EFFECT OF SALT CONCENTRATION AND TEMPERATURE ON MOZZARELLA CHEESE AND CHEDDAR CHEESE TEXTURE

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DECLARATION

I hereby declare that the work embodied in here is the result of my own research except for the excerpt as cited in the reference and has not been submitted for a higher degree to any other University or Institution.

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Effect of Salt Concentration and Temperature on Mozzarella Cheese and Cheddar Cheese Texture

ABSTRACT

Cheese is a product made from ruminant milk such as cows, goats, sheep, and buffalo. Cheese is assumed to have existed from 8000 to 10,000 years ago in the Middle East. As time changes, the cheese manufacturers are affected by the demand from consumers. Nowadays, there are more than 1800 reported cheese variations in the world. The difference in the variation comes from the different salting processes, storage temperatures, and aging. The utilization of salt and temperature affect the cheese-making process of creating different cheese textures in terms of physical, sensory, and chemical properties. However, there is a lack of information on the effect of salt and temperature on the physical quality of cheese among small, local cheesemakers and manufacturers, especially those from rural areas. The objectives of this study are (1) to determine the effect of salt concentration on the physical properties of mozzarella cheese and cheddar cheese, and (2) to identify the effect of temperature on the physical properties of mozzarella and cheddar cheese. Two types of cheese were used in the study, mozzarella, and cheddar cheese. The cheese weighed 200g was cut into four strips and brined in three different salt concentrations: 10%, 20%, and 25% for 4 hours. The cheese was also vacuum-packed and kept at two different temperatures: 10^{o}C and -10^{o}C. Three days of trial were set: Day 5, Day 10, and Day 15. Two types of tests are done to determine the effect of the salt concentration and temperature. A compression test was done to determine the hardness of the cheese. A beam bending test was done to determine the cohesiveness and the ability of the cheese to resist the load. Results showed that the length of the compressed cheese was long in 10% salt brine solution at a temperature of -10^{o}C and short in 25% salt brine solution at 10^{o}C. The weight used in the beam bending test was higher in a 25% salt brine solution at 10^{o}C and lower in a 10% salt brine solution at -10^{o}C. It indicates that the higher the salt concentration and temperature used in the cheese-making process, the firmer and harder the cheese texture produced for both mozzarella and cheddar cheese.

Keywords: Salt, temperature, mozzarella cheese, cheddar cheese

Kesan Penggunaan Garam dan Suhu Terhadap Tekstur Keju Mozzarella dan Keju Cheddar

ABSTRAK

Keju adalah produk dihasilkan dari susu ruminan seperti lembu, kambing, berbiri dan kerbau. Dianggarkan, keju telah wujud sejak 8000 ke 10,000 ribu tahun lalu di Timur Tengah. Selaras peredara mas, pengusaha keju bertambah oleh kerana permintaan yang tinggi dari pengguna. Kini, 1800 jenis keju telah dilaporkan wujud di dunia. Perbezaan di antara keju-keju ini disebabkan oleh proses pengasinan, suhu simpanan dan proses penuaan. Penggunaan garam dan suhu memberi kesan terhadap proses pembuatan keju dalam menghasilkan pelbagai variasi tekstur keju dari segi fizikal,deria dan sifat kimia. Namun, terdapat kekurangan infomasi mengenai kesan penggunaan garam dan suhu terhadap kualiti fizikal keju di kalangan pembuat keju kecil-kecilan dari tempatan, terutama yang berada di kawasan pedalaman. Objektif kajian ini adalah (1) untuk mengkaji kesan penggunaan kepekatan garam terhadap sifat fizikal keju mozzarella dan keju cheddar, dan (2) untuk mengkaji kesan penggunaan kepekatan garam terhadap sifat fizikal keju mozzarella dan keju cheddar. Dua jenis keju telah digunakan di dalam kajian ini: mozzarela dan cheddar. Keju seberat 200g telah dipotong menjadi empat jalur dan direndam di dalam 3 jenis larutan garam: 10%, 20% dan 25% selama 4 jam. Kemudian, keju-keju telah dibungkus secara vakuum dan disimpan di dalam dua suhu yang berbeza: 10^{o}C dan -10^{o}C. Tiga hari telah ditetapkan sebagai hari pengujian: Hari 5, Hari 10 dan Hari 15. Dua jenis ujian telah dijalankan untuk mengkaji kesan penggunaan kepekatan garam dan suhu. Ujian mampatan telah dilakukan untuk menilai kekerasan keju. Ujian kelenturan telah dilakukan untuk menilai kesepaduan dan kebolehan keju menahan beban. Keputusan kajian menunjukkan bahawa nilai mampatan keju yang tinggi dapat dilihat daripada keju yang diasinkan di dalam 10% larutan garam pada suhu -10^{o}C manakala keju yang diasinkan di dalam 25% larutan garam pada suhu 10^{o}C menunjukkan nilai mampatan yang rendah. Di dalam ujian kelenturan, keju yang diasinkan di dalam 25% larutan garam pada suhu 10^{o}C menunjukkan daya tahan bebanan yang tinggi manakala keju yang diasinkan di dalam larutan 10% pada suhu -10^{o}C menunjukkan daya tahan beban yang rendah. Ini menunjukkan bahawa semakin tinggi kepekatan garam dan suhu digunakan ke atas keju, semakin keras dan kuat tekstur bagi keju mozzarella dan cheddar.

Kata Kunci: Konsentrasi garam, Suhu, Keju Mozzarella, Keju Cheddar

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%	Percentage	10
°	Degree	16
C	Celsius	16
Kg	Kilogram	28
F	Fahrenheit	34
K	Kelvin	34
R	Rankine	35
Re	Reaumur	35

LIST OF ABBREVIATIONS

		Page
COVID-19	Coronavirus Disease 2019	5
MCO	Movement Control Order	5
HS Code	Harmonized System Code	10
USD	United States Dollar	10
US	United States	12
UK	United Kingdom	12
Ph	Potential of Hydrogen	17
DNA	Deoxyribonucleic Acid	17
NaCl	Sodium Chloride	29
SI	International System of Units	34

CHAPTER 1

INTRODUCTION

1.0 Introduction

In this chapter, the background study of the effect of salt concentration and temperature on mozzarella cheese and cheddar cheese was conducted by using two types of tests on two different types of cheese. The tests will prove the effect of salt concentration on the textural properties of mozzarella and cheddar cheese. This research was done at different temperatures to prove the effect of temperature on the textural properties of mozzarella and cheddar cheese. This study included the problem statement, hypothesis, research objective, scope of the study, the significance of the study, and limitation of the study.

1.1 Research Background

Cheese is a by-product of milk that is used mainly as food for humans. Cheese is obtained from different types of milk, such as cow's milk, goat's milk, camel's milk, and buffalo milk. Each type of milk will produce a different cheese type, taste, texture, and health benefits.

However, to ensure the cheese is in good condition, preservation techniques and storage methods need to be concerned. In this study, the effect of salt concentration and temperature on the physical properties of mozzarella cheese and cheddar cheese is evaluated.

Two types of tests will be done in this study, including with compression test and beam bending test. The significance of the compression test is to study the firmness of the cheese. As for the beam bending test, it is to learn about the cohesiveness of the cheese.

1.2 Problem Statement

Proving the effect of the salt concentration on the physical properties of the mozzarella cheese and cheddar cheese will show the importance of salt in the cheese-making process and their credibility as preservative agents for cheese.

This study also supports the theory of cheese preservation via the temperature method by using two different temperatures to show how temperature affects the physical properties of the cheese.

Eventually, this study will help small local cheese-makers, especially those from rural areas, solve their problem of producing the best cheese suitable for their preference in terms of the cheese's physical qualities.

1.3 Hypothesis

H_0: Salt concentration and temperature affect the physical properties of the mozzarella and cheddar cheese

H_a: Salt concentration and temperature does not affect the physical properties of the mozzarella and cheddar cheese

1.4 Research Objective

I. To determine the effect of salt concentration on the physical properties of mozzarella and cheddar cheese

II. To determine the effect of temperature on the physical properties of mozzarella and cheddar cheese

1.5 Scope of Study

The scope of this study focuses on determining the effect of the salt concentration on the physical properties of mozzarella cheese and cheddar cheese by using a different salt concentration in brine water.

This study also focuses on determining the effect of the temperature on the physical properties of the mozzarella cheese and cheddar cheese by using two different temperatures.

Two types of tests determine the effect of salt concentration and temperature on the physical properties of mozzarella and cheddar cheese. The results were collected and analyzed. Statistical analysis was performed on the collected data by using comparative analysis.

1.6 Significance of Study

The scope of the study focuses on the objectives to validate the hypothesis. The highlight of this study is to study the effects of salt and temperature on the physical properties of mozzarella cheese and cheddar cheese. The importance of this study is to prove the effectiveness of the salt concentration on the physical properties of mozzarella cheese and cheddar cheese by using the beam bending test.

The second is to determine the effect of the temperature on the physical properties of mozzarella cheese and cheddar cheese using the compression test. The results from this study will validate the effectiveness of salt concentration and temperature in determining the quality of cheese in terms of its physical attributes.

1.7 Limitation of the Study

The main limitation of this research is the pandemic COVID-19. Due to the pandemic, movement control orders (MCO) were applied. The student's limited ability to go back to campus is also one of the reasons. Another reason is the financial problems that hinder the travel from home to the campus. Finance problems also lead to poor experimentation work. The research was conducted at home with a minimal supply of materials.

Second is the lack of facilities. There is no suitable apparatus at home compared to the laboratory. The solution is achieved by modifying some home appliances and buying appropriate gadgets.

Finally, there is a lack of knowledge and experience in conducting the cheese. Aside from reading, help, and guidance from my family and supervisor contributed to the completion of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Cheese Industry in Malaysia

Cheese is a versatile product with a broad range of flavours and textures, produced from a by-product of ruminants, milk. The milk used to make cheese may come from various ruminants such as cows, goats, and buffalos. Cheese is primarily functional for its organoleptic properties and as a portion of the dietary meal for humans. Cheese can be used either raw or cooked. There are more than 1800 varieties nowadays (*Different Types of Cheese*, 2021). About 400 of them are made in France, while 750 varieties are produced in Britain (Perlman, 2016). Andic et al. (2010) stated that there are more than 100 varieties of cheese available in Turkey.

In Malaysia, there has been an increasing trend in western food consumption, especially in the utilization of cheese, since 2020. Some of the well-known cheese brands in the Malaysian market are Beqa, Tatura, Bridel, Floridia, Rich's, Oldenburger, Sorrento, Pauls, Westgold, South Cape Yoplaif, Farmers Union, Dairy Farmers, and Mama lucia. The popularity of cheese has increased since the COVID-19 strike.

Another factor contributing to the increasing trend of cheese usage is the spread of information among the public about the nutrition of cheese. There were six types of cheese-based food in Malaysia that became a trend and were popular among the people. The trending cheese-based foods are Cheese Tea, Basque Burnt Cheesecake, Korean food with cheese, Instant noodles with cheese, "Pisang Goreng cheese," and Japanese cheese tart (K., 2021).

Figure 2.1: 6 popular cheese based food of all time

(Source: *6 Unforgettable Cheese Trends in Malaysia*, 2021)

Due to the increased consumption of cheese among Malaysia's citizens since 1961, there are 44 companies established in Malaysia (*List of Cheese Companies in Malaysia*, 2020). There are 19 companies in Peninsular Malaysia. Thirteen in Sarawak, nine in Sabah, and three are unknown. Of the 44 companies, 27 are in the manufacturing of cheese. Another eight are involved in cheese trading. Four out of 44 companies became cheese distributors, and two went into cheese exportation. The remaining three companies had more than one type of business. Two of them involve manufacturing and trading, and the remaining one involves manufacturing, trading, and distributing (*List of Cheese Companies in Malaysia*, 2020)

The most famous type of cheese involved is cheddar cheese, followed by Gouda cheese, mozzarella cheese, goat cheese, and cheese powder. Besides this, there is blue cheese, cream cheese, Edam, Parmesan, Feta, Chevre, Romano, soft cheese, semi-hard cheese, aged cheese, and unsalted cheese (*List of Cheese Companies in Malaysia*, 2020).

2.1.1 Exportation of Cheese in Malaysia

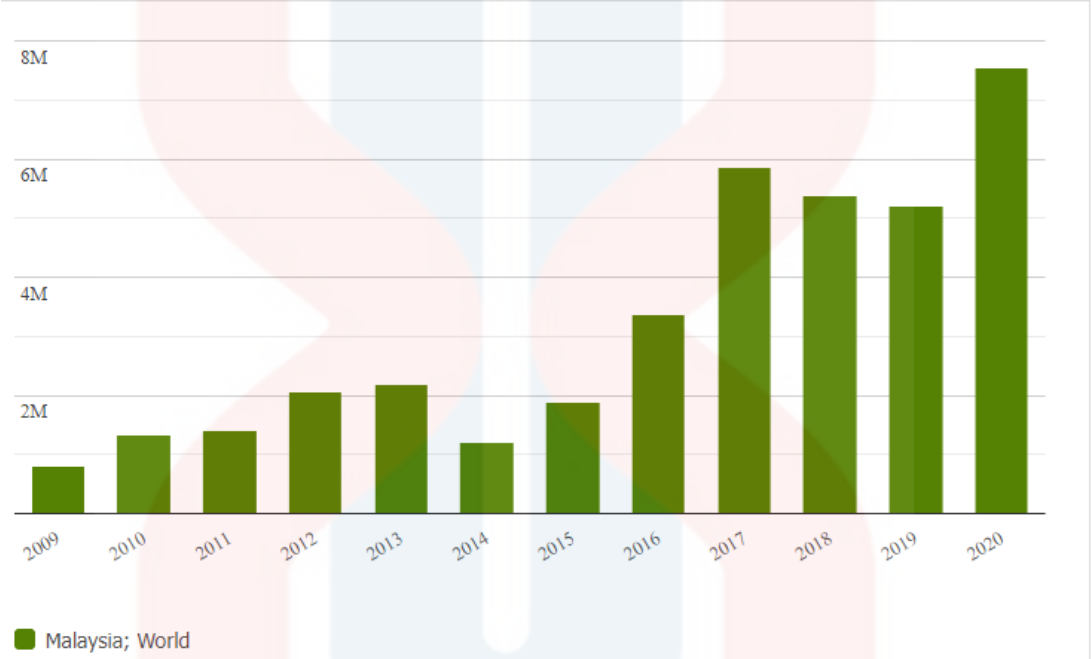

Figure 2.2: Export Value (USD) of Cheese (cheese and curd) in Malaysia

(Source: *Annual International Trade Statistics by Country (HS02)*, 2021),

In 2019, Malaysia was ranked 72 in the world's export of cheese (Selina Wamucii, 2020). (*Annual International Trade Statistics by Country (HS02)*, 2021) stated that the value of cheese exported from Malaysia in 2020 was USD 7.55 million, an increase of 45% compared to 2019. It was the highest amount of cheese exported from Malaysia since 2009.

Malaysia's export markets are Singapore, Brunei, Trinidad, Tobago, Mauritius, Hong Kong, Guyana, Turkey, Cambodia, Vietnam, and China. There are different classes of cheese according to (*Annual International Trade Statistics by Country (HS02)*, 2021).

Classification of Cheese	HS Code
Grated / Powdered	040620
Blue Veined Cheese & Other veined-cheese produced by *Penicillium roqueforti*	040640
Cheese	040690
Pr[oc]essed Cheese (Not grated / powdered)	040630
Fresh cheese (Unripen / uncured cheese)	040610

Table 2.1: Classification of cheese

(Source: *Malaysia Cheese Market Insight," n. d)*

2.1.2 Importation of Cheese in Malaysia

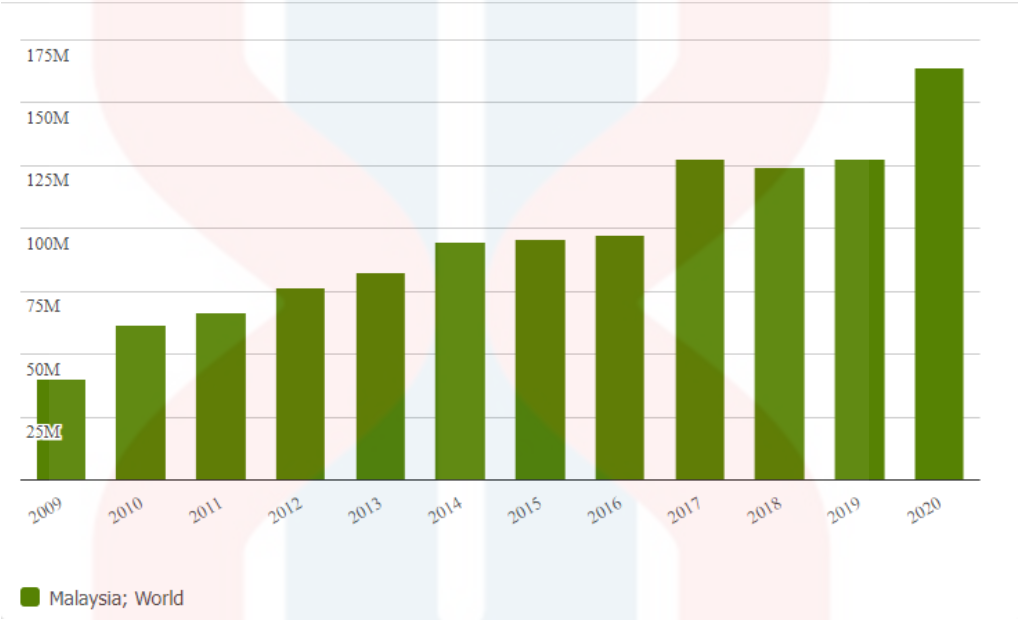

Figure 2.3: Import Value (USD) of Cheese (cheese and curd) in Malaysia

(Source: Annual International Trade Statistics by Country (HS02), 2021)*)*

Increased utilization of cheese among Malaysian citizens results in an increasing number of cheese imports. According to ("Annual International Trade," 2021), the value of the imported cheese and curd to Malaysia was USD 153 million in 2020, with the value increasing by 28% in 2019. The imported cheese in Malaysia comes from a few countries such as Australia, New Zealand, the United States (US), Denmark, Singapore, the United Kingdom (UK), Germany, the Netherlands, France, and Indonesia. With the same classification of cheese as in table 2.1, the distribution of imported cheese is as below.

Classification of Cheese	HS Code	Import Value
Grated / Powdered	040620	12.8%
Blue Veined Cheese & Other veined-cheese	040640	0.062%
Cheese	040690	29%
Processed Cheese (Not grated / powdered)	040630	42%
Fresh cheese (Unripen / uncured cheese)	040610	14.8%

Table 2.2: Classification of cheese and their imported value

(Source: *Annual International Trade Statistics by Country (HS02)*, 2021)

2.2 Cheese Origin

Cheese is a fermented milk-based product produced by dairy animals such as cows, goats, sheep, buffaloes, camels, horses, and yaks. There is an assumption that cheese originated from 8000 to 10,000 years ago in the Middle East (National Historic Cheesemaking Center Museum and Green County Welcome Center, 2020). According to ancient Greek mythology, there was proof in the Egyptian tomb that cheese originated, was made, and processed in Egypt from sheep's milk (*The Origin of Cheese – When Was Cheese First Made,* 2022).

There is two theory of the cheese first production. First, it is believed that cheese are produced from the combination of milk with fruit juice. The acid from fruit juice interact with the milk that results in the curdling of the milk. The validity of this theory is yet to prove by cheese expert.

Figure 2.4: Cheese produced from animal stomach

(Source: Old European culture, 2015)

Second, the early production of cheese is that it was accidentally produced when travellers stored the milk in a bottle or sack made from the animal stomach. Their intention is to conserve or prolong the milk constituent as they travel from one place to another, either by horses or camels. As time goes by, the acid from the stomach, called rennin, is produced and interacts with the milk. The milk coagulates within the stomach and produces curd, which can be eaten fresh out of the stomach. The interaction between

rennin and milk changed not only the physical form of the milk. They also enhanced the taste of the end product by adding more nutritional benefits to the cheese.

Since then, cheese has been widely produced since then. Due to the hot climate in the Middle East, the cheese produced is believed to be very salty, strong-tasting, and crumbly. Nowadays, it can be considered the same with feta and cottage cheese. The massive production and the consumption of cheese in the Middle East spread from Egypt toward north Greece and Rome. Eventually, cheese consumption and production expanded to Europe, where different types of cheese are produced due to different environments and climates.

Since the expansion occurred, hundreds of cheese varieties have existed. In the Roman Empire led by Julius Caesar, it is reported that there are hundreds of varieties of cheese that exist all over Europe and the Middle East. The expansion of cheese consumption is believed to have entered America earlier than Asia. But some research shows that a cheese named "rushan" exists in China. Rushan is believed to be consumed by Sani and Bai people during the Ming Dynasty. The Tibetans also consumed cheese of their own type during the same time period. (National Historic Cheesemaking Center Museum and Green County Welcome Center, 2020)

A record from the (National Historic Cheesemaking Center Museum and Green County Welcome Center, 2020) shows that cheese was introduced in America by European immigrants. The manufacturing of cheese started early in the 17th century in the old world and was brought to the new English colonies by English puritan dairy farmers. Since then, cheese has been produced and developed all over America, with Wisconsin being the center of cheese manufacturing. Until now, Wisconsin has been the

oldest cheesemaker in America, with 180 years of history. Today, there are hundreds of cheeses that have been produced and consumed throughout the whole world.

2.3 Production of Cheese

All variations of cheese in the world start with the same basic process. The main ingredient in cheese is milk. In the cheese-making process, heat and the addition of the coagulant are the keys to producing the cheese. The flavour, texture, and appearance of the cheese are determined by the use of the flavouring agent, and the aging process depends on what type of cheese is produced (S. Clyde Weaver, 2020). A fromager, or cheesemonger, is responsible for the cheese-making process.

The basic process of making cheese starts with the preparation of milk. The milk from neither cows, goats, sheep, nor buffaloes needs to be adjusted where it involves the manipulation of the protein-to-fat ratio. Some of the processes involved are pasteurization or heat treatment. This step is done to kill organisms that can cause spoilage in milk and prime the milk for the starter culture to grow effectively. After the heat treatment, the milk is left to cool to 32^{o}C for the starter culture.

Next is the acidifying process. A starter culture is added to the heated milk to induce the fermentation process. There are two types of starter culture, and the first is direct acidification. Vinegar or citric acid is used in direct acidification. The second is adding culture, such as living bacteria (Instructables, 2019). According to S. Clyde

Weaver (2020), the starter culture needs to be added to the milk at a temperature of 32ºC and the temperature must be maintained for 30 minutes. This process is to ensure the ripening process occurs, the Ph drops, and the flavour begins to develop.

The third step in the cheese-making process is curdling the milk. Naturally, an animal can digest milk from its mother with the aid of the rennin enzyme. The same thing happens in milk curdling when, in the past, cheesemakers used natural rennin to curdle the milk. But nowadays, they use commercial rennet. Rennet inactivates proteins in kappa casein and turns them into para-kappa casein. It allows milk to coagulate into lumps called "curds." Other than traditional rennet, another type of coagulant that can be used is bacterial or vegetable rennet, which comes from the DNA of a veal calf's stomach cells. Microbial rennet is produced by a fungus, and lastly, a plant coagulant is produced from the sap of a fig tree or a milk thistle (Fox, 1993)

Figure 2.5: Separating curd by using cheese harp

(Source: Science buddies, 2021)

After curdling, the curd must be cut to make it easy when separating the curd and whey. First, the curd must put at rest until reach Ph 6.4. At this moment, a large from of curd if formed. A cheesemaker will cut the curd into small pieces, create more surface area that allow the curd and whey to separate. The cheesemonger cut the curd by using cheese harp with the style of cutting is either crisscross vertically, horizontally or diagonally. The cutting style affect the level of moisture of a cheese produced. The larger the cutting size, the higher the moisture of the cheese produced.

Then the curd must be process by stirring, cooking and washing. This is done to continue the process of separating the curds and the whey. As the processed continue the curds continue to acidify and release moisture. The longer the curd cooked, the drier the cheese will be produced (Instructables, 2019). At this stage, the curd also can be processed through washing. By replacing the whey with water, it affect the texture and flavour of the cheese. Washed curd such as Gouda, and Swedish Fontina tend to have more elastic texture ad nice, mild flavour.

Next step is draining the whey, where at this point, the curd and whey are separated. The curd should look like a big mat at this moment. Usually the cheese maker will use drainer that install on the cheese vat. In some type of cheese, a presser is used by the cheese maker to force more whey out in order to produce harder cheese type such as Cheddar cheese. After draining process, the cheddaring process continue. Cheddaring is a process where the curd mat is cut into section and flip repeatedly before milling. This step is not necessarily done. Usually it is done to put pressure on the stack that force more moisture out and ensure the curds to further acidify (Rice, 2021). Cheddaring process will produced a denser crumbly cheese texture.

The 8th step is salting. Salting is the process by which flavour is added to the cheese. The salting can be done either by sprinkling dry salt or submerging the cheese into a brine. Mozzarella cheese is one example of a cheese that uses the brining technique, while drier cheeses will use dry salt. Other than salt, spices such as black pepper, garlic, habanero, and cloves, as well as herbs such as basil, chives, and rosemary can also be used. This helps create a more sensory profile in cheese.

After salting, the shaping of the cheese is done. Usually, a mold is used in the shaping process, where malleable and soft cheeses are put into the mold to remove extra moisture and produce standardized shapes. There were two types of mold, one of which is the basket where there is an open on one end. The other type of mold is a hoops-shaped or bottomless mold. Usually, these molds come in the shapes of either a round or a rectangle.

Last but not least, is aging. Different cheeses need different aging times, but some of the cheeses, such as fresh cheese, may not need this processing. Aging should be done in a controlled, cool environment to preserve the moisture and create the flavour and texture of the cheese. Some cheeses may age in a day, and some may age in years. With a longer aging process, some cheeses develop fungus that adds colours and additional flavour to the cheese. In aging, there are two types of ripening: interior-ripened cheeses and surface-ripened cheeses. Interior-ripened cheeses are used to ensure the aging process occurs from the inside out, such as cheddar and Swiss cheese. The surface-ripened cheeses ensure the aging process happens from the outside, such as Muenster and Brie cheese.

2.3.1 Cheese Nutrition

Cheese has always been misunderstood by the average consumer as being unhealthy. The truth about cheese nutrition has been exposed by many experts and doctors. Cheese indeed contains high levels of sodium and fat, but other benefits from it can outweigh the flaws. In general, cheese contains calcium, fat, protein, Vitamin A, B12, phosphorus, zinc, riboflavin, and Vitamin K-12 (Bhavya, 2021). According to Streit (2019), nine types of cheese are believed to be the healthiest. They are included with Blue cheese, Parmesan, Mozzarella, Swiss, Feta, Cottage, Cheddar, and Goat cheese. Aside from this, Ware (2017) stated that cheese contains many health benefits.

First, cheese support bone health by providing calcium, magnesium, zinc, vitamins A, D, and K. with the nutrition provided the cheese aid in the bone development of children and helps in preventing osteoporosis. Second, the calcium content in the cheese can enhance dental health by promoting tooth formation and protecting teeth from cavities.

Low fat, low-sodium cheese such as Swiss cheese is recommended to help reduce blood pressure. Other types of cheese with low-fat content and low sodium content that are available for reducing blood pressure include Cottage, Ricotta, Goat's cheese, Feta cheese, and Parmesan. However fat-free cheese is not recommended to all since the cheese has been through extreme processing procedures.

In 2014, research has been done that concluded dairy products could give a good source of glutathione and antioxidant that help in preventing neurodegeneration. The antioxidant present in cheese can also help to protect against the negative effect of sodium

(Ware, 2017). Cheese is also a good source of calcium, so it might help people lose weight. Lastly, cheese is believed to have benefits for the cardiovascular system and brain from Omega-3 fatty acids. The cheese that contains Omega-3 fatty acid can be found in a certain type of cheese, such as the one produced from cow's milk that has been fed with Alpine grass.

Another issue regarding cheese consumption is that some people might have allergic reactions due to lactose intolerance. However, there are some types of cheese on the market suitable for those who are lactose intolerant. Those who are lactose intolerant may consume cheddar, Swiss, Parmesan, cottage, feta, ricotta, and cream cheese, but they must get advice from their doctors and control the amount of consumption.

2.3.2 Type of Cheese

Among the 1800 varieties of cheese that exist in the world nowadays, these cheeses can be divided into different categories depending on the production method, appearance, aroma, and taste. There were six categories of cheese. There was hard cheese, semi-hard cheese, blue mold cheese, white mold cheese, red mold cheese, fresh cheese, goat cheese (*Cheese Types | Everything You Need to Know About Cheese | Castello | Castello*, n.d.).

Hard cheese is categorized as a firm, natural, and tough rind with an abundance of flavour, and commonly, cheese that falls into this category is hard to eat on its own

(*Hard Cheese| Everything You Need to Know About Hard Cheese | Castello | Castello*, n.d.). This is because, to create this type of cheese, the cheesemonger must ensure the separating and draining processes are done as thoroughly as possible before the pressing process is completed. They are also usually brined and waxed. Hard cheese is kept to age between 2 and 36 months or longer to produce more flavour, less creamy, and grainier cheese. An example of a hard cheese is Parmesan, Emmental, Pecorino, Parmigiano-Reggiano, and Grana-Padano.

Semi hard cheese is a firm, slightly springy texture, delicate blend of savour, tangy flavour and dense. It can be characterised as mild and aromatic cheese as they have soft touch of hazelnuts and seared butter. Usually semi hard cheese are done by compressing the curds into solid and aged in between 1-6 month depend on cheese type. They also waxed or cloth coating to protect the cheese from bacteria, fungus and excessive drying. Cheese falls into this category is Cheddar, Havarti and Gruyere (*Everything You Need to Know about Semi-Hard Cheese | Castello | Castello*, n.d.)

The next category is blue mold cheeses, such as French Roquefort, Creamy Gorgonzola, Dorset Blue Vinney, Stilton, and Danish Blue. French Roquefort is one of the oldest types of blue cheese. They appeared in the 7th century and were put to age in a cave outside the village of Roquefort, France. Usually, blue cheese is made from cows, goats, or sheep's milk and aged between 3 and 6 months. The characteristic of blue cheese is that it has streaks of blue or green fungus. In taste, they may vary from mild to sharp, creamy to crumbly. They may have a slight hint of mushrooms. To create the blue streak, mold spores are added to the cheese-making process. The cheesemaker pokes an air tunnel into the cheese to encourage the mold to grow and spread throughout the cheese (*Blue Mould Cheese | Everything You Need to Know about Blue Cheese | Castello | Castello*, n.d.).

White mold cheese is a cheese produced from cow's milk with a creamy and mild buttery taste. Usually, they are aged from 4 to 9 weeks. For white mold cheese, the longer it ages, the softer the cheese at the centre, the stronger the flavour, and the runnier the texture. To make this type of cheese, usually, the cheesemaker will rub or spray the white penicillin mold into the cheese. As the aging goes on, the cheese will be covered by a fuzzy white mold that acts as its protective skin. White mold cheese such as Brie, French Normandy Camembert, Le Chevrot, and St. Marcellin is essential to a cheeseboard, appetizer, dessert, bake, and dipping sauce for vegetables, fruit, and wheat biscuits (*White Mould Cheese | Everything You Need to Know about White Mould | Castello | Castello*, n.d.).

Red mold cheese is the next category where the appearance of the cheese is covered in a reddish rind. Usually, they are stored in a very humid environment to encourage the growth of mold. The procedure to produce this type of cheese is repeatable because the cheese must be washed frequently, either with wine or salty brine. The principle of red mold cheese is that the thinner the cheese, the more liquid will permeate and soften the cheese. The cheese may have a strong smell but has gentle and subtle flavours. Examples of red mold cheese include French Morbier, Reeblocon, and Taleggio cheese.

Cream cheese, feta cheese, mozzarella, and burrata cheese fall under the fresh cheese category. Fresh cheese is made from fresh curds without being pressed or aged, and it is usually enjoyed fresh within a few days. Some of the fresh cheeses may have a grainy texture, such as cottage cheese, a smooth and creamy texture, such as cream cheese, or low-fat content, such as quark cheese. Texture, In general, fresh cheese may have either a mild and savoury, tangy and sharp, or velvety texture. The cheese does not have a rind and is easily melted. Fresh cheese has an easy-going quality that can please

all audiences in various dishes (*Fresh Cheese | Everything You Need to Know about Fresh Cheese | Castello | Castello*, n.d.)

Lastly is the goat cheese. Goat cheese is made from goat's milk. It has many different flavours and textures, such as crumbly-creamy, young-mature, and mild-tangy. Goat cheese is a versatile cheese produced in white, coated with ash, infused with herbs, or wrapped in grape leaves. Capric acid promotes the development of good intestinal bacteria in humans. Goat cheeses are low in calories and have low lactose content. They have a tart flavour, soft, and almost spreadable. As the cheese ages, it will become firm without hardening, rumbly with a creamy flavour and a hint of hazelnut and dried herds as the age increases. One specialty of goat cheese is that fresh goat cheese never develops a rind (*Goat Cheese | Everything You Need to Know about Goat Cheese | Castello | Castello*, n. d)

Other than the six categories described above, the cheese is also categorized into six other categories, which consist of fresh cheese, bloomy-rind, washed-rind, blue, semi-hard, and hard cheese (V, 2021). As described above, each type of cheese has its characteristics. The same goes for bloomy-rind and washed-rind cheeses.

Bloomy-rind cheese, also known as soft-ripened cheese, is a cheese that ages and matures from the outside in. The mold is growing on the exterior surface of the cheese to create a more intense flavour. The cheese is produced by using *Penicillium candidum*. (*Your Favourite Cheese Might Be Made With a Bloomy Rind*, 2019). The bloomy-rind cheese has a paste-like texture with a smooth, buttery, and rich flavour. They also appear to be in a pure white to orange colour. The cheesemaker will let the cheese age longer to create a higher flavour and softness in the cheese. Examples of bloomy-rind cheeses are camembert, brilliant-savarin, brie, and Chaource. (V. 2021) (*Your Favourite Cheese Might Be Made With a Bloomy Rind*, 2019).

Washed-rind cheese is a cheese that is washed either with brine, brandy, beer, or wine. The purpose of washing is to promote the growth of desirable mold on the cheese. Washed cheese is stored in a high-moisture area. Washed-rind cheese possesses a milder taste compared to the aroma that is suggested as stinky. (Chefs, 2021). Stinking bishop, Limburger, epoisses, and Taleggio are examples of washed-rind cheese. (V. 2021).

2.4 Mozzarella Cheese

Figure 2.6: Mozzarella cheese

(Source: Morais, 2017)

Mozzarella cheese is a soft cheese that falls into the class of the Pasta filata family, where the cheese is made with the principle of 26lavour26 stretching of curd in hot water to obtain a smooth texture. Mozzarella is made either by starter culture or by a direct acidification technique. Mozzarella cheese was nominated as one of the healthiest cheeses (Streit, 2019). They have a high moisture content, ranging from 50% to 80%. According to AH & Tagalpallewar (2017), the appearance and texture of the cheese are creamy white, pale ivory, mild, smooth-textured, and they might have a slight lactic acid with filamentous structure. They are mostly gluten-free. Mozzarella is also described as white, more piquant, and having an aromatic 26lavou (AH & Tagalpallewar, 2017).

As unique as its name, mozzarella originated in Italy, made from Italian water buffalo or cow's milk. Buffalo milk is considered to produce a higher quality of mozzarella cheese in terms of aroma and physical attributes (Barbosa et al., n.d). Buffalo has higher fat content, protein, ash, calcium, and total solids (AH & Tagalpallewar, 2017). In the cheese-making process, mozzarella is usually moulded into spheres or ovals and stored in water to keep the moisture and shape. Fresh mozzarella cheese is creamier and softer than processed cheese. They can be stored in brine, whey, or water solution to make them last for a few days. Some versions of mozzarella cheese undergo an aging process to extend the shelf life and enhance the 26lavou of the cheese. Scamorza is one example of mozzarella. Scamorza is smoked mozzarella cheese.

Mozzarella also pairs beautifully with other foods. They pair well with fresh tomatoes, pesto, fruits, olives, tapenades, and basil. Mozzarella benefits humans as it helps with improving gut health, promoting immunity, and fighting inflammation in the body.

2.5 Cheddar Cheese

Figure 2.7: Variety of Cheddar cheese

(Source: *Interesting fact about cheddar cheese*, 2020)

Cheddar cheese is one of the cheeses that fall into the semi-hard cheese category. Cheddar originated in England in the village of Cheddar, Somerset. The cheese is made and aged in a cave that provides the perfect humidity for the cheese to mature. Cheddar cheese has been nominated by Streit (2019) as one of the healthiest cheeses in the world. Cheddar is made from pasteurized cow's milk that coagulates using either calf rennet or rennet substitute (McSweeney et al., 2017). Cheddar is dry and aged cheese. Due to its properties of semi-hard cheese, cheddar cheese may have a maximum of 39% of moisture content according to AH & Tagalpallewar (2017). As the cheddar ages, the cheese's flavour changes from rich and mellow to sharp and complex. The texture also changes with age, becoming crumbly and granular instead of firm and smooth.

The appearance of cheddar cheese is either white, off-white, yellow, or orange. In Wisconsin, they coloured the cheddar with achiote seeds. Prior to cheddaring, the annatto seed and vegetable dye are added to produce an orange-coloured cheddar cheese. In addition to the annatto seed, it also gives a nutty flavour to the cheese produced. (*Wisconsin Cheddar: It Doesn't Get Any Better*, n.d.)

Cheddar is rich in protein, calcium, and vitamin K2, which help with heart and bone health. Vitamin K2 helps to prevent calcium from being deposited in the walls of arteries and veins. Cheddar also contains fat, specifically the saturated fat of the cheese produced from whole milk. Other than being high in sodium, in cheddar, there are vitamin A, phosphorus, selenium, riboflavin, and zinc (Garone, 2021).

Nowadays, in the market, cheddar cheese can be seen in a block form. In the past, cheddar was shaped into cylindrical shapes weighing 10-20 kg each. Today, the cheese block comes in various weights and types, starting from mild, medium, sharp, and extra sharp. The cheese is labelled as their taste profile so that the consumer can choose the most suitable cheese for their consumption. As the name goes, the taste of the cheese comes from the different aging periods. For example, mild cheese is aged for 2-3 months, sharp cheese is aged for 6-9 months, and extra sharp cheddar is usually aged at least 15 months (Neighborly Farms, 2019).

Cheddar cheese can be added to food as a flavour enhancer. According to (*Wisconsin Cheddar: It Doesn't Get Any Better*, n. d.) cheddar makes a great pairing with wine, such as merlot, Riesling, and pinot grigio. They also paired well with a few types of beer, such as hoppy pale ale, stout, and apple cider. As for food, the cheddar can be paired with sausages, crackers, tomatoes, apples, and dried fruit and nuts. They are also great to be served as a cheese course with Madeira or brandy.

2.6. Salt

Figure 2.8: Variety type of salt

(Source: Cassetty, 2019)

Salt, or sodium chloride (NaCl), is a mineral substance that has been used in our daily life since ancient times. In the past, salt was considered a valuable mineral that could be obtained from nature. In some parts of the world, such as Africa, the Roman, Greek, and Semitic peoples, salt is one of the main items in sacrificial offerings to God and religious rituals.

There is also a road named after this precious mineral in the city of Italy, called Via Salaria (Ralston et al., 2021). Salt is also used as currency by the people of Tibet,

Ethiopia, and some other countries in Africa in the form of cakes. They were also used as a valuation allowance for the army in Rome (Ralston et al., 2021).

Nowadays, salt is common in people's lives, and it is used as a food additive both for human and animal consumption. World large salt producers came from China, the US, India, Germany, Canada, and Australia in the early 21st century (Brazier, 2017).

Salt, or NaCl, has a molar mass of 58.44. They are salty-flavoured, colourless, odourless, and have a Ph of 6.7–7.3 with a 1.2 density (Lück, 1997). Salt is used by humans and animals as a flavouring and seasoning agent. They are also used in preservation, tanning, dyeing, and bleaching (Brazier, 2017).

Salt is necessary for humans and animals as it helps maintain the fluid level in the body. Salt also helps to prevent low blood pressure with a proper dietary intake in everyday consumption (Brazier, 2017). Too much salt leads to some diseases and may be fatal for some people. Effect of the excessive amount of salt results in osteoporosis, kidney disease, and hypertension. Whereas too little salt consumption may lead to Addison disease, blockage in the small intestine, heart failure, and diarrhea. (Brazier, 2017). Aside from health, salt is used to make some of the products that humans use in daily life. They included soap, baking soda, hydrochloric acid, caustic soda, chlorine, glaze, and porcelain.

Salt can be obtained from three sources, including seawater, natural brine, and rock salt. Seawater salt is usually consumed by maritime countries. Each type of seawater has a different range of concentration, ranging from 1-5%. Enclosed waters, such as the Mediterranean and the Red Sea, have higher concentrations compared with open seawater. The process of turning seawater into salt requires the evaporation method. It can use either solar or artificial heat (Ralston et al., 2021).

Natural brines can be found mainly in the Dead Sea, Austria, France, Germany, India, the US, and the UK. Evaporation techniques are used in the manufacturing of salt from natural brines. Solar power is used in maritime countries, especially in the Dead Sea area (Ralston et al., 2021).

Rock salt, or commercial salt, comes from rock masses and beds around Pakistan, Iran, the US, Canada, Germany, Nova Scotia, and China. Rock salt is usually mined or quarried. Some of the mined salt undergoes brine treatment before reaching commercial form. In high purity rock salt, they usually being grounded, screened, and put into the market (Ralston et al., 2021).

There are four categories of salt in the world, including sea salt, rock salt, fine salt, and cleaning salt (*Different Types of Salt, Uses, & Flavours Explained*, 2021). Sea salt, as being described, is produced by the evaporation process of seawater. The characteristic of salt that falls under this category is that the salt comes in various colours. They are also known as gourmet salt. Some of the benefits of sea salt are that they contain zinc, potassium, and iodine naturally, create a high profile of flavour, and retain the minerals and nutrients obtained from the sea. Salt that falls under the sea salt category is included with smoked salt, Hawaiian salt, Celtic salt, fleur de sel, and flake salt (*Different Types of Salt, Uses, & Flavours Explained*, 2021).

Himalayan salt, kosher salt, Kala Namak salt, curing salt, and pretzel salt, are those that fall under the rock salt category. The benefit of rock salt is that it contains high natural minerals, is an eye-appeal for the cocktail glasses and gives flavour and additional texture to the baked goods. Other than that, rock salt can also be used to cure and remove toxins from meat (*Different Types of Salt, Uses, & Flavours Explained*, 2021).

Next is fine salt. As it was named, the salt lies within this category are extremely fine salt grains extracted from salt brine. Fine salt creates a cleaner product, is inexpensive, and is one of the most popular salts used in cooking. Fine salt dissolves more easily, making it perfect for sprinkling and seasoning. These are types of salt under the category, of table salt, canning and pickling salt, popcorn salt, and salt powder.

The last category is cleaning salt where the salt is mixed with some other minerals and chemicals to enhance the antibacterial properties. Another function of cleaning salt is to break down magnesium and calcium content. The purpose of cleaning salt is to clean the surfaces of the kitchen, bathroom, and any other places and things that polish or deodorize as long as the life expectancy of appliances. Cleaning salt also helps in wiping off the rust and shining the copper and brass. Water softener salt is the salt that does the work. They are available either in pellet form, cube form, or crystal form (*Different Types of Salt, Uses, & Flavours Explained*, 2021).

2.6.1 Role of Salt in Cheese Production

Salting is one of the procedures in the cheese-making process that makes salt one of the main components in determining the type of cheese produced. Though some cheeses do not require salt in their process, such as mozzarella cheese, salt does its job in aiding a successful cheese creation. The main role of salt in cheese production is to stop the further growth of lactic acid and starter bacteria in the milk (*Why Is Salt Added as an*

Ingredient When Making Cheese? Well, it's Not Just for Flavour! (2019). The process of acidification needs to slow down or stop to ensure the lactose does not convert into lactic acid (Webber, 2017).

Salt also helps kill the bacterial and other harmful growth in the cheese (Cultures for Health, 2016) and control the influence of microbial and enzymatic activities (*Salt in Cheese*, 2007). The flavour of the cheese is reported to be influenced by the salt content in the cheese. According to Guinee (2004), other than flavour, salt did make a small contribution to the dietary sodium for human daily consumption, except for high-salt cheese. Salt, in a way, acts as a natural preservative agent. With the osmotic pressure produced by the salt, dehydration occurs in the cheese, leading to the prevention of bacterial and pathogen growth (*Salt in Cheese*, 2007), Salt as a preservative is also shown to contribute to minimizing spoilage of cheese, controlling the cheese's moisture and whey expulsion during the draining process (Webber, 2017).

In brining, the salt concentration can influence the flavour, aroma, textural properties, rheology, cooking performance, and overall quality (Guinee, 2004). By rubbing salt or brining, the texture on the outside of the cheese may develop a good rind, which can produce a better flavour intensity, such as bloom-rind cheese (*Why Is Salt Added as an Ingredient When Making Cheese? Well, It's Not Just for Flavour!*, 2019).

Salt is a necessary component in the cheese-making process. In the production of cheese, cheese salt is a type of salt that must be used to produce the cheese, regardless of the type of cheese. Other than cheese salt, the use of non-iodized salt is accepted either in flakes or grains. However, the use of iodized salt is not permitted as it can inhibit the bacterial growth in the cheese. The use of non-iodized salt can help slow down the drastic aging process in cheese. Other than non-iodized salt, high-quality sea salt is reported to be preferable for producing cheese (Cultures For Health, 2016).

2.7 Temperature

Temperature is a measure of the hotness and coldness of an object or place. The temperature is expressed on any type of arbitrary scale. Temperature serves as an indication of heat direction where the heat flows from hot area to cold area. However, the temperature is not equivalent to a thermodynamic system, similar to density as in mass or volume (The Editors of Encyclopaedia Britannica, 2021).

There are five types of scales used in the world. The degree Fahrenheit (^{o}F) was introduced by Daniel Gabriel Fahrenheit between 1700 and 1730. The standard measurement in (^{o}F) is that the water is frozen at 32^{o}F and boiled at 212^{o}F. This scale is used by US citizens and a few other countries as their main scale. A few other countries that use the degree Fahrenheit are the Bahamas, Cayman Island, Liberia, Marshall Island, Palau, and the Federated States of Micronesia.

The second scale is named after Anders Celsius when he proposed the scale back in 1742. The degree Celsius (^{o}C) is used widely throughout the world except for those countries that use degrees Fahrenheit. This scale is also used mainly in scientific theory and research.

Kelvin (K) was proposed by an engineer and physicist, William Thompson, later known as Lord Kelvin, in 1848. The Kelvin scale is an absolute temperature scale and is also one of the international standards (SI) for scientific temperature measurement.

In 1859, other scales were introduced by Macquom Rankine, known as the Rankine scale (^{o}R). Rankine is widely used today in engineering fields such as the aerospace industry. The heat computation is done by using degrees of Fahrenheit. (The Editors of Encyclopaedia Britannica, 2021)

Lastly is the Reaumur (^{o}Re) scale, which was introduced by Rene Antoine Ferchault de Reaumur in 1730. This scale was widely used in Europe back in the 18th and 19th centuries. Nowadays, this scale is no longer used by Europeans except when they measure the temperature of the mixture in brewing syrup in food production and during the cheese-making process. (The Editors of Encyclopaedia Britannica, 2021)

An Italian mathematician-physicist known as Galileo Galilei invented the thermometer to measure the temperature in 1592.

Since then, the pattern of the thermometer has been improvised. Nowadays, thermometers are widely used in manufacturing, scientific research, and medical practice. A few types of thermometers exist suited to their field of work.The first type is a liquid thermometer that has been used in the past. The liquid thermometer has a wide-span temperature measurement. They are built by using either mercury or coloured alcohol, sealed in the glass tube with nitrogen or argon. The second is the gas thermometer. It is a type of thermometer used to measure very low temperatures.

Next, electronic digital thermometer. This type of invention is created to produce harmless thermometers with more accurate measurements. Digital thermometers are made by using thermistors and resistors. According to Gallagher (2006), digital thermometers are used to measure temperature by using a smart temperature transmitter.

The infrared thermometer is usually used in medical practice. The infrared thermometer uses infrared by focusing the light to measure the body temperature. Since the COVID-19 pandemic strike, the use of infrared thermometers has been widespread in the country.

Magnetic thermometers are one of the creations that are used to measure very low temperature in precision detection. Lastly, the thermography technique has been used in mapping temperature. They use a visual representation of temperature on surfaces or land (The Editors of Encyclopaedia Britannica, 2020).

2.7.1 Role of Temperature in Cheese Production

The temperature are the main thing to consider in making a cheese as they influence the end product of the cheese. As early in the cheese making procedure, the milk must be heat or pasteurised and cool down to 32^{o}C in order to ensure the milk is ready for starter culture growth (S. Clyde Weaver, 2020).

After cheese are made, they need undergoes aging process. Though not all type of cheese need aging, the cheese that depends on aging to develop extra character must be kept in cold temperature at optimum range from 12-15^{o}C. Too low temperature might induce some microbes that lead to cheese spoilage. Whereas too high can cause rapid aging and spoilage especially cheese contain in high moisture. However there are some cheese that requires lower temperature such as cheddar cheese that vacuumed-sealed in bags. They are kept in 1.6-4.4^{o}C (Caldwell, 2017). The need of low temperature also beneficial in mould cheese type as they help the bacteria growth in the cheese and creates milder taste in end product.

Temperature also affect cheese texture and taste. Jones, (2021) stated that, to experience the taste and texture of cheese to the fullest, the cheese need to be at room temperature at range of 20-22^{o}C. To ensure the cheese are in optimum quality after frozen, Mandl (2009) stated that, the cheese must be place into airtight container and thawed in refrigerator at least for 7 hour. So that the quality of the cheese are preserve.

In term of food security, there are four major pathogen that cause foodborne disease. They are *Escherichia coli* (E.coli), *Salmonella spp., Staphylococcus aureus and Listeria monocytogens* (Flores, n.d.) Therefore a proper sanitation during the cheese making process are needed to avoid the any foodborne disease. Dairy product such as cheese need to be stored at 2-4^{o}C in clean refrigerator with protective covering or own space (Committee, 2015). The cheese also must not be keep with the vegetables and it is also advisable to not buy cheese in bulk. These are precaution step for food security and to ensure the cheese are in the best form.

2.8 Compression Test

Compression test is a test of a material that undergoes inward opposite forces or in other term is called as squashed or crushed. Compression test are done to determine the response of material applied with force or load to measure the stress or deformation of the material. Other parameter that can be observe from the test are yield strength, compressive strength, elastic limit and elastic modulus (*Compression Test*, n.d.).

In compression test, material that always being used to test are wood, concretes, composite, stone, brick, polymers, grouts, foam and metals. These material can be test with compression test depend on their application. There are few types of compression test that are common including, uniaxial, biaxial, triaxial, cold temperature, elevated temperature, fatigue and creep, top-load, flexure and spring (*Compression Test*, n.d.).

In cheese production, compression test are done to study the mechanical properties of the cheese (Felfoul et al., 2021). Texture profile analysis (TPA) are the properties of cheese that being determine through this test. Within TPA, researcher usually look into some parameters such as hardness, fracturabilty, cohesiveness, springiness and adhesiveness (Peleg, 2019). However in conducting compression test, few things need to be considered like the specimen size, test condition, probe's geometries and set deformation as they can affect overall result of TPA (Peleg, 2019).

2.9 Beam Bending Test

A beam bending test is performed to evaluate the quality of a material and its ability to resist fracture and deformities. The mechanism of the bend test is applying force at the midpoint of the material causing a concave surface. The main function of the beam bending test is to determine the bending strength, fracture strength, and resistance to fracture (*What Is a Bend Test?*, n.d.).

In the beam bending test, material that undergoes the test are usually metal, wood, plastic, polymers, and ceramic with common shapes of cylindrical, rectangular, sheets, strips, pipes, and shell specimens. There are four types of tests to consider. There are guided bend tests, semi-guided bend tests, free bend tests, and fracture toughness tests (*What Is a Bend Test?* N.d.).

TPA is also used as a study material when using beam bending tests on cheese samples. Sensory parameters can also be obtained by using the beam bending test thru partial least square regression (Everard et al., 2007). The sensory parameters that can be obtained are firmness, chewy, rubbery, and TPA, it involves hardness, fracture ability, cohesiveness, springiness, and adhesiveness. (Everard et al., 2007).

CHAPTER 3

METHODOLOGY

3.1 Material and Apparatus

This study used Mozzarella cheese, cheddar cheese, thermometer, digital scale, glove, non-iodized salt, water, Container, timer, vacuum sealer, plastic bag, cutting board, knife, scissor, sand, balloon, rubber band, ribbon, and ruler.

3.2 Method

3.2.1 Preparation of Salt Brine

a. Light Brine (10% Concentration)

97.36g of non-iodized salt was put into a container and dissolved into 1 litre of water at room temperature. The water was stirred continuously until the salt dissolved completely. The 10% salt solution produced was put aside at room temperature while the cheese was prepared.

b. Medium Brine (20% Concentration)

194. 72g of non-iodized salt was put into a container and dissolved into 1 litre of water at room temperature. The water was stirred continuously until the salt dissolved completely. The 20% salt solution produced was put aside at room temperature while the cheese was prepared.

c. Saturated Brine (25% Concentration)

240.03g of non-iodized salt was put into a container and dissolved into 1 litre of water at room temperature. The water was stirred continuously until dissolved. A few grains of salt are seen in the container due to the concentrated solution. The 25% salt solution produced was put aside at room temperature while the cheese was prepared.

3.2.2 Preparation of Cheese, Brining and storage

a. Mozzarella Cheese

9 blocks of mozzarella cheese weighing 200g were taken out of the refrigerator and placed on a table at room temperature. After the temperature of the cheese was brought to room temperature, each block of cheese was cut into four, resulting in four strips of cheese. 36 strips of cheese were produced and labelled with numbers and consonants.

For the brining process, all labelled cheese was divided into three sections. Cheese 1, 4, 7 were put into the container with a 10% salt brine solution. Cheese 2, 5, and 8 were put into a container with a 20% salt brine solution. Lastly, cheeses 3, 6, and 9 were put into containers at a 25% salt brine concentration. All the cheese was left to brine at room temperature for four hours before being divided into separate storage.

After 4 hours, the cheese was taken out of the container, weighed, and put into a plastic sealer. The cheese was put in order of a, and c, and b, and d in each plastic. Each plastic was labelled according to the cheese number and type, then sealed.

The vacuum-packed cheese was put into two different stores at different temperatures. Cheese packs with labels a, and c were put into the refrigerator at a temperature of 10^{o}C, while cheese packs with labels b and d were put into the freezer at

a temperature of -10 ^{o}C. The cheese was put into the respective storage for 5, 10, and 15 days before being used in the beam bending test and compression test.

b. Cheddar Cheese

9 blocks of cheddar cheese weighing 200g were taken out of the refrigerator and placed on a table at room temperature. After the temperature of the cheese was brought to room temperature, each block of cheese was cut into four, resulting in four strips of cheese. 36 strips of cheese were produced and labelled with numbers and consonants.

For the brining process, all labelled cheese was divided into three sections. Cheese 1, 4, 7 were put into the container with a 10% salt brine solution. Cheese 2, 5, and 8 were put into a container with a 20% salt brine solution. Lastly, cheeses 3, 6, and 9 were put into containers at a 25% salt brine concentration. All the cheese was left to brine at room temperature for four hours before being divided into separate storage.

After 4 hours, the cheese was taken out of the container, weighed, and put into a plastic sealer. The cheese was put in order of a, and c, and b, and d in each plastic. Each plastic was labelled according to the cheese number and type, then vacuum-sealed.

The vacuum-packed cheese was put into two different stores at different temperatures. Cheese packs with labels a, and c were put into the refrigerator at a temperature of 10 ^{o}C, while cheese packs with labels b and d were put into the freezer at a temperature of -10^{o}C. The cheese was put into the respective storage for 5, 10, and 15 days before being used in the beam bending test and compression test.

3.2.3 Compression Test

Compression test is a test of a material that undergoes inward opposite forces or in other term is called as squashed or crushed. It is done to determine the response of material applied with force or load to measure the stress or deformation of the material. (*Compression Test*, n.d.).

In this study, all cheese was put to the test on day 5, day 10, and day 15. On Day 5, before the test, the cheese from the freezer was taken out and put into the refrigerator. The cheese was tested between 18 and 24 hours after the relocation from the freezer to the refrigerator.

3500g of sand was weighed and put into a container. The sand acted as a weight to compress the cheese. The pack of cheese labelled with an "a" and a "c" was used in this test. The sealed pack was cut open, and one cheese strip was weighed and measured for height. Then, the cheese was put into an empty container.

The container of sand was put into the container that contained one cheese strip and left for 5 minutes. After 5 minutes, the container was removed. The cheese strip was weighted and its height was recorded. The step was repeated on all cheese strips labelled "a" and "c" on Day 5, Day 10, and Day 15.

3.2.4 Beam Bending Test

A beam bending test is performed to evaluate the quality of a material and its ability to resist fracture and deformities. The mechanism of the bend test is applying force at the midpoint of the material causing a concave surface. The main function of the beam bending test is to determine the bending strength, fracture strength, and resistance to fracture (*What Is a Bend Test?*, n.d.).

In this study, all cheese was put to the test on day 5, day 10, and day 15. On Day 5, before the test, the cheese from the freezer was taken out and put into the refrigerator. The cheese was tested between 18 and 24 hours after the relocation from the freezer to the refrigerator.

The structure for the bending test was built up from two empty cylinder containers. The sand was put into each container as a weight to hold the load. The load used in the test was made of balloons filled with sand. There were two types of weight, which were 20g and 50g, and they were tied with a rubber band as a holder.

The pack of cheese labelled with “b” and “d” was used in this test. The sealed pack was opened and all the cheese strips were weighted. To run the test, one cheese strip was put on top, in between the two cylinders that resemble a bridge. A ribbon was cut by 15cm and placed around the cheese. A hole was made and the hook was placed.

Loads were placed hanging on the hook, starting with a 20g balloon and followed by a 50g balloon. The load increased one balloon at a time until the cheese broke. The weight was recorded when the cheese broke into two pieces.

3.3 Statistical Analysis

All the data was collected and a comparative technique was used. The result was displayed in the bar chart and compared. The result has also been compared with other research for analysis.

CHAPTER 4

RESULT & DISCUSSION

Cheese is a product made from the milk of ruminant animals such as cows, goats, sheep, buffalo, and camels. Milk collected undergoes a few procedures starting from heating, acidifying, curdling, draining, cheddaring, salting, shaping, and aging before the cheese was produced and consumed. There were over 1800 types of cheese estimated to exist in the world nowadays (*Different Types of Cheese*, 2021)with 400 varieties of cheese made in France and 750 varieties of cheese produced in Britain (Perlman, 2016). There were also more than 100 varieties of cheese available in Turkey (Andiç et al., 2010)

Due to the different varieties of cheese on the market, there were different processes in the cheese-making procedure depending on the typed of cheese produced. Other than the different types of acidifier or starter culture used in the cheese process, salting, aging, and temperature were also important in determining the cheese typed produced and its physical properties (S. Clyde Weaver, 2020).

4.1 Results of Compression Test on Mozzarella and Cheddar Cheese

4.1.1 Mozzarella Cheese

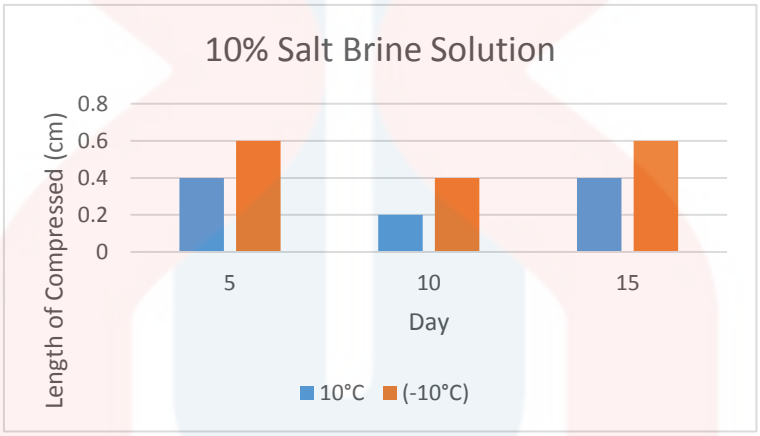

Figure 4.1: Compression Test of Mozzarella cheese brined in 10% salt brine solution

Figure 4.1 showed that for 10% salt brine solution, the compression was the lowest on Day 10 at 10^{o}C and -10^{o}C. This showed that the cheese was the hardest on Day 10. Temperature affected the compression of the cheese. The cheese showed its softness when it stored at -10^{o}C on Day5 and Day 15 with 0.6cm of compressed length while at 10^{o}C,the softest was on Day 5 and Day 15 with 0.4cm length of compressed.

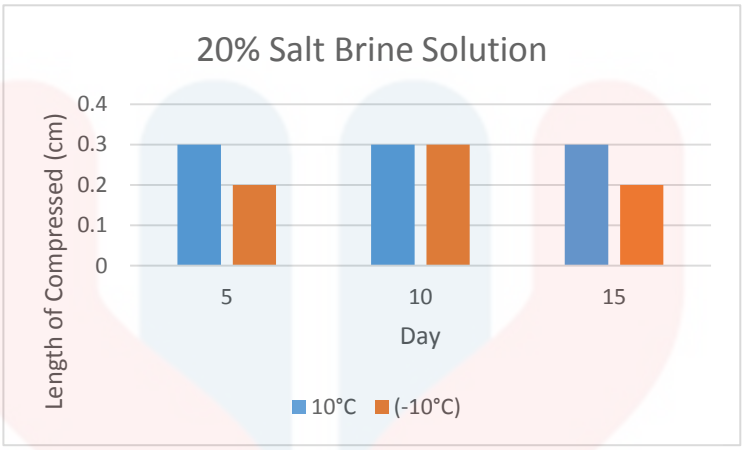

Figure 4.2: Compression Test of mozzarella cheese brined in 20% salt brine solution

Figure 4.2 showed that for 20% salt brine solution, the compression was the lowest on Day 5 and Day 15 at -10^{o}C. This showed that the cheese was the hardest on Day 5 and Day 15.Temperature affected the compression of the cheese. The cheese showed its softness when it stored at -10^{o}C on Day10 with 0.3cm of compressed length while at 10^{o}C,the softest was on Day 5 and Day 15 with 0.3cm length of compressed.

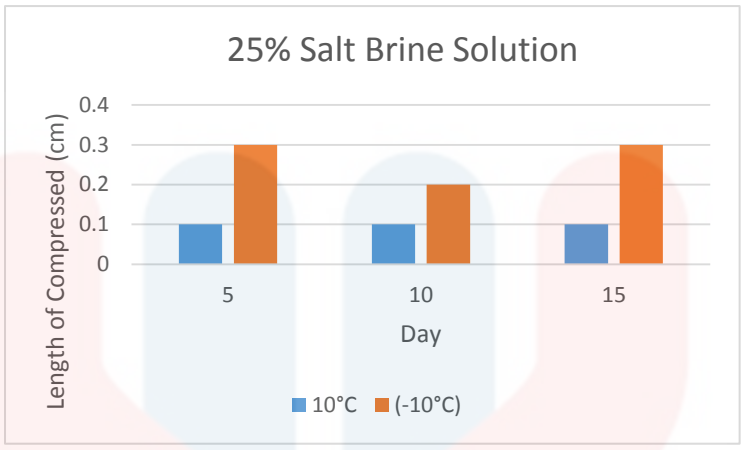

Figure 4.3: Compression test of Mozzarella cheese brined in 25% salt brine solution

Figure 4.3 showed that for 25% salt brine solution, the compression was the lowest on Day 10 at 10°C and -10°C. This showed that the cheese was the hardest on Day 10 Temperature affected the compression of the cheese. The cheese showed its softness when it stored at -10°C on Day5 with 0.3cm of compressed length while at 10°C,the result showed the same length of compression on Day 5, Day 10 and Day 15.

4.1.2 Cheddar Cheese

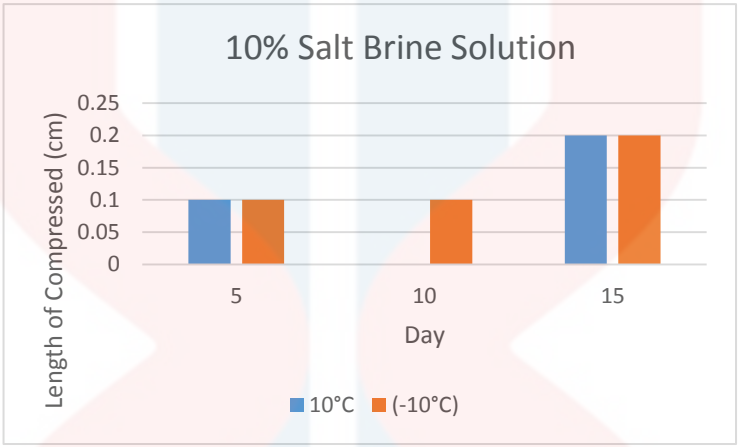

Figure 4.4: Compression test of cheddar cheese brined in 10% salt brine solution

Figure 4.4 showed that for 10% salt brine solution, the compression was the lowest on Day 10 at 10^{o}C. This showed that the cheese was the hardest on Day 10 with no length of compressed recorded. Temperature affected the compression of the cheese. The cheese showed its softness when it stored at 10^{o}C and -10^{o}C on Day15 with 0.2cm of compressed length

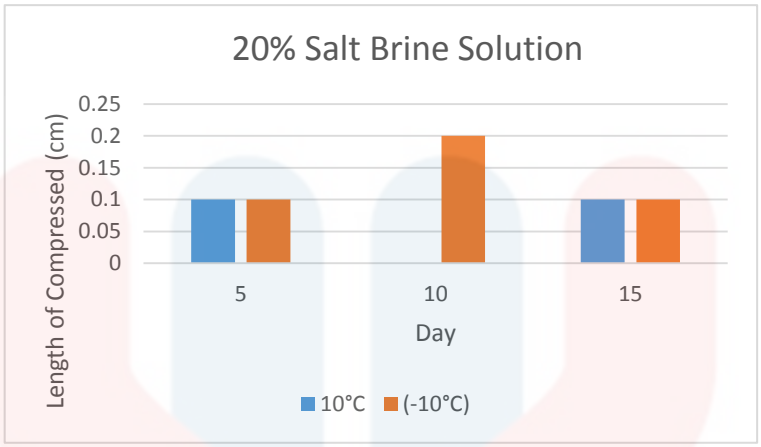

Figure 4.5: Compression test of cheddar cheese brined in 20% salt brine solution

Figure 4.5 showed that for 20% salt brine solution, the compression was the lowest on Day 10 at 10°C. This showed that the cheese was the hardest on Day 10 with no length of compressed recorded. Temperature affected the compression of the cheese. The cheese showed its softness when it stored at -10°C on Day10 with 0.2cm of compressed length while at 10°C,the softest was on Day 5 and Day 15 with 0.1cm length of compressed.

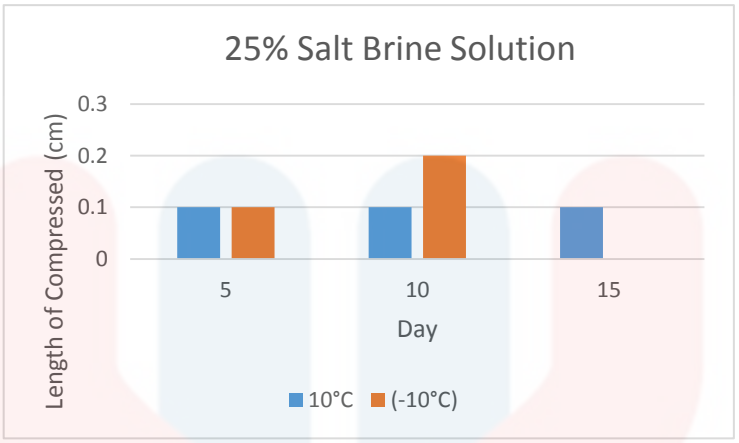

Figure 4.6: Compression test of cheddar cheese brined in 25% salt brine solution

Figure 4.6 showed that for 25% salt brine solution, the compression was the lowest on Day 15 at -10°C. This showed that the cheese was the hardest on Day 15 and the softest on Day 10. Temperature affected the compression of the cheese. The cheese showed its softness when it stored at -10°C on Day10 with 0.2cm of compressed length while at 10°C, the hardest cheese are measured at 0.1cm on Day 5, Day10 and Day15.

4.2 Results of Beam Bending Test on Mozzarella and Cheddar Cheese

4.2.1 Mozzarella Cheese

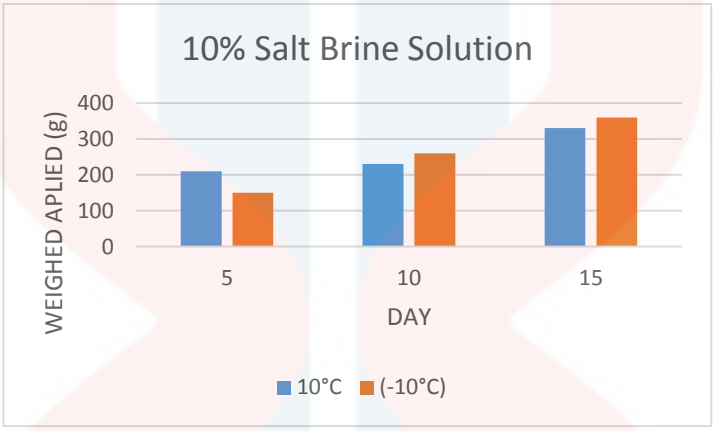

Figure 4.7: Beam bending test of mozzarella cheese brined in 10% salt brine solution

Figure 4.7 showed that for 10% salt brine solution, the bending was the lowest on Day 5 at -10ºC and 10ºC. This showed that the cheese was the weakest on Day 5 and the strongest on Day 15. Temperature affected the strength of the cheese. The cheese showed its strength when it stored at -10ºC on Day15 with 360g of weight resistance while at 10ºC, the strongest cheese can be found on Day 15 with 330g of weight resistance.

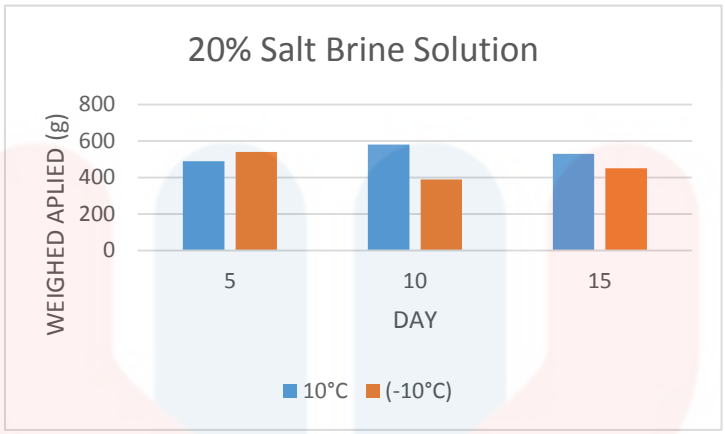

Figure 4.8: Beam bending test of mozzarella cheese brined in 20% salt brine solution

Figure 4.8 showed that for 20% salt brine solution, the bending was the lowest on Day 10 at -10^{o}C. This showed that the cheese was the weakest on Day 10. Temperature affected the strength of the cheese. The cheese showed its strength when it stored at 10^{o}C on Day10 with 580g of weight resistance while at -10^{o}C, the strongest cheese can be found on Day 5 with 540g of weight resistance.

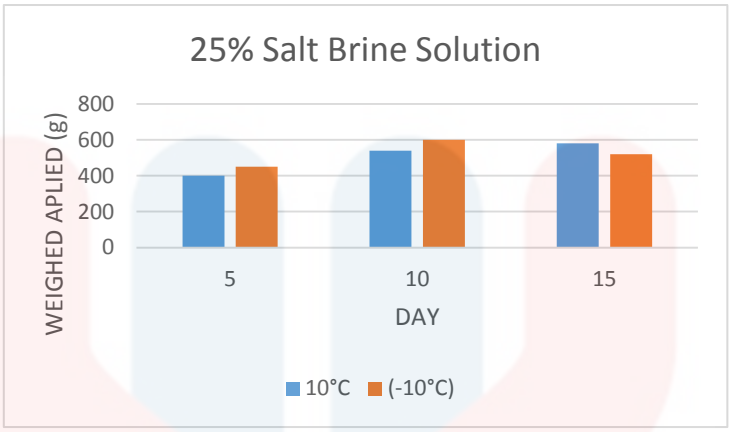

Figure 4.9: Beam bending test of mozzarella cheese brined in 25% salt brine solution

Figure 4.9 showed that for 25% salt brine solution, the bending was the lowest on Day 5 at -10ºC and 10ºC. This showed that the cheese was the weakest on Day 5 and the strongest on Day 10. Temperature affected the strength of the cheese. The cheese showed its strength when it stored at -10ºC on Day10 with 600g of weight resistance while at 10ºC, the strongest cheese can be found on Day 15 with 580g of weight resistance.

4.2.2 Cheddar Cheese

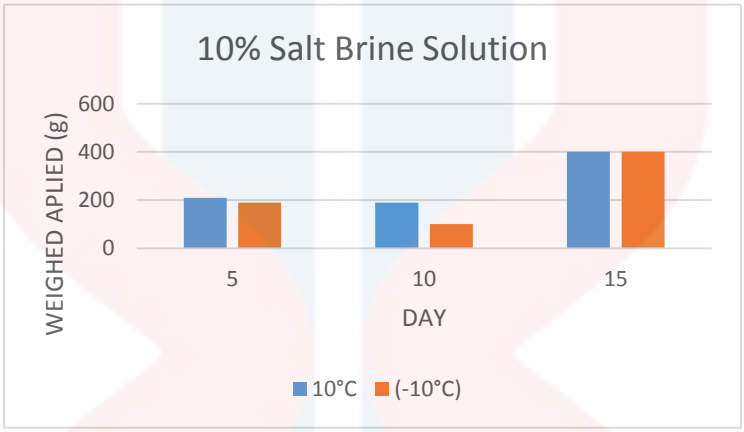

Figure 4.10: Beam bending test of cheddar cheese brined in 10% salt brine solution

Figure 4.10 showed that for 10% salt brine solution, the bending was the lowest on Day 10 at -10^{o}C and 10^{o}C. This showed that the cheese was the weakest on Day 10 and the strongest on Day 15. Temperature affected the strength of the cheese. The cheese showed its strength when it stored at 10^{o}C and -10^{o}C with 400g of weight resistance.

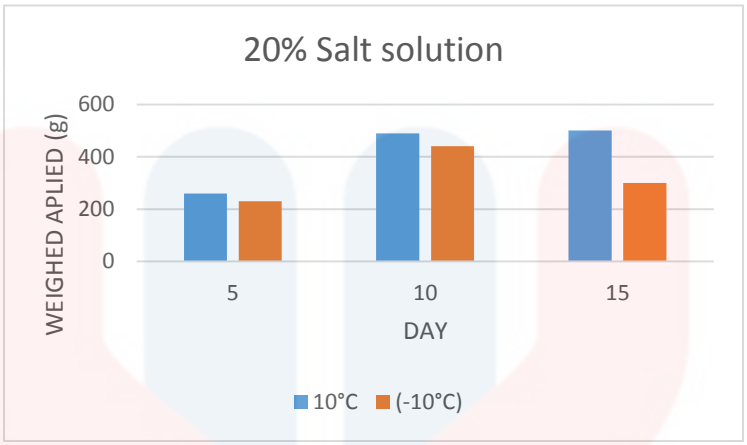

Figure 4.11: Beam bending test of cheddar cheese brined in 20% salt brine solution

Figure 4.11 showed that for 20% salt brine solution, the bending was the lowest on Day 5 at -10ºC and 10ºC. This showed that the cheese was the weakest on Day 5 and the strongest on Day 15.Temperature affected the strength of the cheese. The cheese showed its strength when it stored at 10ºC on Day15 with 500g of weight resistance while at -10ºC, the strongest cheese can be found on Day 10 with 440g of weight resistance.

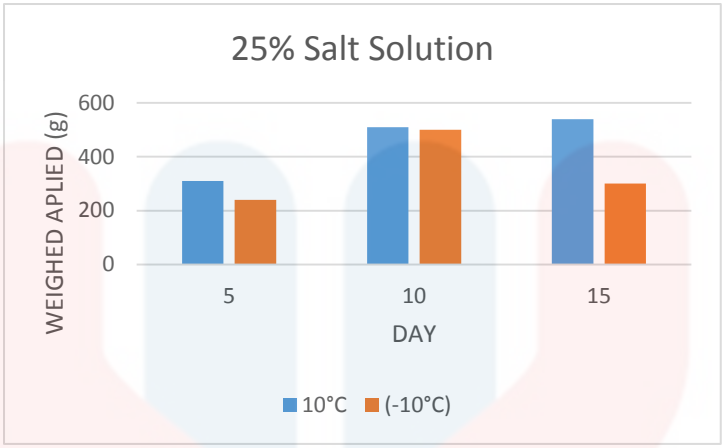

Figure 4.11: Beam bending test of cheddar cheese brined in 25% salt brine solution

Figure 4.12 showed that for 25% salt brine solution, the bending was the lowest on Day 5 at -10^{o}C and 10^{o}C. This showed that the cheese was the weakest on Day 5 and the strongest on Day 15. Temperature affected the strength of the cheese. The cheese showed its strength when it stored at 10^{o}C on Day15 with 540g of weight resistance while at -10^{o}C, the strongest cheese can be found on Day 10 with 500g of weight resistance.

4.3 Discussion

4.3.1 Effect of Salt concentration on Cheese Texture

Our study showed salt concentration played a major role in determining the texture of the cheese. The results from the compression test and beam bending test showed that 10% salt brine solution shows the softest cheese texture, followed by cheese from 20% salt brine solution and 25% salt brine solution. This concludes that cheese brined in a 10% salt brine solution produces softer cheese compared to cheese brined in a 25% salt brine solution.

Bernardino (2019) concluded that this happened due to the osmosis process between the cheese strips and the salt brine solution. A higher concentration of salt results in less moisture content in the cheese, thus creating a firmer and tougher texture.

Bae et al. (2017) stated that the usage of salt in cheese making is mainly for moisture control, which results in the formation of firm cheese. As salt can reduce the moisture, it will result in firmer and dryer cheese as the usage of salt increases in the cheese-making process.

Murtaza et al. (2014) also concluded that when the concentration of salt is low, the textural properties of the cheddar cheese are reduced in terms of their hardness, toughness, and crumbliness. From our study, the result showed, the cheese becomes more

resistant to fracture and loses cohesiveness when the concentration of salt brine solution increases.

Bae et al. (2017) stated that, with the increase in salt concentration in the cheese-making process, the cheese matrix becomes firmer and stiffer. Thus, the cohesiveness of the cheese will decrease and become more resistant to fracture. Cervantes et al. (1983) also concluded that an increase in salt concentration caused an increase in firmness and a decrease in cohesiveness.

Significant data from the study is small as the dataset was limited due to the improper placement of experiments, apparatus, and machines. However, as the results showed, there was an effect of the salt concentration on the cheese texture. For better results, proper conduct of the experiment was needed.

4.3.2 Effect of Temperature on Cheese Texture

Our study showed temperature played a major role in determining the texture of the cheese. The results from the compression test and beam bending test showed that the cheese kept at -10Oc produced softer cheese while the cheese kept at 10Oc produced firmer textural cheese. Cervantes et al.(1983) concluded that frozen-thawed cheese results in a softer cheese texture compared to unfrozen cheese.

Lawrence et al. (1987) conclude that the higher the temperature of storage, the more brittle and less springy the cheese will be. This shows that the cheese kept at -10Oc

produced cheese with a softer texture compared to cheese kept at 10Oc. The result from this study was also supported by Felfoul et al. (2021), as they concluded that cheese becomes harder as the storage temperature increases.

Eroglu et al. (2015) state that cohesiveness is a measurement of the deformed cheese before it breaks. In our study, the cheese becomes more resistant to fracture. They also have increased flexibility and a decrease in cohesiveness when the concentration of salt brine solution increases. Ivanov et al. (2017) concluded that as the temperature increases, there is a tendency for a decreasing value of cohesiveness. However, Zheng et al. (2016) concluded that there is no correlation between the temperature and the firmness, springiness, chewiness, and resilience of the cheese.

Alinovi et al. (2020) concluded that cheese put into frozen storage results in oxidized, bitter sensory attributes and considerably reduces the sensory quality of the mozzarella cheese. However, Mandl (2019) reported that frozen cheese must be kept in an airtight container, and should be thawed in the refrigerator for at least 7 hours to improve the quality of the frozen cheese. In this study, vacuum-packed sealers were used to store the cheese. The cheese was thawed in the refrigerator for 18 hours before the test. Therefore, the quality of the cheese was preserved to its maximum value.

Significant data from the study is small as the dataset was limited due to the improper placement of experiments, apparatus, and machines. However, as the results showed, there was an effect of the temperature on the cheese texture. For better results, proper conduct of the experiment was needed.

CHAPTER 5

CONCLUSION AND RECCOMENDATION

5.1 Conclusion

In conclusion, the salt concentration and temperature did affect the textural properties of mozzarella cheese and cheddar cheese. The salt concentration controls the moisture of the cheese. The higher the salt concentration, the lower the moisture content of the cheese, so it creates a firmer and tougher texture.

A similar result was observed for temperature. The higher the temperature, the firmer and tougher the texture of the cheese. This created a cheese with better cohesive intensity. In this study, the toughest and firmest cheese could be obtained from a 25% salt solution, while the softest cheese could be obtained from a 10% salt solution. In this research also, 10^{o}c shows greater cheese performance in terms of toughness and cohesiveness. While -10^{o}c shows great performance in terms of softness. Future work needs to be carried out to improve the data.

5.2 Recommendation

Recommendations and improvements on recent worked were vital for future worked. First, the proper conduct of the experiment was needed. The experiment needed have been done in the laboratory with a proper apparatus and machine. Due to restriction movement ordered (RMO), the experiment was carried out at home. Thus, the experiment was carried out in the absence of a few vital machines and equipment for a more thorough studied. Next, it was recommended to expand the researched area to observation on Ph, moisture, organic compounds, and aging. Data analysis would added more information on cheese processing.

Other than that, a studied on different types of cheese, such as parmesan, Gouda, feta, and camembert cheese, was suggested as they were easily obtained on the market. Plus, a bigger sample size would increase the validity of the data.

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APPENDIX A

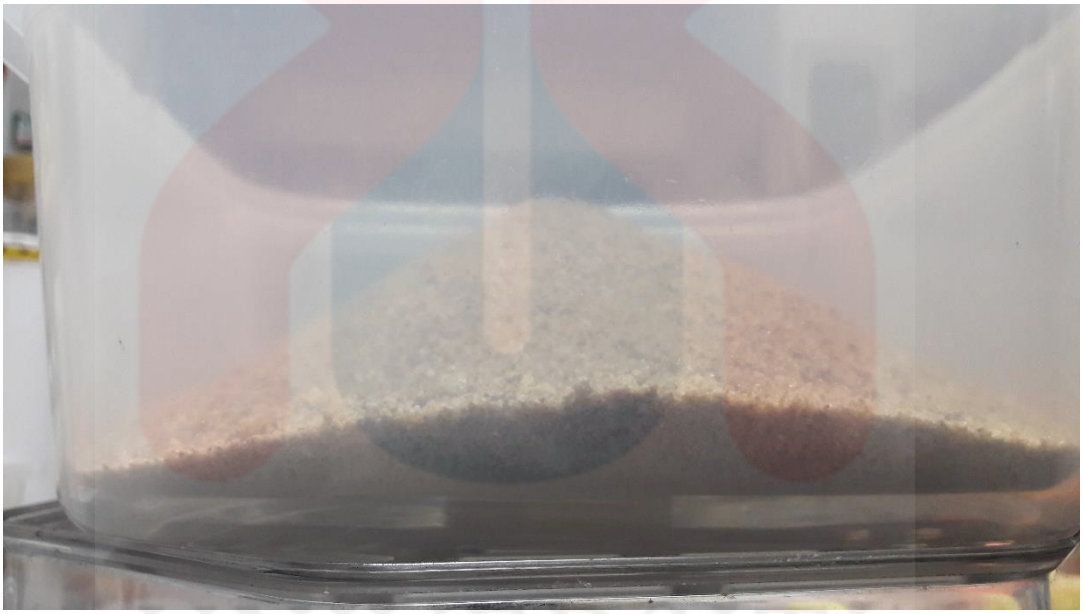
MATERIAL AND APPARATUS

APPENDIX B

BRINING

APPPENDIX C

COMPRESSION TEST



APPENDIX D

BEAM BENDING

TURNITIN REPORT

Effect of Salt concentration and Temperature on Mozzarella Cheese and Cheddar Cheese Texture

ORIGINALITY REPORT

18%	13%	6%	10%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

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2	sclydeweaver.com Internet Source	1%
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4	Submitted to University of Wisconsin - Stout Student Paper	<1%
5	www.webstaurantstore.com Internet Source	<1%
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