

**SENSORY EVALUATION OF WEST AFRICA CHEESE COATED
WITH BLACK PEPPER (PIPER PEPPER)AND GREEN PEPPER
(BELL PEPPER) CAPSICUM SPP**

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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.

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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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ABSTRACT

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 change

s. 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.

nce (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 phytochemicals 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, *Mentha 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 sa

me 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 technological and scientific advancements in its materials and production process. Currently, cheese production is very high-level, thanks to modern materials and incorporated technology. 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. When considering 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, u

Unpasteurized milk presents 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 microorganisms, enzymes, peptides, aromatic compounds, chemical agents (Ca^{2+}), 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 preservation 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 compre

hend 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-à-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 Kamwal, 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

d 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 br

ought 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, an

d 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 CO₂ and N₂ can influence taste compounds, MAP using gas blends like CO₂ 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 CO₂. 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 undesirable microorganisms are discussed.

a. High-pressure processing (HPP)

For hard and semi-hard cheeses, high-pressure processing, or HPP, is a technique used to manage unwanted microbes. HPP 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 HPP 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. HPP treatments can be used to control microbial growth and prevent spoilage during cheese production. During HPP 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*, wh

ich 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 lysozyme, 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 % ar