, 2012). Comparatively, the *wagashi* treated with ginger sample had the highest potassium content. However, the difference between the *wagashi* sample and the *wagashi* treated with African Nutmeg sample was not much. WHO (2012) in a report stated that, decreased potassium intake has been linked to diseases such as cardiovascular and hypertension diseases, and proper consumption levels could be defensive against these diseases. These results were further supported by Ogbuewu et al. (2014) in a study stating that, low potassium ratio in diet is associated with elevated blood pressure. The WHO (2012), recommends a potassium consumption of a minimum of 90 mmol/day (3510 mg/day) for adults. This is an indication that the various *wagashi* samples have low potassium content.

5.2.2 Iron (Fe) content

The iron content of the control (*wagashi*) sample was 0.79mg per 100g. The iron content of the *wagashi* treated with ginger extracts sample was 1.51mg per 100g. The iron content of the *wagashi* treated with African Nutmeg extracts sample was 2.29mg per 100g. Iron has a lot of essential roles in the body. It aids in the transportation of oxygen to the tissues from the lungs by red blood cell haemoglobin, as a transport medium for electrons within cells, and as an integral part of vital enzyme systems in various tissues (FAO & WHO, 2001). Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (WHO, 2001) stated that daily consumption of Iron (Fe) intakes required for growth under the age of 18 years is within the range of 0.93-1.88mg whiles iron (Fe) intakes required for growth above the age of 18 years is within the range of 1.37- 2.94mg for males and females respectively. Furthermore, 1.13mg and 1.50mg are required for postmenopausal and lactating women respectively. These requirements is an indication that the *wagashi* samples are good sources of iron (Fe) especially *wagashi* treated with ginger extracts sample and *wagashi* treated with African Nutmeg extracts sample with *wagashi* treated with African Nutmeg extracts sample recording the highest iron (Fe) content.

5.2.3 Phosphorus (P)

The Phosphorus (P) content of the control (*wagashi*) sample was 302.00mg per 100g. The Phosphorus (P) content of the *wagashi* treated with ginger extracts sample was 144.00mg per 100g. The Phosphorus (P) content of the *wagashi* treated with African

Nutmeg extracts sample was 353.00mg per 100g. Madell (2020) reported that the recommended dietary allowance (RDA) of Phosphorus (P) is the following:

- Adults (ages 19years and older) - 700mg
- Children (ages 4 to 18years) - 1,250mg
- Children (ages 1-3years) - 460mg
- Infants (ages 0-6months) - 100mg

From the above data, the *wagashi* samples were fairly good sources of Phosphorus (P) with *wagashi* treated with African Nutmeg extracts sample having the highest content of phosphorus followed by the control (*wagashi*) sample. However, *wagashi* treated with ginger sample recorded the lowest content of Phosphorus (P). Phosphorus aids in keeping bones healthy and strong; helps the body make energy and move muscles.

5.2.4 Magnesium (Mg)

The Magnesium (Mg) content of the control (*wagashi*) sample was 35.94mg per 100g. The Magnesium (Mg) content of the *wagashi* treated with ginger extracts sample recorded the highest value of 63.61mg per 100g. The Magnesium (Mg) content of the *wagashi* treated with African Nutmeg extracts sample was 56.65mg per 100g. Magnesium serves as a co-factor of several enzymes involved in RNA and DNA synthesis, energy metabolism, protein synthesis, and maintenance of the electrical potential of cell membranes and nervous tissues (FAO & WHO, 2001). Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (2001) recommended nutrient intakes for magnesium (Mg) in milligrams (mg) required for growth from 0-9years is within the range of 26-100mg whiles Magnesium (Mg) intakes required for Adolescent's growth within the ages of the 10–18 years is within the range of 220 - 230mg. Magnesium (Mg) intakes required for Adult's growth within the ages of the 19–65 years is within the range of 220 - 260mg for females and males respectively Magnesium (Mg) intakes required for Adult's growth within the ages of the 65+ years is within the range of 190 - 224mg. These requirements are an indication that the *wagashi* samples were good sources of magnesium (Mg) for children 9years and below especially *wagashi* treated with ginger sample and *wagashi* treated with African Nutmeg extracts sample.

5.2.5 Calcium (Ca)

The Calcium (Ca) content of the control (*wagashi*) sample was 444.40mg per 100g. The Calcium (Ca) content of the *wagashi* treated with ginger extracts sample was 661.00mg. The Calcium (Ca) content of the *wagashi* treated with African Nutmeg extracts sample was 708.30mg. Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (2001), recommended nutrient intakes for Calcium (Ca) in milligrams (mg) intakes required for growth from 0-9years is within the range of 300 -700mg whiles Calcium (Ca) intakes required for Adolescent's growth within the ages of the 10–18 years is 1000mg for females and males. Calcium (Ca) intakes required for Adult's growth from 19years to menopause is 750mg and post menopause is 800mg for females and Calcium (Ca) intakes required for Adult's growth from 19 – 65years is 750mg and 65 + is 800mg for males. Calcium (Ca) intakes required for Pregnancy (last trimester) is 800mg and Lactation 750mg. These requirements are indications that the *wagashi* samples are good sources of calcium (Ca).

5.3 What is the Texture Profile of *wagashi* treated with Ginger and African Nutmeg Extracts?

Cheese texture is considered to be a determinant of the overall opinion and preference of the consumers (Zheng, Liu, & Mo, 2016).

The categories of Texture Profile Analysis are:

- Hardness – the initial force used to deform
- Cohesiveness – how the item holds itself together
- Springiness – the rate at which a deformed item reform
- Adhesiveness – rate at which a food item comes away from probe (instrumental) or roof of mouth/teeth (sensorial)
- Resilience – measurement of how a sample recovers again from deformation in relation to force and speed derived.
- Gumminess – energy required to break down a semisolid food until ready to swallow.
- Chewiness – energy needed to masticate a solid food until it is ready for swallowing.

Texture Profile Analysis (TPA) which includes the measurement of chewiness, gumminess, adhesiveness, springiness, cohesiveness, hardness and resilience was performed on *wagashi* samples at room temperature using a texture analyser TA-XT2 (Stable Micro Systems, Godalming, England). The results for the Texture Profile Analysis of *wagashi* samples (TPA) also showed that texture of the samples was hard, gummy and chewy because of the high values recorded. According to literature, protein content affects the texture of cheese. The hardness resulted from the high protein content in the 'wagashie' samples (Arthur, 2016).

5.3.1 Hardness

The control (*wagashi*) sample recorded the lowest score for hardness which was 3231.57. This was below the results obtained by Arthur (2016), who found the hardness of *wagashi* to be 4862. The *wagashi* treated with African Nutmeg extracts sample recorded the highest score for hardness followed by *wagashi* treated with ginger extracts sample with scores of 17594.92 and 12409.98 respectively. The control (*wagashi*) sample recorded the lowest score because the control (*wagashi*) sample had the highest moisture content. This can be explained that fresh curds usually present low hardness and this is in relation to their high moisture content (55–65%) and loose structure (Rachidatou et al., 2019).

5.3.2 Adhesiveness

Adhesiveness is known as the negative force area for the primary bite and signifies the work required to overcome the attractive forces between the surface of a food and the surface of other materials with which the food comes into contact (Chandra, & Shamasundar, 2014). It is the rate at which item comes away from probe (instrumental) or roof of mouth/teeth (organoleptic). The control sample recorded -19.66 for adhesiveness. The *wagashi* treated with ginger extracts sample recorded the maximum adhesive value of -24.53 whereas *wagashi* treated with African Nutmeg extracts sample recorded the minimum adhesive value of -8.54. The higher value of adhesiveness implies soft texture (Chandra, & Shamasundar, 2014). This is an indication that *wagashi* treated with ginger extracts sample has the softest texture compared to the other samples.

5.3.3 Springiness

The springiness is known as a textural variable which is linked to the elasticity of the sample. Springiness is therefore related to the height that the food recovers back during the period that elapses during the first bite and the start of the second bite (Chandra & Shamasundar, 2014). The control sample recorded 0.76 for springiness. The *wagashi* treated with ginger extracts sample recorded 0.82 for springiness and *wagashi* treated with African Nutmeg extracts sample recorded the highest value of

0.87 for springiness. If springiness is high, then it needs more chewing energy in the mouth (Chandra & Shamasundar, 2014).

5.3.4 Cohesiveness

Cohesiveness is the proportion of the positive force area during the second compression to that of the first compression. The cohesiveness shows the strength of the internal bonds that make up the body of the food and this is the degree to which a food can be deformed before it breaks (Chandra & Shamasundar, 2014). The control sample recorded a value of 0.40 cohesiveness whiles *wagashi* treated with ginger and African Nutmeg extracts samples recorded the same value of 0.42 for cohesiveness. Cohesiveness specifies the capability of how a food can hold together.

5.3.5 Gumminess

Gumminess is referred to as the product of hardness and cohesiveness. It is an attribute of semisolid food with a high degree of cohesiveness and a low degree of hardness (Chandra & Shamasundar, 2014). The control sample recorded a value of 1442 for gumminess. The *wagashi* treated with ginger extracts sample recorded a value of 5056 for gumminess. The *wagashi* treated with African Nutmeg extracts sample recorded the highest value of 7454 for gumminess. The *wagashi* treated with African Nutmeg extracts sample recorded the highest hardness value and also recorded the highest gumminess value which is in accordance with what Chandra and Shamasundar (2014) stated, that higher gumminess value arises from a higher hardness value. Gumminess is referred to as the measurement of energy needed to break down a semisolid food product until it is ready to gulp down.

5.3.6 Chewiness

Chewiness is referred to as the product of both gumminess and springiness, which is equivalent to the product of hardness x cohesiveness x springiness. Chewiness is very hard to measure accurately, this is because chewing comprises of crushing, tearing, penetrating, cutting, shearing and compressing along the sufficient lubrication by saliva at body temperature (Chandra & Shamasundar, 2014). The control sample recorded the highest value of 9886.28 for chewiness. The *wagashi* treated with ginger extracts sample recorded a value of 4145.23 for chewiness. The *wagashi* treated with African Nutmeg extracts sample recorded a value of 6526.98 for chewiness. Arthur (2016) reported during a study that Simões (2013) stated that chewiness value decreased with decrease within the concentration of added cow milk.

5.3.7 Resilience

Resilience is the measure of how a sample returns to formation both in terms of speed and force. Simply put, it is an elastic reformation of the food product (Chandra, & Shamasundar, 2014). The control sample recorded a value of 0.12 for resilience whiles *wagashi* treated with ginger and African Nutmeg extracts samples recorded the same value of 0.17 for resilience.

5.4 What is the Shelf-Life of *Wagashi* treated with Ginger and African Nutmeg Extracts?

In recent years, diverse measures have been stated for the establishment of shelf-life, mostly founded on the discovery of microbial alteration, as well as sensorial and physico-chemical changes (Valero, Carrasco & García-Gimeno, 2012). The various samples were divided into 10 pieces of 10g each and divided into two groups. One group was put into a food saver bag and sealed with a vacuum machine. The other group was inserted into nylon bags which were not vacuum packaged. This served as the control at each storage period. The shelf life of the *wagashi* samples was carried out for 15 days.

5.4.1 Microbiological analysis

During this study, yeast and moulds count were chosen as the variation factor determining the shelf-life of the *wagashi* samples. It was observed after the study that the control sample which was non- vacuum/ normal packaged (nylon bags) sample had undergone spoilage by the fifteenth (15^{th}) day. The spoilage was characterized mainly by discoloration, off odour, moisture exudation and mould growth as a result of gases produced by yeast and other spoilage organisms in the samples, and had gone rancid just as observed by Arthur (2016) in a study conducted.

5.4.1.1 Yeast and mould

It was observed that, the control sample stored in the nylon bag had the highest yeast and mould count throughout the storage period. Similarly, Badmos et al. (2018) during a study reported that, the control cheese had the highest yeast and mould count compared with the treated samples during the storage time. In general, the yeast and mould count were lower in the samples that were vacuum packaged as compared to the samples packaged in nylon bags. By the 15^{th} day, the control sample packaged in nylon bags developed a foul smell, moisture exudation and discoloration. The other samples did not show any signs of spoilage but yeast and mould enumeration increased. At the end of the microbiological test, all the samples with the exception of the wagashi sample packaged in a transparent nylon bag can be classified as safe and wholesome for consumption according to the FDA specification (Table 4.5 and Table 4.6)

5.4.2 Sensory evaluation

At the end of the sensory testing, it was observed that vacuum packaged *wagashi* sample (sample 780) had the highest rating in colour, mouthfeel and aftertaste. Interestingly, at the end of the sensory testing, vacuum packaged *wagashi* treated with ginger extracts (sample 202) had the highest rating for aroma and flavor. Nylon packaged *wagashi* treated with ginger extracts (sample 175) had the lowest rating. The most generally accepted sample was vacuum packaged *wagashi* sample (sample 780).

5.4.2.1 Colour

Colour is the primary focus of attraction for every product. Therefore, colour happens to be a very important sensory attribute during a sensory assessment test (Anaglih, 2015). Color can increase acceptability or rejection of a food. (Hartman, 2016). On day 0, the wagashi samples received satisfactory scores which ranged between 7.90 and 8.20, with Vacuum Packaged *wagashi* and Vacuum Packaged *wagashi* treated with ginger extracts samples recording the highest. These values represent "liked moderately" and "liked very much" on the hedonic scale respectively. Also, on day 5, all the samples received scores above the mid-point mark of 5 on the hedonic scale. Vacuum packaged *wagashi* sample rated the highest with a score of 7.90 and the lowest was *wagashi* packaged with transparent nylon bag with 6.10. These values represent "liked slightly" and "liked moderately" on the hedonic scale respectively. On day 10, Vacuum Packaged *wagashi* treated with ginger extracts sample rated the highest score of 7.30 and *wagashi* packaged with transparent nylon bag (control) sample received the lowest with 5.00. However, on day 15 *wagashi* packaged with transparent nylon bag (control) could not be evaluated because the product had deteriorated and unfit for consumption. However, on day 15 Vacuum Packaged *wagashi* sample received the highest rating of 6.60. *Wagashi* treated with African Nutmeg extracts packaged with transparent nylon bag and vacuum packaged *wagashi* treated with African Nutmeg extracts sample received the lowest rating of 6.30.

5.4.2.2 Aroma

Stimulation of taste buds in the mouth is caused by a pleasant aroma from food, making the system prepared to accept the food product whereas an unpleasant aroma may lead to an instantaneous rejection of food before tasted (Anaglih, 2015). On day 0, the most liked samples for sensory attribute 'aroma' were the *wagashi* treated with African Nutmeg packaged with transparent nylon bag and Vacuum Packaged *wagashi* treated with African Nutmeg with a score of 8.20. On day 5, scores ranged between 7.70 and 7.20 these scores may be interpreted as "like very much" on the 9-point hedonic scale. On day 10, the samples (Vacuum Packaged *wagashi* treated with ginger and Vacuum Packaged *wagashi*), recorded the highest rating score of 7.40 and 7.30 respectively. Due to deterioration of the *wagashi* packaged with Transparent nylon bag sample, no data was recorded on day 15 for *wagashi* packaged with Transparent nylon bag. Nonetheless, Vacuum Packaged *wagashi* treated with ginger received the highest ratings on day 15 with 6.40. *Wagashi* treated with African Nutmeg packaged with Transparent nylon bag was rated the lowest with 5.00 which represent 'neither like nor dislike' on the 9-point hedonic scale.

5.4.2.3 Flavour

Flavor is the combined senses of taste, aroma and mouthfeel (Choi, 2021). On day 0, the most liked sample for sensory attribute 'flavor' was the Vacuum Packaged *wagashi* with 8.50 ratings. It was observed that, on day 5, the samples (*wagashi* treated with African Nutmeg packaged with transparent nylon bag and Vacuum Packaged *wagashi* treated with African Nutmeg), recorded the lowest score of 7.30. Also, on day 10, the lowest scores recorded were *wagashi* packaged with transparent nylon bag and Vacuum Packaged *wagashi* with each scoring 7.00 and 7.10 respectively. Due to deterioration of the *wagashi* packaged with Transparent nylon bag sample, no data was recorded on day 15 for wagashi packaged with Transparent nylon bag sample. Even so, Vacuum Packaged *wagashi* treated with ginger received the highest ratings on day 15 with a score of 6.60 and *wagashi* treated with ginger packaged with transparent nylon bag received the lowest rating of 6.00. Both of which represents "liked slightly" on the hedonic scale.

5.4.2.4 Mouth feel

Mouth feel encompasses textural and chemical sensation such as astringency, spice heat, cooling and metallic flavor (Choi, 2021). On day 0, scores ranged between 7.40 and 8.10. *Wagashi* packaged with transparent nylon bag and Vacuum Packaged *wagashi* samples rated highest. On day 5, vacuum packaged wagashi samples received the highest rating of 7.80 and wagashi packaged with transparent nylon bag received the lowest score of 6.80. On day 10, Vacuum Packaged *wagashi* treated with ginger was rated the highest of 7.30 and *wagashi* packaged with transparent nylon bag the lowest with a score of 6.80. However, on day 15 *wagashi* packaged with Transparent nylon bag could not be evaluated because the product had deteriorated. Even so, on day 15 Vacuum Packaged *wagashi* sample received the highest rating of 6.90. *Wagashi* treated with ginger packaged with Transparent nylon bag and *wagashi* treated with African Nutmeg packaged with Transparent nylon bag received the lowest rating of 6.30 and 6.20 respectively.

5.4.2.5 Aftertaste

Aftertaste is caused by the remaining chemicals from food or drink that stick around on the gustatory cells on the tongue, back of the throat, epiglottis, and the upper esophagus (Siebenthal, 2014). On day 0, scores ranged between 7.70 and 8.30. Vacuum Packaged *wagashi* treated with ginger sample had the highest grading with a score of 8.30 and *wagashi* treated with African Orchid Nutmeg extracts packaged with transparent nylon bag sample received the least ratings 7.70. Nonetheless, both scores indicated an acceptance on the hedonic scale. On day 5, vacuum packaged *wagashi* samples received the highest rating with 7.70 and the lowest being *wagashi* packaged with transparent nylon bag with 6.90. On day 10, Vacuum Packaged *wagashi* was rated the highest with a score of 7.30 and *wagashi* packaged with transparent nylon bag the lowest with a score of 6.10. However, on day 15 *wagashi* packaged with Transparent nylon bag could not be evaluated because the product had deteriorated. Even so, on day 15 Vacuum Packaged *wagashi* sample received the highest rating of 7.30. *Wagashi* treated with ginger packaged with transparent nylon bag and *wagashi* treated with African Nutmeg packaged with transparent nylon bag received the lowest rating of 6.50 and 6.30 respectively.

5.4.2.6 Overall acceptability

The overall acceptability of a product or an item, contributes significantly to customers willingness to accept and patronize such product or item (Anaglih, 2015). For Overall acceptability, Vacuum Packaged *wagashi* samples was best preferred at 0 day with a score of 8.4 indicating "liked very much" on the hedonic scale. On day 5, vacuum packaged *wagashi* sample received the highest rating score of 7.80 and the lowest was *wagashi* packaged with transparent nylon bag with 7.00. On day 10, Vacuum Packaged *wagashi* treated with ginger extracts sample was rated the highest with a score of 7.20 and *wagashi* packaged with transparent nylon bag was the lowest with a score of 6.30. Further on 15th day of storage, these samples had shown deceasing trend in their overall acceptability However, *wagashi* packaged with transparent nylon bag could not be evaluated because the product had deteriorated. Even so, on day 15 Vacuum Packaged *wagashi* sample received the highest rating of 7.00. *Wagashi* treated with ginger packaged with transparent nylon bag and *wagashi* treated with African Nutmeg packaged with transparent nylon bag received the lowest rating of 6.40 and 6.20 respectively.

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

6.0 Overview

This chapter focuses on the summary, conclusions, recommendations and suggestions for further research of the research. It summarizes the entire research study, draws conclusions from the findings and makes possible recommendations. It also includes suggestions for further on research works on *wagashi*.

6.1 Summary of Findings

Wagashi, an important local dairy product has a very short shelf life. This hinders its storage for trade by consumers. One of the measures to enhance the shelf life of *wagashi* is the use of preservatives. Spices and herbs are commonly used for their medicinal, preservative and antioxidant properties. Among different natural herbs and spices, this study focused on utilizing ginger and African Nutmeg, which are powerful antimicrobial and antioxidant proven by various studies as a preservative in *wagashi*. This research studied the effects of treating *wagashi* with ginger and African Nutmeg extracts. The mineral and nutritional compositions, texture profile analysis, microbiology and sensory characteristics of all the *wagashi* samples were analyzed. *Wagashi* treated with African Nutmeg extracts sample had the highest ash and protein content, the control sample had the highest moisture and fat content and *wagashi* treated with ginger extracts sample had the highest carbohydrate content. *Wagashi* treated with ginger extracts sample had the highest potassium (K) and Magnesium (Mg) content. *Wagashi* treated with African Nutmeg extracts sample had the highest Iron (Fe), Phosphorus (P) and Calcium (Ca) content *Wagashi* treated with ginger extracts sample recorded the highest pH value. The *wagashi* treated with African Nutmeg extracts sample recorded the highest score for hardness. The *wagashi* treated with ginger extracts sample recorded the highest adhesive value. *Wagashi* treated with African Nutmeg extracts sample recorded the highest value for springiness. *Wagashi* treated with ginger and African Nutmeg extracts samples recorded the highest value for cohesiveness. The *wagashi* treated with African Nutmeg extracts sample recorded the highest gumminess value. The control sample recorded the highest value for chewiness. *Wagashi* treated with ginger and African Nutmeg extracts samples recorded the highest value for resilience. Though all six wagashi samples were generally accepted by the panelists, the vacuum packaged *wagashi* samples had the highest rating.

6.2 Conclusions

Wagashi treated with ginger and African Nutmeg extracts had improved physicochemical attributes. Results from the proximate and mineral analyses of *wagashi* containing ginger and African Nutmeg extracts indicated an increase in the protein, carbohydrate, fat and mineral composition content. Incorporation of ginger and African Nutmeg extracts reduced yeast and mould growth in the product. Furthermore, incorporation of ginger and African Nutmeg extracts into *wagashi* increased the shelf life of the product. Also, vacuum packaging technique adopted greatly influenced the results observed. The forgoing results led satisfactory to conclude that, incorporation of ginger and African Nutmeg extracts into *wagashi* will increase the nutritional and mineral content of the food product and provide consumers with the health benefits associated with these spices. Generally all samples were accepted. Based on the results from the sensory test it can be concluded that *wagashi* treated with ginger and African Nutmeg extracts could be a viable alternative to the control sample.

6.3 Recommendations

The consumption of the samples especially *wagashi* treated with Ginger and African Nutmeg extracts should be encouraged since they have the highest ash content which shows a higher mineral content, because the body uses minerals for many cellular actions.

From the results and discussion, the following recommendations were made:

- Producers of *wagashi* should consider producing *wagashi* with ginger and African Nutmeg extracts for their nutritional benefits.
- Also, on the whole, *wagashi* treated with Ginger and African Nutmeg extracts had reduced fat content in the product. It is therefore recommended as a healthier option for people trying to lose weight or reduce their fat intake.
- The results of this study show that, all the *wagashi* samples most especially *wagashi* treated with ginger and African Nutmeg extracts are good sources of calcium and it is therefore recommended for people of all ages to consume especially children and the elderly to build and maintain strong bones and teeth.
- The *wagashi* samples showed a good source of magnesium (Mg) especially *wagashi* treated with ginger and African Nutmeg extracts. It is therefore recommended for adults and children at 9years and below to help keep blood pressure normal, bones strong and the heart rhythm steady.
- It is recommended that *wagashi* could be vacuum packaged to reduce the risk of spoilage and contamination.

6.4 Suggestions for Further Research

From this work and its findings, the following suggestions were recommended for future studies for the production, evaluation and packaging of *Wagashi* treated with Ginger and African Nutmeg Extracts as a functional dairy food to improve *Wagashi* quality and to protect consumer health:

- This research focused only on the physicochemical, mineral, texture profile analysis, microbiological and sensory analysis of *wagashi* and *wagashi* treated with ginger and African Nutmeg extracts. It is therefore recommended that research should be carried out on the combination of ginger and African Nutmeg extracts at varied levels.
- This study focused only on detection and enumeration of yeast and mould. Further microbiological research should be done on the detection and enumeration of other microorganisms such as Aerobic mesophiles, *Bacillus cereus*, *E. coli*, *Enterobacteriaceae*, *Salmonella spp.*, Feacal coliforms, *Staphylococcus aureus* and *Enterococcus*.
- Free Fatty Acids (FFA) should be analyzed to ascertain the presence of both saturated and unsaturated fatty acids.
- Other common herbs and spices can be tested for their potential to act as preservatives in *wagashi.*
- Other packaging materials should be taken into consideration to find the most suitable packaging material to further extend the shelf-life of *wagashi* whiles maintaining its freshness and quality.

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APPENDICES

APPENDIX 1

Introductory Letter

HED/A13/VOL.3/180

January 15, 2020

The Head

Department of Nutrition and Food Science

University of Ghana-Legon

Accra

Dear Sir/Madam,

INTRODUCTORY LETTER

MS EL-FREDA KORKOR OGLI

We write to introduce, Ms. El-Freda Korkor Ogli, an MPhil student with the index number (8180100019) in the Department of Home Economics Education, University of Education, Winneba, who is conducting a research titled: **"Evaluation and Packaging of Wagashi treated with Ginger (*gingiber officinalis*) and African Nutmeg (*monodora myristica*) extracts as a Functional Dairy Food"**

We would be very grateful if you could give her the assistance required.

Thank you

Yours faithfully,

………………………..

PROF. PHYLLIS FOSTER

APPENDIX 2

Materials used in Product Preparation

Table I.1: Materials used in product preparation

S. N	MATERIAL USED	DETAILS
1	Cheese Cloth	
2	Refrigerator	
3	Colander	
4	Vacuum Sealer	
5	Food Saver Bag	
6	Transparent Nylon Bag	
7	Thermometer	
8	Kjeldahl digestion and distillation set	
9	Digital electronic balance	
10	Oven	
11	Muffle furnace	
12	pH meter	HANNA Instruments, model HI 9321, USA
13	Texture Analyser	TA-XT2 (Stable Micro Systems, Godalming, England)
14	Chopping board	
15	Stainless Steel Knife	
16	Table Top Burner	
17	Cooking pot	
18	Perforated Spoon	
19	Cheese Mould	
20	Beakers	
21	Watch Glass	
22	PerkinElmer Atomic Absorption Spectrophotometer	AAS; Model AAnalyst 400, Minneapolis, U.S.A.
23	Volumetric flask	
24	Whatman Filter Paper	
25	Fume chamber	
26	porcelain can	
27	Soxhlet extractor	
28	Pipettes and micropipettes	
29	Petri plates	
30	Hand cloves	

APPENDIX 3

Chemicals Used

Table 1.2: Chemicals Used

S, N	CHEMICALS USED	DETAILS
1	sulphuric acid	
2	Potassium Sulphate	
3	Copper Sulphate	
4	sodium hydroxide	
5	Boric acid	
6	Hydrochloric acid	
7	Ammonia	
8	petroleum ether	
9	Nitric acid	
10	Perchloric acid	
11	potato dextrose agar	

APPENDIX 4

Texture Profile Analysis

ATTRIBUTES	DEFINITION	INSTRUMENTAL
Hardness	the initial force used to deform	Force necessary to attain a given deformation
Adhesiveness	rate at which item comes away from probe (instrumental) or roof of mouth/teeth (organoleptic)	Work necessary to overcome the attractive forces between surface of the other materials with which the food comes in contact (tongue, teeth etc.).
Springiness	the rate at which a deforms item reforms	rate at which a deformed material was not goes back to its under formed condition after the deforming force is removed
Cohesiveness	how the item holds together	The strength of the internal bonds making up the body of the product.
Gumminess	energy required to disintegrate a semisolid food until ready to swallow	Energy required to disintegrate a semisolid food product to a state ready for swallowing. It is the product of hardness and cohesiveness.
Chewiness	energy required to chew a solid food until it is ready for swallowing	Energy required to masticate a solid food product to the state ready for swallowing. It Is related to the primary parameters of hardness, cohesiveness and springiness.
Resilience	it is an elastic recovery of the sample	Measurement of how a sample recovers from deformation in relation to speed and force derived.

APPENDIX 5

PLATES

Colander

Perforated spoon

Tablespoon & Teaspoon

Scale

Cheese cloth

Plastic bowl

Stainless Steel Knife

Chopping board

Table top burner

Cooking pot

Food Saver Bag

Vacuum Packaging Sealer

Thermometer

Vacuum packaged *Wagashi*

Vacuum packaged *Wagashi* treated with African Nutmeg

Vacuum packaged *Wagashi* treated with ginger extracts

Wagashi packaged with transparent nylon bag

Wagashi treated with ginger extracts packaged with transparent nylon bag

Wagashi treated with African Nutmeg packaged with transparent nylon bag

Cow Milk

Curd

Ginger Extracts

***Wagashi* cut into pieces**

Spoiled *wagashi* sample

African Nutmeg

***Wagashi* sample**

Calotropis procera

APPENDIX 6

Data of Texture Profile Analysis Results

Test ID	Batch		Force 1	Area-FT 1:2	Time-diff. 1:2	Area-FT 1:3	Area-FT 2:3	Area-FT 4:6	Time-diff. 4:5	Hardness	Fracturability	Adhesiveness	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
			g	g.sec	sec	g.sec	g.sec	g.sec	sec	g	g	g.sec					
			Force 1	Area F-T 1:2	Time Difference 1:2	Area F-T 1:3	Area F-T 2:3	Area F-T 4:6	Time Difference 4:5	Force 2	Force 3	Variable	J#/F#	I#/G#	K#*O#	P#*N#	H#/E#
Start Batch Wagashi	Wagashi																
Wagashi raw01	Wagashi		6781.02	25368	15.005	296363	4268.25	154104	12.94	8129.16		-5.412	0.862	0.52	4227.02	3645.3	0.168
Wagashi raw02	Wagashi		9493.94	362166	15.005	406528	4436.27	169409	12.275	693.085	12171.5	-9.187	0.818	0.417	288.823	236.275	0.122
Wagashi raw03	Wagashi		7349.98	331967	15.005	362722	3075.53	121848	9.775	354.135	9696.22	-24.726	0.651	0.336	118.963	77.498	0.093
Wagashi raw04	Wagashi		4954.55	332579	15.005	377916	4533.66	140065	10.99	6601.86		-23.027	0.732	0.371	2446.8	1792.1	0.136
Wagashi raw05	Wagashi		5687.76	235952	15.005	258837	2288.49	8791.77	11.005	379.629	7791.04	-35.927	0.733	0.34	128.947	94.572	0.097
Wagashi nutmeg01	Wagashi		121745	79923	15.005	90577	10654	27898	12.62	17033.9		-10.696	0.841	0.308	5246.51	4412.59	0.133
Wagashi nutmeg02	Wagashi		124837	555026	15.005	654275	9924.98	292945	13.015	16190.2		-9.39	0.867	0.448	7248.98	6287.61	0.179
Wagashi nutmeg03	Wagashi		162098	674834	15.005	800799	125964	374681	13.235	20253.8		-11.961	0.882	0.468	9476.41	8358.57	0.187
Wagashi nutmeg04	Wagashi		136026	639161	15.005	757184	118023	351522	13.48	16901.8		-2.107	0.898	0.464	7846.66	7049.18	0.185
Wagashi ginger01	Wagashi		4040.86	262325	15.005	316255	5393.02	147466	11.93	5484.98		-19.657	0.795	0.466	2557.59	2033.46	0.206
Wagashi ginger02	Wagashi		129102	689596	15.005	803658	114062	32972	12.23	17018.5		-30.644	0.815	0.41	6982.26	5690.98	0.165
Wagashi ginger03	Wagashi		9978.26	517797	15.005	593183	7538.6	222932	11.915	13374.2		-33.257	0.794	0.376	5026.36	3991.27	0.146
Wagashi ginger04	Wagashi		106614	486607	15.005	556249	6964.22	228823	12.895	13762.2		-14.555	0.859	0.411	5661.31	4865.22	0.143
End Batch Wagashi	Wagashi																
Average:	Wagashi (F)	AVERAGE("BATCH")	9717.58	472378	15.005	545365	7298.61	223109	12.177	10475.2	9886.25	-17.735	0.812	0.41	4404.36	3733.43	0.151
S.D.	Wagashi (F)	STDEV("BATCH")	3736.21	189555	0	223281	3595.56	9471.69	1.061	7188.41	2196.39	10.996	0.071	0.062	3107.04	2739.44	0.035
Coef. of Variation	Wagashi (F)	STDEV("BATCH") / AVERAGE("BATCH") * 100	38.448	40.128	0	40.942	49.264	42.453	8.713	68.623	22.217	-62.002	8.713	15.184	70.545	73.376	22.992
End of Test Data																	

APPENDIX 7

Data of Proximate Composition Results

sample ID	%Fat	%Ash	%protein	%moisture	%carbohydrate
Wagashi 1	3.57	2	19.62	55	19.81
Wagashi 2	3.52	1.892537	20.74563	55.5	18.34184
Ginger 1	2.13	1.5	20.04125	52.5	23.82875
Ginger 2	2.23	2	21.29188	51.74129	22.73683
Nutmeg 1	1.94	2.5	22.13563	51.5	21.92438
Nutmeg 2	1.98	2.5	22.83813	50	22.68188

APPENDIX 8

Data of Mineral Composition Results

sample ID	potassium mg/100g	iron mg/100g	phosphorous mg/100g	magnesium mg/100g	calcium mg/100g
Wagashi 1	111.3	0.79	302	35.94	449.4
Wagashi 2	120.2	0.79	302	35.94	439.4
	0	0	0	0	0
Ginger 1	122.1	1.51	144	63.61	661
Ginger 2	122.1	1.51	144	63.61	661
	0	0	0	0	0
Nutmeg 1	112.3	2.29	353	56.65	708.3
Nutmeg 2	112.3	2.29	353	56.65	708.3

APPENDIX 9

Data for PH Results

Sample Name	PH
wagashi 1	6.3
wagashi 2	6.24
Africa Nutmeg 1	6.62
Africa Nutmeg 2	6.59
Ginger 1	6.61
Ginger 2	6.7

APPENDIX 10

ANOVA (Minerals Composition)

Minerals		Sum of Squares	Df	Mean Square	F	Sig.
iron mg/100g	Between Groups	2.236	3	.745	.	.
	Within Groups	.000	2	.000		
	Total	2.236	5			
phosphorous mg/100g	Between Groups	57029.842	3	19009.947	38019894667.718	.000
	Within Groups	.000	2	.000		
	Total	57029.842	5			
magnesium mg/100g	Between Groups	828.650	3	276.217	.	.
	Within Groups	.000	2	.000		
	Total	828.650	5			
calcium mg/100g	Between Groups	75904.904	3	25301.635	101206538139.231	.000
	Within Groups	.000	2	.000		
	Total	75904.904	5			

APPENDIX 11

ANOVA (Proximate Composition)

		Sum of Squares	Df	Mean Square	F	Sig.
%Fat	Between Groups	2.950	3	.983	339.136	.003
	Within Groups	.006	2	.003		
	Total	2.956	5			
%Ash	Between Groups	.612	3	.204	3.263	.243
	Within Groups	.125	2	.063		
	Total	.737	5			
%protein	Between Groups	6.554	3	2.185	4.258	.196
	Within Groups	1.026	2	.513		
	Total	7.581	5			
%moisture	Between Groups	21.407	3	7.136	10.093	.091
	Within Groups	1.414	2	.707		
	Total	22.821	5			
%carbohydrate	Between Groups	20.477	3	6.826	15.463	.061
	Within Groups	.883	2	.441		
	Total	21.360	5			

APPENDIX 12

Descriptive Statistics

Sample		**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Variance**
Proximate	%Fat	6	1.94	3.57	2.5617	.76893	.591
	%Ash	6	1.50	2.50	2.0650	.38386	.147
	%protein	6	19.62	22.84	21.1133	1.23132	1.516
	%moisture	6	50.00	55.50	52.7067	2.13640	4.564
	%carbohydrate	6	18.34	23.83	21.5533	2.06688	4.272

Mean = averages
S. deviation= How near it is to analyse
Variance= variation that exist between the two variables (difference)

APPENDIX 13

Descriptive Statistics

Sample		N	Minimum	Maximum	Mean	Std. Deviation	Variance
Minerals	potassium mg/100g	6	111.30	122.10	116.7167	5.26210	27.690
	iron mg/100g	6	.79	2.29	1.5317	.66880	.447
	phosphorous mg/100g	6	144.00	353.00	240.0005	106.79873	11405.968
	magnesium mg/100g	6	35.94	63.61	52.0667	12.87361	165.730
	calcium mg/100g	6	449.40	708.00	606.1337	123.21112	15180.981

Mean = averages

S. deviation= How near it is to analyse

Variance= variation that exist between the two variables (difference)

Appendix 14

Descriptive Statistics

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
iron mg/100 g	Wagashi 1	1	.7900	.	.	.	.	.79	.79
	Nutmeg 1	2	2.2900	.00000	.00000	2.2900	2.2900	2.29	2.29
	Wagashi 2	1	.8000	.	.	.	.	.80	.80
	Ginger 1	2	1.5100	.00000	.00000	1.5100	1.5100	1.51	1.51
	Total	6	1.5317	.66880	.27304	.8298	2.2335	.79	2.29
phosphorous mg/100 g	Wagashi 1	1	302.0000	.	.	.	.	302.00	302.00
	Nutmeg 1	2	353.0005	.00071	.00050	352.9941	353.0069	353.00	353.00
	Wagashi 2	1	144.0010	.	.	.	.	144.00	144.00
	Ginger 1	2	144.0005	.00071	.00050	143.9941	144.0069	144.00	144.00
	Total	6	240.0005	106.79873	43.60040	127.9221	352.0789	144.00	353.00
magnesium mg/100 g	Wagashi 1	1	35.9400	.	.	.	.	35.94	35.94
	Nutmeg 1	2	56.6500	.00000	.00000	56.6500	56.6500	56.65	56.65
	Wagashi 2	1	35.9400	.	.	.	.	35.94	35.94
	Ginger 1	2	63.6100	.00000	.00000	63.6100	63.6100	63.61	63.61
	Total	6	52.0667	12.87361	5.25563	38.5566	65.5767	35.94	63.61
calcium mg/100 g	Wagashi 1	1	449.4000	.	.	.	.	449.40	449.40
	Nutmeg 1	2	708.0005	.00071	.00050	707.9941	708.0069	708.00	708.00
	Wagashi 2	1	449.4010	.	.	.	.	449.40	449.40
	Ginger 1	2	661.0000	.00000	.00000	661.0000	661.0000	661.00	661.00
	Total	6	606.1337	123.21112	50.30073	476.8315	735.4358	449.40	708.00

%Fat	Wagashi 1	1	3.5700	.	.	.	.	3.57	3.57
	Nutmeg 1	2	1.9600	.02828	.02000	1.7059	2.2141	1.94	1.98
	Wagashi 2	1	3.5200	.	.	.	.	3.52	3.52
	Ginger 1	2	2.1800	.07071	.05000	1.5447	2.8153	2.13	2.23
	Total	6	2.5617	.76893	.31392	1.7547	3.3686	1.94	3.57
%Ash	Wagashi 1	1	2.0000	.	.	.	.	2.00	2.00
	Nutmeg 1	2	2.5000	.00000	.00000	2.5000	2.5000	2.50	2.50
	Wagashi 2	1	1.8900	.	.	.	.	1.89	1.89
	Ginger 1	2	1.7500	.35355	.25000	-1.4266	4.9266	1.50	2.00
	Total	6	2.0650	.38386	.15671	1.6622	2.4678	1.50	2.50
%protein	Wagashi 1	1	19.6200	.	.	.	.	19.62	19.62
	Nutmeg 1	2	22.4900	.49497	.35000	18.0428	26.9372	22.14	22.84
	Wagashi 2	1	20.7500	.	.	.	.	20.75	20.75
	Ginger 1	2	20.6650	.88388	.62500	12.7236	28.6064	20.04	21.29
	Total	6	21.1133	1.23132	.50268	19.8211	22.4055	19.62	22.84
%moisture	Wagashi 1	1	55.0000	.	.	.	.	55.00	55.00
	Nutmeg 1	2	50.7501	1.06073	.75005	41.2198	60.2803	50.00	51.50
	Wagashi 2	1	55.5000	.	.	.	.	55.50	55.50
	Ginger 1	2	52.1200	.53740	.38000	47.2916	56.9484	51.74	52.50
	Total	6	52.7067	2.13640	.87218	50.4647	54.9487	50.00	55.50
%carbohydrate	Wagashi 1	1	19.8100	.	.	.	.	19.81	19.81
	Nutmeg 1	2	22.3000	.53740	.38000	17.4716	27.1284	21.92	22.68
	Wagashi 2	1	18.3400	.	.	.	.	18.34	18.34
	Ginger 1	2	23.2850	.77075	.54500	16.3601	30.2099	22.74	23.83
	Total	6	21.5533	2.06688	.84380	19.3843	23.7224	18.34	23.83

Mean = averages
s. deviation= How near it is to analyse
Variance= variation that exist between the two variables (difference)

APPENDIX 15

Descriptive

Sample		**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Variance**
Wagashi pH	pH	6	6.24	6.70	6.5100	.19058	.036
	Valid N (listwise)	6					

APPENDIX 16

Sensory Evaluation

NAME ……………..…………………………………… DATE ……………………….

INSTRUCTIONS

You are provided with coded samples. Before you start the analysis, take a slice of cucumber to cleanse your mouth. Take a sample, indicate its code in the column and assess the colour, aroma, flavour, mouth feel, after taste and overall acceptability.

Using the 9-points hedonic scale below indicate your perception for each parameter.

1- Dislike extremely
2- Dislike very much
3- Dislike moderately
4- Dislike slightly
5- Neither like nor dislike
6- Like slightly
7- Like moderately
8- Like very much
9- Like extremely

Sample Code	Colour	Aroma	Flavour	Mouth Feel	After Taste	Overall Acceptability
300						
175						
561						
780						
202						
986						

COLOR

MEAN ± STANDARD DEVIATION

sample ID	day 0	day 5	day 10	day 15
300	8.10±0.32	7.10±0.99	5.00±0.96	S
175	8.00±0.67	7.20±1.03	6.20±0.79	6.40±0.70
561	7.90±0.74	7.10±0.99	6.60±1.08	6.30±0.82
780	8.20±0.42	7.90±0.74	7.20±0.79	6.60±0.70
202	8.20±0.63	7.70±0.95	7.30±0.68	6.50±0.85
986	8.10±0.74	7.50±0.85	7.10±0.99	6.30±1.06

AROMA

MEAN ± STANDARD DEVIATION

sample ID	day 0	day 5	day 10	day 15
300	8.00±0.82	7.20±1.03	6.20±1.23	S
175	7.40±0.84	7.30±0.95	6.90±0.99	6.00±0.70
561	8.20±0.79	7.30±0.95	6.60±1.08	5.00±0.97
780	8.10±0.88	7.70±0.68	7.30±0.68	6.10±0.99
202	7.60±0.84	7.50±0.97	7.40±0.97	6.40±1.08
986	8.20±0.79	7.60±0.84	7.20±0.78	6.20±1.33

FLAVOR

**MEAN ± STANDARD DEVIATION **

sample ID	day 0	day 5	day 10	day 15
300	8.30±0.68	7.00±1.25	6.40±1.08	
175	8.00±1.05	7.40±0.97	7.10±1.10	6.00±0.94
561	8.10±0.57	7.30±1.25	6.70±1.25	6.10±1.37
780	8.50±0.53	7.50±0.85	7.10±0.88	6.20±1.23
202	8.10±0.99	7.60±0.97	7.20±0.68	6.60±1.17
986	8.30±0.68	7.30±0.95	7.20±0.92	6.20±1.14

MOUTHFEEL

MEAN ± STANDARD DEVIATION

sample ID	day 0	day 5	day 10	day 15
300	8.10±0.57	6.80±1.23	6.30±1.25	S
175	7.4±0.84	7.50±1.09	6.70±1.25	6.30±1.06
561	7.80±0.79	7.50±1.18	6.50±1.51	6.20±1.14
780	8.10±0.32	7.80±0.92	6.90±0.99	6.90±1.29
202	7.70±0.82	7.70±0.95	7.30±0.68	6.60±1.08
986	8.00±0.82	7.60±0.97	7.00±0.94	6.40±1.17

AFTERTASTE

MEAN ± STANDARD DEVIATION

sample ID	day 0	day 5	day 10	day 15
300	8.10±0.57	6.90±0.99	6.10±1.28	s
175	8.10±0.88	7.60±0.97	6.80±1.03	6.30±0.95
561	7.70±0.48	7.50±1.08	6.50±1.08	6.50±0.85
780	7.80±0.92	7.70±0.83	7.30±0.68	6.90±1.15
202	8.30±0.68	7.60±0.84	7.10±0.88	6.70±0.88
986	8.00±0.67	7.50±1.08	7.00±1.16	6.30±1.34

OVERALL ACCEPTABILITY

MEAN ± STANDARD DEVIATION

sample ID	day 0	day 5	day 10	day 15
300	8.10±0.57	7.00±0.67	6.30±1.05	S
175	7.80±0.79	7.40±0.84	6.80±1.03	6.40±0.97
561	8.10±0.57	7.20±1.14	6.60±1.27	6.20±0.79
780	8.40±0.52	7.80±0.79	7.00±0.82	7.00±1.05
202	8.10±0.74	7.40±0.84	7.20±0.92	6.50±0.97
986	8.20±0.63	7.10±0.88	7.10±0.99	6.50±1.08