# SENSORY EVALUATION OF WEST AFRICAN CHEESE COATED WITH BLACK PEPPER AND GREEN PEPPER

**BY**

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## CERTIFICATION

The is to certify that this project has been read and approved as meeting the requirement of the Department of Agricultural Technology, Institute of Applied Sciences, Kwara State Polytechnic, Ilorin for the award of National Diploma in Agricultural technology.

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## DEDICATION

This project is dedicated to Almighty God, Who granted me the wisdom, moral knowledge and understanding and Who made it possible for me to embark on and complete this project work.

**ACKNOWLEDGEMENT**

I Thank Almighty God for sparing my life to this moment and for bestowing on me grace, all honour, praise and adoration to the Almighty God.

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I give great and undiluted appreciation to my parents for their support; morally, spiritually and financially, and all those who had in one way or the other assisted me and see me through this programme.

I will like to congratulate and thank the entire student of agricultural technology department, Kwara state polytechnic Ilorin, and that i will miss you all.

*ABSRACT*

*The experiment was carried out to evaluate the sensory properties of west African cheese prepared using different pepper: black and green pepper, The cheese was prepared conventionally using fresh bovine milk and without sweeteners, flavour or colourant. Seven (7) treatments N, G1, G2, G3, B1. B2 and B3, with 0%, 10%, 20% and 30% green or black respectively, each with three replicates. The result shows that B3 cheese with 30% black pepper addition had better taste, aroma, texture and overall acceptance and comparing favourably with the control N cheese and better than other treatment. The B3 cheese with 30% black pepper addition was therefore recommended*.

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# CHAPTER ONE

## 1.0.INTRODUCTION

### 1.1.INTRODUCTION

Among animal-based food products, dairy items (e.g., milk, cheese, yoghurt) are an important category of globally consumed foods (Adesogan & Dahl, 2020). Consequently, numerous development efforts are underway to provide suitable PB alternatives for traditional dairy products. Unfortunately, many fail to provide equivalent nutrition to their animal-based counterparts, often having lower protein, fat, calcium, vitamins and other micronutrients (Adamczyk et al., 2022). In addition, many of these products fail to meet consumers' sensory or quality expectations (Jaeger et al., 2023). As such, many PB dairy alternative products currently under development or already in the marketplace do not garner the necessary market share to help consumers make dietary changes. Milk still remain the most complete food and nutrient source for human and living things alike (Adesogan & Dahl, 2020).

Milk contains not less than 8.25 % of milk solid nonfat and not less than 3.25 % of milk fat. Since it contains high amount of nutrient thus microorganisms can grow easily in raw milk. Cheese can be considered as an aged old form of food preservation due to exclusion of whey and maturing process during manufacturing. Processed cheese is a product obtained by heat melting and mixing of natural cheese with suitable coagulants. Processed cheese is made by further processing of natural cheese usually with different aromas and degrees of maturity. Processed cheese can be categorized in to two types known as cheese blocks with a firm consistency, high acidity, relative low moisture content and cheese spreads with a soft consistency, low acidity, high moisture content but various flavoring can be added (Rifky et al., 2018). It contains 30% or 45% fat, counted on total solids. Cheese for processing is of the same quality as cheese for direct consumption and cheese with defects regarding surface, color, texture, size and shape as well cheese with a limited shelf life can also be used for processing.

Incorporation of spice like pepper to the cheese spread is having more that taste variation among consumers. it contains high amount of moisture results high water activity. It induces the growth of micro flora especially mold and bacteria which are mostly associated with food spoilage (Fox, 2000). So it has high chance of deterioration under favorable condition.

Phytogenic are plant base, which when ingested or locally applied in appropriate quantity confer one or more specific demonstrated health benefits (Kamaly et al., 2018). Phytogenic shows antagonistic and antioxidant effects towards some pathogens, reduce the risk of spoilage, diarrhea, enhance digestive environment, enhance immune functions, reduce cholesterol level, synthesis several vitamins and reduce lactose intolerance (Kamaly et al., 2018). Because of these potential roles and many more there has been a growing interest in the use of probiotics as preservative and flavouring in the dairy industries (Adesogan & Dahl, 2020). The efficacy of added phytogenic depends on dosage level. Their viability must be maintained throughout the product shelf life and must enhance product consumers' acceptance.

Spices and the likes have been used as flavouring and preservatives in dairy environment, Menthe sp,. Allium sp., Thymus sp., Chaerophyllum sp., Capsicum annum and Capsicum frutescens are most favorite flavour and preservatives used (Kamaly et al., 2018). Aside from their health benefits, they have established themselves in certain numbers in the gastrointestinal tract beneficial roles (Kamaly et al., 2018).

## 1.2.Objectives

### Main aim of the study

To evaluate the sensory efficacy of black pepper and green pepper in West African cheese.

### Specific objectives

i. To determine the sensory properties of West African cheese prepared using varying levels of black pepper.

ii. To determine the sensory properties of West African cheese prepared using varying levels of green pepper.

## 1.3.Justification

Spices such as *Capsicum annum and Capsicum frutescens* and the likes have been used favourably in milk industries as flavouring and preservatives. Belonging to the same group of spices are black pepper and green pepper, with the potential to proffer greater flavouring and consumer preference. Thus there is a need to develop a local processed cheese spread with high higher sensory qualities using varying levels of black pepper and green pepper.

# CHAPTER TWO

## 2.0.LITERATURE REVIEW

### **2.1.**CHEESE

Cheese production is a process dating back several thousands of years, and cheese, which is found in every part of the world, has found its place on the top of the foodstuffs chart thanks to its nutritional value and rich diversity. The earliest indication of a cheese making process is in cave paintings around 5000 BC, representing the oldest technological application of enzymes (Harboe et al., 2010). This application has made possible the intentional conversion of milk into cheese, making it safer and longer-lasting. Since its beginning, the technology of cheese production has changed, thanks to tech nological and scientific advancements in its materials and production process. Currently, cheese production is very high-level, thanks to modern materials and incorporated technol ogy. Cheese quality is affected by the genotypic and phenotypic characteristics of animals, the chemical and microbiological properties of milk, and production technology (Fox et al., 2017). An important factor in the diversity of milk from the same breed comes from dairy cultures and the type of rennet used in cheese production, because they affect chemical processes during production and ripening. Currently, cheese quality is still affected by the same factors, but due to globalization and industrial advancements, originality and dissimilarities within certain regions have been lost. Large-scale cheese production is mainly based on the usage of pasteurized milk and cheesemakers are supplied by a few worldwide producers of dairy cultures and rennet. Whenconsidering the same type of cheese production (i.e., hard cheese), this means that differences between producers are based solely on the quality of milk and the selection of rennet and dairy cultures. The characteristics of milk affecting cheese quality are regulated by animal genetics, which creates the possibility of using quantitative genetics to preserve biodiversity and indigenous traits. Raw milk and cheeses from raw, unpasteurized milk present rich sources of beneficial microbes, such as lactic acid bacteria (LAB) with probiotic properties (Cipolat et al., 2018). The isolation of indigenous LAB cultures and their use in cheese production can result in the preservation of biodiversity and better diversification between cheese producers globally and regionally. Microencapsulation is seen as a novel approach to the preservation of biodiversity and to delivering important ingredients into cheese, although it should be borne in mind that the successful encapsulation of payload relevant to cheese production, such as microorgan isms, enzymes, peptides, aromatic compounds, chemical agents (Ca2+), and even essential oils, can be extremely challenging. Furthermore, combinations of more than one active ingredient can make the process of encapsulation even more complex (Cipolat et al., 2018). Considering that little research on this topic has been undertaken, this paper aims to investigate current progress in DNA characterization and the use of quantitative genetics for improving desired traits in dairy animals, rennet production, and analysis, the isolation and production of lactic acid bacteria, and the possible applications of microencapsulation in the development of new, innovative, and sustainable technologies in cheese production, with an emphasis on indigenous forms and the preservation of biodiversity (Bergamoschi et al., 2016).

Cheese is a nutritious and versatile dairy food manufactured from buffalo, cow, goat, and sheep milk. It is estimated that more than 500 distinct cheese varieties are currently produced worldwide. Cheese-makers strive to maintain consistent and uniform raw material quality in cheese production. Yield, flavour, texture and appearance of fresh cheese is influenced by many factors such as milk composition, seasonal and dietary variations in milk consistency (Fox, 2004). Therefore, raw milk collection, addition of coagulating enzymes, coagulum formation and curd formation are among the key steps involved in making fresh cheese. The curd can be utilized to produce different types of cheeses. The safety and quality of semi-hard cheeses as well as hard cheeses depend on how they are preserved. Several approaches are available for meeting this goal. For example, traditional methods like cooling can be used to make cheese last longer while maintaining its taste (Karoui et al., 2006). Another crucial aspect is controlling the growth of microorganisms because they have the ability to affect the standard and safety of cheeses. The aim of conservation methods is to decrease the development of spoilage organisms and kill the hazardous ones at the same time not interfering with lactic acid bacteria which give the cheese its final properties. Moreover, the use of lactic acid bacteria (LAB) probiotics to modulate intestinal bacteria symbiosis may serve to enhance cheese fermentation and safety (Shalkos et al., 2023). Moreover, the environment should also be considered when choosing food preservation techniques along the supply chain to ensure the quality and safety of hard and semi-hard cheeses it is necessary to critically evaluate methods of preservation. During their manufacturing sensory properties should also be preserved besides extending the shelf life of the said cheeses. To achieve this, appropriate preservation techniques must be employed. Storage and maturation processes can compromise the safety and quality of cheeses through various ways including microbial growth, enzymatic reactions and oxidation. The primary objective behind pres ervation is to inhibit degradation reactions, kill disease-causing organisms and check the activities of spoilage microorganisms. In order to keep semi-hard and firm cheeses fresh, a number of methods like preservatives, temperature manipulation and packaging can be used (Najera et al., 2021). To ensure that cheeses remain safe to eat, procedures have been put in place to maintain their flavor, texture and appearance. Moreover, sustainable preservation methods used elongate shelf life hence reduce the amount of cheese disposed along the food chain (Shalkos et al., 2023). In the domain of hard and semi-hard cheeses, this article attempts to comprehend and expound the many different techniques and their corresponding technologies that are utilized to ensure their quality as well as safety. This study also looked at traditional preservation methods but focused more on current or modern ways which can be applied at the time of storage and marketing. The safety, shelf life, and sensory properties pertaining these foods vis-`a-vis preservation techniques were also investigated. Moreover, it considers how environment friendly such technologies may be and their contribution towards sustainable food systems. In general, the goal is to enhance the quality and safety of hard and semi-hard cheeses by providing a comprehensive comprehension of the various approaches and their advantages and disadvantages (Najera et al., 2021).

### 2.2.Classification of cheese

Bovine, ewe, goat, or water buffalo milk, starter cultures, coagulant (either rennet or acid), and salt are the main components in a wide variety of cheeses, the number of which can reach approximately 1500 (Sachan and Karnwal, 2022). Various efforts have been attempted to categorize different types of cheese into relevant groupings or families, to aid researchers, retailers, and cheese technologists in their studies and assisting consumers in making informed choices (Allaisy et al., 2023). The classification criteria encompass dairy species, coagulating agent (rennet or acid), texture/moisture content, maturity level (matured or fresh), and microbiota (internal bacterial, surface/smear bacterial, internal or surface mold, propionic acid bacterium). The classification of cheeses in traditional schemes mostly relies on their rheological qualities, which are directly linked to the moisture content. Cheeses are categorized as extremely hard, hard, semi-hard, semi-soft, or soft depending on these properties (Allaisy et al., 2023). Despite being commonly used for classification, this approach has significant limitations as it combines cheeses with distinct qualities and manufacturing methods. Cheddar, Parmigiano Reggiano, Grana Padano, and Emmental are commonly classified as hard cheeses. However, despite this classification, they possess distinct characteristics and are produced using distinct processes. Efforts have been undertaken to enhance the specificity of this system by incorporating variables such as the source of the cheese milk, coagulation process, coagulum cutting, curd scalding, whey drainage, salting method, and molding technique (Almena and Mietton, 2014). In addition in their 1972 study, Walter and Hargrove proposed a classification system for cheeses based on their manufacturing technique. They identified a total of 18 unique forms of natural cheese, which they further categorized into eight families: very hard, hard, semisoft, and soft. Ottogalli, 2001 categorized cheeses into three primary categories: Lacticinia (resembling milk), Formatica (having a specific shape), and Miscellanea (many types). The Lacticinia category comprises products made from milk, cream, whey, or buttermilk through the process of coagulation using acid (lactic or citric), with or without the application of heat. A little quantity of rennet is frequently employed to enhance the solidity of the resulting coagulum, such as in the case of Quarg and cottage cheese. The Lacticinia category consists of seven families, encompassing a variety of products that range from yogurt-like items to whey-based products such as Ricotta. The Formatica category encompasses a wide range of cheese types, all of which undergo coagulation with the use of rennet. This is a diverse assortment of varieties, categorized into five classes primarily based on their moisture content: very hard, hard, semi hard, semisoft, and soft. Additionally, the classification takes into account the degree and manner in which the varieties ripen, including internal ripening caused by bacteria, surface ripening caused by white mold, internal ripening caused by blue mold, and surface ripening caused by bacterial smear. The Miscellanea group comprises a diverse assortment of cheeses, including processed, smoked, grated, and pickled variations. It also encompasses cheeses that incorporate non-dairy elements such as fruit, vegetables, and spices, as well as cheese analogues and cheeses produced utilizing ultrafiltration technology (Ottogalli, 2001). McSweeney et al. (2004) and Fox et al. (2017) introduced an intricate categorization system that relies on the subsequent criteria.

1. Dairy animal species include cows, sheep, goats, and water buffalo.

2. Coagulant: enzymatic (rennet), isoelectric (acid), and acid-heat.

3. Texture (moisture content): extremely firm, firm, moderately firm, moderately soft, and soft.

4. Ripening agents can be categorized into four types: internal-bacterial, surface mold, internal mold, and surface bacterial smear.

5. Eyes/Openings: There are several enormous eyes, a few little eyes, and irregular openings.

**2.3. Types of hard and semi-hard cheeses**

Definition and characteristics

1. Hard and semi-hard which have different features and methods of production. Hard cheeses are like Cheddar. They ripen for 45 days or more with moisture content not exceeding 51 %. Also, they can be cooked at high temperatures and undergo processes such as cheddaring, milling and pressing. Mahon-Menorca or Appenzeller are examples of semi-hard cheeses that mature within 2–8 months while their moisture varies between 49% and 56 %. Curd washing might be applied to them; also cutting into small grains and then acidifying using starter cultures during the process may happen (Mordivinova et al., 2023). Some semi-hard varieties acquire complex microflora on their surfaces as well as being smear-ripened during maturation.
2. Popular varieties Parmigiano Reggiano, Emmentaler, Gouda, Cheddar, Graviera Kritis, Idiazabal, Manchego, Raclette, and Tete de Moine are popular hard, semi-hard cheeses and soft cheese. The flavors, textures, and features of these cheeses are unique. Hard Parmigiano reggiano has a granular texture and a deep, nutty flavor. Swiss cheese Emmentaler has big pores and a mild, nutty flavor. Gouda is a creamy, mellow, buttery semi-hard cheese. Sharp, acidic cheddar is a popular hard cheese. Greek semi-hard cheese Graviera Kritis tastes sweet and nutty. Spanish semi-hard cheese Idiazabal tastes buttery and smokey. Spanish sheep's milk hard cheese Manchego has a deep, nutty flavor. Raclette is a creamy, flavorful Swiss semi-hard cheese that melts well. Tete de Moine, a cylindrical Swiss semi-hard cheese, tastes delicate and nutty (Zabeleta et al., 2016).

### 3.4. Preservation of cheese

**Key factors influencing quality and safety preservation**

The top factors that affect the maintenance and safety of hard and semi-hard cheese are milk quality, cheese-making techniques, conditions for ripening and Storage. The kind of milk utilized in making cheese has a great impact on its composition and microbiological features. To ensure that the cheese has no faults and has the right moisture content and pH levels, all procedures used in making cheese such as curd acidification and draining must be checked carefully (Zabeleta et al., 2016).

Protein decomposition and the creation of different tastes during cheese aging are brought about by biochemical changes. These changes are affected by how ripe the cheese is, alongside the temperature and moisture. Appropriate storage methods such as keeping them in the refrigerator and using packaging that prevents oxidation and microbial growth are essential for maintaining the quality and safety of hard as well as semi-hard cheeses. Usually, the excellence and safety of hard or semi hard cheeses largely depend on the close attention paid to milk quality, accurate processing methods, suitable ripening conditions and storage practices (Fasco et al., 2010).

**Quality preservation techniques**

Traditional methods have been used to store firm and semi-firm cheeses but these can destroy the quality and safety of matured products meant for wider consumption. With the increase in demand for cheese with longer shelf lives among more people who prefer eating it, technology has become the main solution when it comes to these two issues. In fact, other techniques have been developed for preserving food items for longer periods such as high hydrostatic pressures, chemical and natural preservatives from plants, vacuum or modified atmosphere packaging, edible coatings and films among others besides these some storage and marketing technologies can be used at later stages like irradiation or light pulses (Allai et al., 2023). Every cheese type requires a specific way of preservation and ideal conditions of usage for ensuring its quality and safety during storage. These techniques also affect on the environment and food chain sustainability. Every kind of cheese requires a different way of preserving and the right kind of conditions to apply during storage to keep it good and safe for consumption. These methods have advantages and disadvantages when utilized in large scale dairy processing plants. In certain places, the agriculture and food industry depends on traditional cheese making methods where raw milk is used plus its native microorganisms that give rise to the unique flavors found in hard and semi-hard cheeses (Pasta et al., 2019).

1. **Aging and maturation**

Aging and maturation hold a very vital position when it comes to the preservation of hard and semi-hard cheeses through traditional methods. It is necessary to carry out preservation research to expand their shelf life because these kinds of cheeses have a long life and therefore can be spoiled due to ripening. To develop its distinct flavor, texture and smell cheese undergoes certain changes in microbiological, biochemical and physicochemical aspects while it matures. These changes are facilitated by starter microflora protease enzymes and milk coagulant enzymes. For ripening cheese needs 15–90 days, depending on the kind Table 1 summarizes ripening times and reasons for different cheese types. Optimum conditions for enzyme function are achieved by controlling the temperature and humidity levels during ripening the cheese's moisture, active acidity, and salt level are further checked throughout storage to maintain organoleptic qualities traditional methods enhancing the aging of firm and semi-firm cheeses (Tulyaganovich et al., 2022).

2. **Salting techniques**

One of the oldest tricks to preserving hard or semi-hard cheese is by using salt. To extend the life of cheese, salt is utilized to inhibit the growth of bacteria that cause it to spoil and also enhances its flavor as well as texture. This is because the salinity draws out moisture while breaking down proteins into simpler compounds which gives cheeses their characteristic taste. Traditional methods for preserving hard and semi-hard cheeses include salting. Different salting methods alter cheese's physio-chemical, sensory, and volatile constituents during ripening. Salting is done during curd processing in conventional hard and semi-hard cheese manufacture. The cheese is brined or rubbed with dried salt. Cheese absorbs salt based on brine concentration, curd wetness, and surface area. Salting reduces moisture, promotes helpful bacteria, and inhibits bad bacteria. Salting helps generate the appropriate flavor profile and extends cheese shelf life. Cheese flavor and quality depend on processing technologies and microbial community structure during manufacture and ripening. Sodium chloride affects taste, aroma, texture, pH, water activity, and microbiological development in cheese manufacture and ripening, making salt reduction difficult. Any salting method alteration may disrupt this delicate equilibrium, affecting cheese quality (Tidona et al., 2022).

### 2.5. Impact of preservation techniques on flavor and texture

The flavor and texture of hard and semi-hard cheeses are affected by preservation techniques. Low temperature freezing can maintain the sensory attributes of the cheese; however, it is essential to use packaging materials that will prevent the cheese from freezing injuries. To improve the shelf life of cheese, its sensory and quality attributes could be retained by using high hydrostatic pressure (HHP) processing during storage. While excessive $CO_2$ and $N_2$ can influence taste compounds, MAP using gas blends like $CO_2$ will hinder bacteria development and maintain cheese quality. Vacuum packaging may also be implemented to preserve cheeses; however, it may induce modifications in flavor and texture. In general, the best way to decide how to store food for future use is to think about three things: how long you want it to last before you eat it; what it should smell, taste, or look like when you do eat (Gim et al., 2012).

### 2.6.Control of undesirable microorganisms

Cheeses are vulnerable to spoilage by diverse microorganisms throughout their aging and storage phases. In order to avoid decay, a range of preservation methods are utilized, such as high-pressure processing, the application of antifungal additives, and the regulation of microbial proliferation by employing elevated levels of $CO_2$ . Rod-shaped bacteria exhibit greater sensitivity compared to cocci, while endospores demonstrate exceptional resistance to high-pressure processing treatments. Antifungal additives, such as sorbates, benzoates (Fente-Sampayo et al., 1995), and natamycin (Martin and Roman, 2017), are commonly employed in cheese production to prevent fungal contamination. The microbiota of cheese can be categorized into two groups: primary starter cultures, consisting of lactic acid bacteria (LAB) that initiate fermentation, and secondary microbiota, which encompasses non-starter lactic acid bacteria (LAB), yeasts, and molds (Martin and Roman, 2017). Stringent control over anaerobic microorganisms is essential to prevent spoiling the taste of cheese by giving out compounds that affect it negatively. Microbial lipases and proteases when available can lead to formation of unwanted flavors and smells thus affecting quality of cheese generally. The presence of anaerobic microorganisms is checked strictly in order to stop them from producing volatile compounds that could affect the taste of cheese (Martin and Roman, 2017).

Below, methods to control un desirable microorganisms are discussed.

**a. High-pressure processing (HHP)**

For hard and semi-hard cheeses, high-pressure processing, or HPP, is a technique used to manage unwanted microbes. HHP treatments can reduce spoilage microorganisms and eliminate pathogens without affecting the lactic bacteria responsible for the final characteristics of the cheese (Numez et al., 2020). However, rod-shaped bacteria are more sensitive than cocci, and endospores are highly resistant to HHP treatments, particularly Clostridium spp. In the case of a 600 MPa treatment applied to cheese at 30 and 50 ripening days, no sensory and proteolytic changes were observed, whereas spoilage microorganisms experienced a greater reduction. Reduction in the microbial count of Enterobacteriaceae, Listeria innocua, molds, and yeasts in raw milk ewe's cheeses treated with high pressure. HHP treatments can be used to control microbial growth and prevent spoilage during cheese production. During HHP treatment, the product is subjected for a short time (10–20 min) to a very high pressure level (400–600 MPa is normally used at the industrial scale) and a temperature below 45 ◦ C. Based on the isostatic principle, pressure applied in HHP treatments is transmitted instantaneously and uniformly throughout food, regardless of size, shape, and composition. It has been documented that pressures exceeding 500 MPa result in a decrease in proteolysis, which prevents the excessive ripening of fresh, soft, and semi-hard cheeses (Calzada et al. 2014). Additionally, it slows down chemical and enzymatic reactions that occur during refrigerated storage, both at retail locations and at home. HHP can inhibit the growth of microorganisms during storage.

**b. Antifungal additives**

Cheeses frequently experience fungal spoilage, resulting in substantial financial losses for the dairy sector. Antifungals are used as surface treatments; however, there may be issues regarding the contamination of cheese with toxins and the resulting health risks. On the other hand, we have antifungal additives, like natamycin, which are frequently employed to inhibit fungal contamination in the manufacturing and preservation of hard and semi-hard cheeses. Natamycin has demonstrated efficacy as an antifungal preservative in a range of food items, such as cheeses, yoghurt, sausages, and juices (Meena et al., 2021). Research has demonstrated that the safety of Mozzarella cheese can be improved by suppressing the proliferation of undesirable microorganisms through the incorporation of natamycin into hydroxyethylcellulose films. Furthermore, natamycin when used in food wrapping films helps maintain the quality of soft cheese by controlling molds and yeasts that may be present in it. Therefore, antifungals like natamycin are essential for preventing fungal contamination and preserving hard and semi-hard cheeses. Cheese is usually preserved using an antifungal called natamycin. This is produced by the bacteria Streptomyces natalensis and S. chattanoogensis, which prevents the growth of small fungi (Meena et al., 2021).

c. Antibacterial additives

Antibacterial additives are used in hard and semi-hard cheeses to prevent the growth of undesirable microorganisms and ensure food safety. These additives can be added during ripening and storage as antifungal and antibacterial agents to avoid problems in ripened cheeses. Some of the regulated additives approved for use in ripened cheeses include lisozyme, sorbic acid/sorbates, nisin, hexamethylene tetramine (HTM), nitrates/nitrites, and propionic acid/propionates, used natural based Essential oil and herbs. These additives play a crucial role in ensuring the safety and quality of hard and semi-hard cheeses by controlling the growth of undesirable microorganisms, however, Lysozyme is a naturally occurring enzyme that is found in large quantities in egg whites and is commonly extracted for industrial purposes. Due to its natural origin, this enzyme has garnered significant attention as a preservative in the food industry. It exhibits bactericidal properties against Gram-positive bacteria, including LAB and clostridia, and to a lesser degree against Gram-negative bacteria. Therefore, its utilization in industry is restricted and This enzyme has been employed to mitigate the occurrence of the "late blowing" defect in hard and semi-hard cheeses due to its efficacy in breaking down the vegetative cells of C. tyrobutyricum and C. perfringens (Meena et al., 2021).

**d. Salt content**

The salt content is essential for inhibiting the proliferation of undesirable microorganisms in hard and semi-hard cheeses. Salt is a significant barrier to bacteria growth in cheese, effectively inhibiting their development and ensuring the safety and quality of the end product. Cheeses which have a moisture content of between 49 % and 56 % are termed as hard cheeses whereas the ones that contain 54%–69 % of moisture fall under the semi-hard category. Certain types of cheese are aged due to bacteria that grow on them. These cheeses have low moisture content, so they age slowly. Using packaging materials with low gas permeability can create an anaerobic environment, which enhances their safety and extends their shelf-life. In addition, salt serves the dual purpose of enhancing the taste of the cheese and facilitating the removal of whey by regulating its expulsion and causing the curds to contract, thus impeding or stopping the proliferation of bacterial cultures. Hence, it is crucial to maintain an optimal salt content to inhibit the proliferation of unwanted microorganisms and guarantee the safety and quality of hard and semi-hard cheeses. Salt is essential for cheese safety and quality. Salt alone does not prevent pathogenic bacteria from growing, but it does when combined with other factors (Gheorghita et al., 2020).

**e. Storage temperature**

In order to inhibit the proliferation of undesirable microorganisms in semi-hard cheeses, it is crucial to uphold suitable storage temperatures. Utilizing low-temperature methods for processing and storing cheese can extend its preservation time, potentially reaching or exceeding one year. This has advantages for both the financial viability of the dairy industry and the environment. Sub-zero temperatures can impede the proliferation of microorganisms, thereby promoting the development of healthier aged cheeses. However, to prevent frostbite, it is imperative to employ appropriate packaging using impermeable materials like plastics. Storing cheese at room temperature can expedite the ripening process, whereas refrigeration inhibits the growth and activity of lactic acid bacteria (LAB) and other microorganisms. Cheddar-type cheeses are typically cured or aged at temperatures as high as 15.6 ◦ while Swiss cheese is held at a temperature range of 22.2–23.3 ◦ C, C for 4–8 weeks to develop its distinctive characteristics. Nevertheless, elevated storage temperatures beyond refrigeration can trigger alterations in the composition of volatile compounds and impact the overall quality of the cheese. The optimal storage temperature for cheese varies depending on the type. However, for semi-hard cheeses such as Cheddar or Gouda, a temperature of approximately 10 ◦ C (50 ◦ F) is generally recommended (Andic et al., 2010).

**f. Packaging**

Cheeses are prone to microbial contamination due to their favorable acidity conditions and high-water activity [196]. The majority of studies on cheese storage and shelf-life focus on issues arising from microbial contamination. Moreover, the absence of a packaging barrier in certain types of cheeses can lead to significant moisture loss, which can contribute to increased hardness and undesirable sensory characteristics. Effective packaging is widely recognized as a highly beneficial method for preventing the chemical, physical, biochemical, and microbiological degradation of cheese. It also extends the cheese's shelf life and enhances its overall quality. These requirements could be fulfilled by synthetic packaging films. Nevertheless, the non-biodegradability of synthetic films has sparked significant environmental concerns. Additionally, consumer demand for safe food products and extended shelf life has led to increased focus on bio-nanocomposite films. Biopolymeric films exhibit lower tensile strength compared to conventional plastic films, but their elongation-at-break values are similar to those of typical plastic coatings. In addition, certain bio polymeric coatings and films possess excellent oxygen barrier properties, with their water vapor permeability being generally higher than that of conventional plastic films, excluding lipid-based edible films (Chong et al., 2019).

## 2.7. Addition of Antioxidant and Antimicrobial Plant-Based Substances in Cheese

Increased consumer demand for natural foods and longer product shelf-life has led to the investigation of alternatives to replace synthetic preservatives with safe natural products. Since ancient times, plants have traditionally been used as natural flavorings and preservatives, and in cheese have often been included in the form of dried plants, extracts, aqueous solutions, or essential oils (EOs). They can be applied during cheese making as ingredients or on the cheese surface to prevent mold growth. In this regard, significant attention has been directed to plant-based products as sources of antioxidants and antimicrobials for dairy products, although bioavailability, health benefits, toxicity at high concentrations, and sensory aspects must be taken into account (Nikoo et al., 2018).

**Pomegranate rind (Punica granatum)** presents antioxidant activity (AA) due to the presence of phenolic compounds that reduce lipid oxidation. Low-fat Kalari cheeses were dipped for 30 s in aqueous solutions of rind pomegranate extracts with concentrations of 1 and 2%(w/w). Cheeses were drained and stored at refrigeration temperatures (1–4 C) for 28 days in polyethylene bags. Texture, flavor, and overall palatability scores were significantly higher for cheeses dipped with pomegranate rind extracts in comparison with control samples (Mahajan et al., 2015).

**Pine needles (Cedrus deodara (Roxb.) Loud.)** contain bioactive phytochemical compounds, phenolic compounds, and acids with AA, and antimicrobial properties. These extracts were used in the same Kalari cheese model. Aqueous concentra tions of 2.5 and 5% of pine needle dry powder were applied by immersion to freshly made cheeses. For both concentrations, a significant decrease in oxidative lipid deterioration and microorganism growth was detected in the cheeses dipped with pine needle extracts. Appearance, texture, flavor, and overall acceptability scores were higher in dipped than in control cheeses (Mahajan et al., 2016).

**Catechins** are a group of flavonoid antioxidants found in many plants and fruits with AA, but these compounds become unstable after a long storage period. Three batches of cheeses made from pasteurized skimmed milk (0.1% fat) containing 125, 250, and 500 ppm of catechins were evaluated for AA. Catechins were added dissolved in 10% polyethylene glycol (PEG) (w/v).

Two control batches were made: with no addition of catechin and PEGtomilk, andwithout catechin but with PEGaddedtomilk. Total phenolic content in cheeses increased during the ripening period, mainly in those made with the higher content of catechin (Mahajan et al., 2015).

**Dried rosemary (Rosmarinus officinalis L.)** shows antibacterial and AA due to its high content of rosmarinic and caffeic acids, in addition to phenolic compounds and flavones. Semi-hard cheeses made with raw and pasteurized cow's milk were coated with lard in a proportion of 3% (w/w) and dehydrated rosemary at 4% (w/w) after 15 ripening days. There were no significant differences in physicochemical parameters after 60 ripening days (fat, ash, acidity, and protein content), but only rosemary-coated cheeses showed a higher moisture content than uncoated control cheeses due to lard protection. Proteolysis activity was also higher in coated cheeses. No internal color differences were observed between control and rosemary coated cheeses, but the external color of coated cheese presented a more greenish tendency, particularly in pasteurized cheeses. The best sensory panel scores were recorded for the raw milk cheeses coated with rosemary due to a mild aroma and spicy flavor (Marinho et al., 2015).

**Chestnut flowers (Castanea sativa Mill.) and lemon balm (Melissa officinalis L.)** may have a potential role as antioxidants and antimicrobials in foods, and in promoting consumer health. Cheeses after 1 and 6 ripening months were manually impregnated with milled dried plants and decoctions of both species. The dose applied to each cheese of chestnut f lower was 799 and 248 mg of dried flower and lyophilized decoction, respectively. In the case of lemon balm, each cheese was coated with 368 and 380 mg of dried flower and lyophilized decoction, respectively. No plants were added to the control cheeses. The results showed a higher loss of moisture in cheeses with plants incorporated than in control cheeses (Marinho et al., 2015).

**Basil (Ocimum basilicum L.),** both as dehydrated leaves (1.37 g) and as decoctions (352.5 mg). After six months of storage, cheeses with basil lost more water, especially those treated with decoctions. A better maintenance of proteins in treated cheeses was observed, which may be related to the increased antimicrobial activity caused by basil components inhibiting the growth of proteolytic bacteria. The color did not change in the cheeses treated with basil decoctions, but those treated with dried leaves showed a greener appearance (Marinho et al., 2015).

**Oregano (Origamun vulgare)** the plant is rich in phenolic compounds (mainly carvacrol and thymol) with antimicrobial and antioxidant activity. The antimicrobial effectiveness of different concentrations of oregano EOs (50, 100, 150, 200 mg/kg curd) was studied in pressed cheeses made with pasteurized cow's milk. Similarly, cheeses made with oregano leaves (10 g/kg cheese) and control cheeses made without oregano were compared. After 30 ripening days at 12 C,nonegative effect on the growth and metabolism of LAB was observed in oregano cheeses. Spoilage microorganisms, such as enterobacteria, molds, and yeasts were not detected during ripening in EO cheeses, compared to control cheeses and cheeses with oregano leaves. The sensory characteristics (flavor and texture) of cheeses made with 200 g/goforegano EOweresimilar to those of cheese samples made with oregano leaves, whereas the control cheese obtained lower sensory scores (Marcial et al., 2016).

# CHAPTER THREE

## 3.0.MATERIALS AND METHODS

### 3.1.Study Area

The experiment was carried out at the Teaching and Research Farm, Department of Agricultural Technology Institute of Applied Sciences, Kwara State Polytechnic, Ilorin, Ilorin Kwara State Nigeria.

### 3.2.Selection of Study Materials

The milk used for the study was freshly collected from dairy cattle early morning the experiment was to be conducted, the cattle was hand milked into a clean and sterilized stainless bucket, turned into an air tight container and kept securely before processing.

The black pepper and green pepper used for the experiment were purchased freshly in the morning of the experiment from a vegetable market within Ilorin metropolis. The peppers were properly rinsed and kept in an air tight polyethylene bag for further use.

### 3.3.Preparation of Pepper

One hundred grams each of black pepper and green pepper were macerated with 20ml of water separately using mortar and pestle, the macerated products were kept separately.

### 3.4.Preparation of Cheese

The fresh early morning milk was transfer into a metal pot, place the pot containing the milk over a slow burning fire and heat to a temperature of $50^0$C for about 30 minutes. The milk was stirred gently during initial and subsequent heating. Digital thermometer was used to determine the temperature. *Calotropis procera* juice extract was added to the warmed milk (about eight medium-sized leaves of C. procera was finely macerated, plus 100 ml water, the extract sieved and add to the warm milk). After about 5 minutes the sieved leaves juice extract was added to the already warm milk and stir. The milk was heat slowly with intermittent stirring until it reaches boiling point. The milk was kept at boiling point until coagulation of curds and separation of whey occur, then remove the pot from fire. The curd and whey was poured into muslin cloth placed over a container for whey collection and to give a firm texture. The cheese was cut into small sizes.

### 3.5.Experimental Trial

Seven experimental trials were set up to include one control, three different levels of black pepper spices and three levels of green pepper spices.

Treatment 1: The control treatment = cheese without spices

Treatment 2: = cheese with 10 g black pepper

Treatment 3: = cheese with 20 g black pepper

Treatment 4: = cheese with 30 g black pepper

Treatment 5: = cheese with 10 g green pepper

Treatment 6: = cheese with 20 g green pepper

Treatment 7: = cheese with 30 g green pepper

### 3.6.Preparation of Cheese with Spices

Treatment 2, 3, 4, 5, 6 and 7 were place in separate polyethylene bag, respective quantity of black or green pepper was added respectively into the polyethylene bag containing the cheese and air-tight. They were placed in boiling water at 100 $^0$C and cooked for 10 minutes, removed and cooled down to room temperature before sensory evaluation.

### 3.7.Sensory Evaluation

Seven different treatments were prepared as described in section 3.5 above and evaluated for quality attributes such as physical appearance, taste, aroma, texture, sound and overall acceptance using a sensory analysis chart questionnaire designed to contained Disagree (DA), neutral (N) and Agree (AG). Ten untrained panelists were used for the sensory evaluation. The panelists were made to taste the treatment cheese and record their perception in the hedonic scale.

### 3.8.Statistical Analysis

The result was collected in triplicates and the mean of the data was subjected to central tendency.

## CHAPTER FOUR

## 4.0.RESULT AND DISCUSSION

### 4.1.RESULT

**Table 1; the result of sensory properties of cheese treated with green or black pepper.**

| | N | G1 | G2 | G3 | B1 | B2 | B3 |
|---|---|---|---|---|---|---|---|
| Physical properties | 3 | 2 | 2 | 2 | 2 | 3 | 2 |
| Taste | 3 | 3 | 2 | 2 | 2 | 2 | 3 |
| Aroma | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| Texture | 3 | 2 | 2 | 2 | 2 | 3 | 3 |
| Sound | 2 | 3 | 2 | 2 | 2 | 2 | 2 |
| Overall acceptance | 3 | 3 | 2 | 2 | 2 | 2 | 3 |

The result of sensory properties of cheese treated with green or black pepper is shown in table 1, above. N, G1, G2, G3, B1, B2 and B3 represent neutral, 10% green pepper, 20% green pepper, 30% green pepper, 10 % black pepper, 20% black pepper and 30% black pepper respectively. While the treatment N contained no black nor green pepper. The result was analyzed on three likert scale 1=DA (disagree), 2= N (neutral) and 3= AG (agree).

### 4.2.DISCUSSION

The result of sensory properties of cheese prepared using two different pepper spices: the green pepper (G), and black pepper (B) as shown in table 1 above revealed that the physical properties of cheese was better enhanced in the neutral and the B2 cheese. The taste of the cheese was better perceived by the taste panelist in the neutral cheese, and the cheese G1 and B3. The panelist agreed that the aroma and texture in the cheese B2 and B3 were better than other treatments. The overall acceptance of all the cheese prepared were agreed to be better in the cheese N, B1 and B3. Rahimi et al. (2020) reported that the physicochemical analyses of black peppery cheese compared to the control sample indicated that the peppery cheese had lower changes in pH, dry matter content and enhanced texture. **Sachan** et al. (2022) reveals spice addition had positive effects on chemical, biochemical and sensory characteristics of white cheese, and thus, white cheese with spice addition is an alternative novel product with a good potential.

# CHAPTER FIVE

# 5.0.CONCLUSION AND RECOMMENDATION

## 5.1. CONCLUSION

The result of the effect of black or green pepper addition on sensory evaluation of cheese revealed that, B3 cheese with 30% black pepper addition had better taste, aroma, texture and overall acceptance comparing favourably with the control N cheese and better than other treatment. The B2 cheese with 20% black pepper addition had good physical properties, aroma and texture, thus ranking next to B3 cheese.

## **5.2.** RECOMMENDATION

- The B3 cheese with 30% black pepper addition, having better enhancement on taste, aroma, texture and overall acceptance compared to control N cheese was therefore recommended.
- Further research to test the chemical, nutritional changes and microbial effect of black and/or green pepper is important for the quality assurance.

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