UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Escola Tècnica Superior d'Enginyeria Agronòmica i del Medi Natural

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

ETSIAMN

THE INFLUENCE OF CHEESE COMPOSITION ON CHEESE SNACKS QUALITY

Final thesis of the Bachelor of Food Science and technology

Author of the work: Gonzalo Cebrián Cánovas

External Tutor: Inga Ciproviča

UPV tutor : Ma Eugenia Martín Esparza

Place of realization: Jelgava,Latvia

Academic course: 2021-2022

Valencia,29 de julio de 2022

TITLE: The influence of cheese composition on cheese snacks quality

ABSTRACT

Cheese is one of the most consumed and famous food products in the world. Its consumption has been a staple in all types of diets for a long time, and lately many ways of consuming this type of food are being developed thanks to its great versatility and its acceptable nutritional information due to its high protein content and high fat content (around 25g per 100g and 35g per 100g respectively). That is why we can find many ways to consume this product, such as grated cheese or crispy bars, but the most popular cheese-based product over the years are snacks made from different cheeses, since they are a great alternative for the consumption of this type of food. The aim of this work is to analyze the composition of different types of cheese affects the production, quality and shelf life of cheese snacks. The experiment consists of two parts. The first part is based on the analysis of chosen cheese (Edam, Emmental and *Semicurado* cheese) in terms of the fat content (based on the ISO 1735-2004), the moisture content (based on the ISO 5534-1985) and the salt content (based on the ISO 5493-2006). And in the second part of the experiment, once the basic parameters in our raw product have been analysed, snacks were processed by using a dryer with microwave energy (Musson-1) and assessed over 5 sessions (one each the characteristics of the snacks, the snacks were kept during 75 days and every 10 or 15 days an analysis was carried out). The evaluated parameters were: the firmness, the peroxide content and the moisture content. Those snacks that have a more different texture and flavor and are not as acceptable among the public are those that have been made with edam cheese as raw material.

KEY WORDS: Cheese, Dryer equipment, Quality parameters, Shelf life, Cheese snacks

AUTHOR OF THE WORK: Gonzalo Cebrián Cánovas

EXTERNAL TUTOR: Inga Ciproviča

UPV TUTOR: Ma Eugenia Martín Esparza

July, Valencia 2022

TÍTULO: La influencia de la composición del queso en la calidad de los snacks de queso

RESUMEN

El queso es uno de los productos alimenticios más consumidos y famosos del mundo. Su consumo ha sido básico en todo tipo de dietas desde hace mucho tiempo, y últimamente se están desarrollando muchas formas de consumir este tipo de alimento gracias a su gran versatilidad y a su aceptable información nutricional debido a su alto contenido en proteínas y su alto contenido en grasas (alrededor de 25g por 100g y 35g por 100g respectivamente). Es por ello que podemos encontrar muchas formas de consumir este producto, como el queso rallado o las barritas crujientes, pero el producto a base de queso más popular a lo largo de los años son los snacks elaborados con diferentes quesos, ya que son una gran alternativa para el consumo de este tipo de alimentos. El objetivo de este trabajo es analizar como la composición de los diferentes tipos de queso afecta a la producción, calidad y vida útil de los snacks de queso. El experimento consta de dos partes. La primera parte se basa en el análisis de los quesos elegidos (Edam, Emmental y Semicurado) en cuanto al contenido de grasa (basado en la ISO 1735-2004), el contenido de humedad (basado en la ISO 5534-1985) y el contenido de sal (basado en la ISO 5493-2006). Y en la segunda parte del experimento, una vez analizados los parámetros básicos en nuestra materia prima, se procesaron los snacks utilizando un secador con energía de microondas (Musson-1) y se evaluaron durante 5 sesiones (cada una de las características de los snacks, y se mantuvieron los snacks durante 75 días y cada 10 o 15 días se realizó un análisis). Los parámetros evaluados fueron: la firmeza, el contenido de peróxido y el contenido de humedad. Los snacks que tienen una textura y un sabor más diferentes y no son tan aceptables entre el público son los que se han elaborado con queso Edam como materia prima.

PALABRAS CLAVE: Queso, Equipo de secado, Parámetros de calidad, Vida útil, Snacks de queso.

AUTOR DEL TRABAJO: Gonzalo Cebrián Cánovas

TUTORA EXTERNA: Inga Ciproviča

TUTORA UPV: Ma Eugenia Martín Esparza

VALENCIA, JULIO 2022

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1. INTRODUCTION

1.1CHEESE SNACKS

The product that has been used as a model to carry out this thesis, it is cheese balls, which are called BOOMBAS, it is very typical in Latvia, and it is a very good accompaniment for all classes of drinks and cocktails, among which wine and beer stand out.

This product is made by drying of rippened cheese using microwave energy.

One of the characteristics to highlight is that it has a high protein content. (SMILTENESPIENS.LV,2022)

It is made up of cheese (pasteurized milk, calcium chloride, microbial enzyme, pure cultures of lactic acid bacteria, cooking salt, colorant beta carotene) whole milk powder. (SMILTENESPIENS.LV,2022)

The production process of the snacks is as follows:

First, proceed to cut cheese in cubes of 1 cm of wide and high.

After having carried out the quality control of our raw product and having added enough flour to avoid stickiness, the drying process begins, but first it is necessary to calculate the parameters for the preparation of these snacks, as shown in section 3.1.2.

Once these parameters have been calculated, the drying process begins and it is necessary to check that the product has not suffered any damage that could be detrimental to the final product, such as the cheese melting and making a dough which will not be in the snacks and it will be a batch not valid for commercialization

Once the snacks are produced, they will remain resting and tempering for around 10 or 15 minutes. Once these 10 or 15 minutes have elapsed, they will be packaged in larger bags, from which some sample are taken to evaluate the necessary characteristics (moisture content, salt content, firmness and peroxide value) and if they have the optimal characteristics in terms of these parameters, the products are then packaged in their corresponding containers, with a net quantity of around 50 or 60 g.

Table 1. Nutritional information of cheese snacks **(SMILTENESPIENS.LV,2022)**

NUTRITIONAL VALUE	
Amount per 100g of product	
Energy value	433 Kcal/ 1796 kJ
Fat	39.3 g
Incl. Fatty acids	22.9 g
Carbohydrates	1.8 g
Incl. Sugars	1.8 g
Protein	26.3 g
Salt	1.4 g

Fig 1 & 2 Original product and research product (cheese snacks)

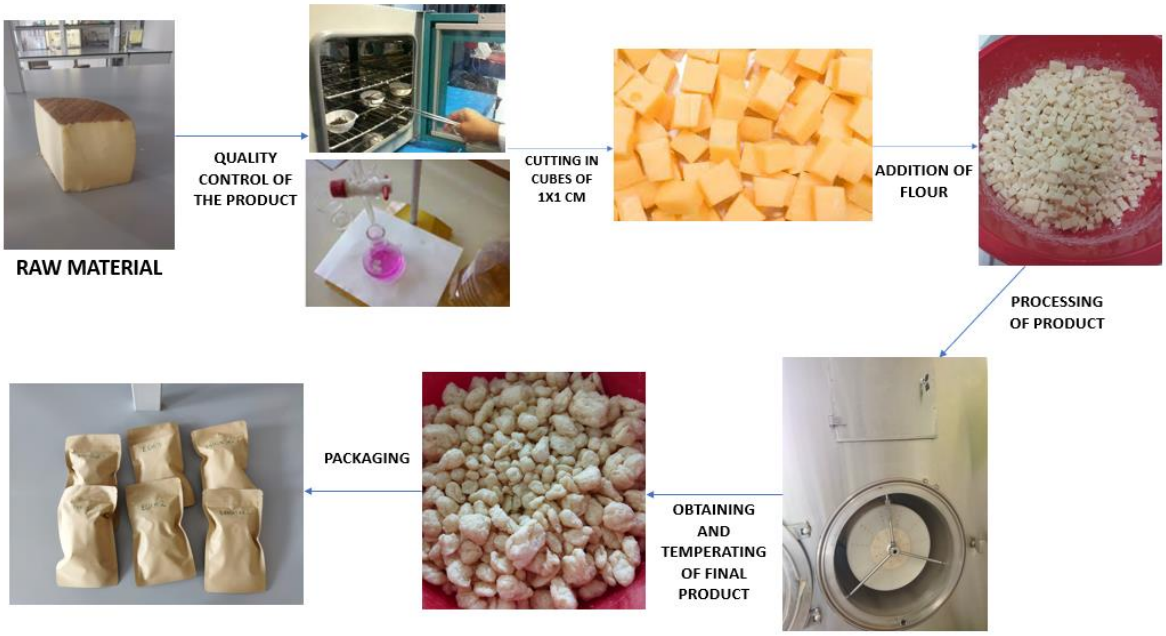

Fig 3 Production process of cheese snacks

1.2 CHEESE SNACKS DRYING PROCESS

Microwave energy helps to shorten the time to which the raw material is subjected to the drying process, and all this happens without degradation of the final product, offering a crunchy texture. (Kince et al., 2015)

The mechanism of microwave drying is as follows:

-microwave energy absorbs most water from food

-absorption of microwave waves result in an increase in temperature, an amount of water evaporates and humidity levels change significantly.

-the increase of internal heat and evaporation of liquid water takes place inside the food; therefore, a large pressure is generated that causes a vacuum to be produced, and this pressure becomes a mechanism for the transport of humidity.

Microwave waves (with a high electromagnetic frequency) enable the water molecules inside the product to be dried to move in a rotational motion during the vacuum drying process. The energy of the vibrating molecules of water molecules coming from the product is then transferred to the cells that are dry, resulting in an increase in thermal energy and, with it, a rise in temperature. It is not necessary to control the temperature since it will be controlled by the energy supplied to the product (Kince et al., 2015)

The use of a reduced pressure in the drying chamber also helps in the drying task, since it results in a decrease in the boiling temperature of the water and also in an increase in the temperature gradient between the surface of the food and its interior. This process helps a lot to maintain the nutritional and sensory properties of the products.

To control the energy input to the product, a unit called magnetrons is used, that in addition to being the device that supplies energy to our microwave, since it is a metallic cylinder with a metallic filament inside, the metallic cylinder behaves as an anode and the metallic filament as a cathode, thanks to all this and to the creation of a powerful magnetic field, the equipment can supply the necessary energy to elaborate the product. It is also about the unit of measurement, which corresponds to a total of 42 kJ, which can evaporate a total of 16 g of water per minute (Kince et al., 2015). The influence of these magnetrons corresponds to the greater or lesser contribution of energy to our product, therefore, the supply of magnetrons to the product must be controlled to avoid production problems

The water content of the product will depend in the same way on the choice of the number of magnetrons to be added to the product, since the greater the number of magnetrons, the greater amount of energy will be supplied to our product and therefore, less quantity of water our product will have at the end, in order to control the energy contribution to our product, the equations presented in the **section 2.3** are used.

1.3 GENERAL INFORMATION ABOUT CHEESE USED IN STUDY

Cheese is the soft, semi-hard, hard or extra-hard product, ripened or fresh, which may be coated, in which the proportion of whey proteins and casein is higher than that of milk (Gonzalez et al.,2018). Its different varieties depend on the origin of the milk used, the production methods followed, and the degree of maturity reached. It can arise from the curdled milk of cows, goats, sheep, buffaloes, camels or other ruminant mammals.

Beneficial bacteria are responsible for acidifying the milk and are essential for the texture and flavor of most cheeses. Molds can also be found on the outside and interior of some of them.

The nutritional data of cheese can vary on its fat content, but in general cheese is a rich source of calcium, protein, and phosphorus. As it basically concentrated milk, 600g of milk are missing to equal this amount of protein and 550 g of calcium. (ASKORA,n.d)

Cheese's nutritional qualities are similar to those of milk, owing to its high quantity of saturated fats, which include triglycerides and saturated fatty acids. This sort of fat has a strong unfavorable impact on heart disease. (HOSPITAL UNIVERSITARIO QUIRÓNSALUD, 2016)

There are thousands of different kinds of cheese. The employment of different species of bacteria and molds, variable levels of fat in the milk, differences in the curing time, different treatments in the process, and different breeds of cows, goats, or mammals and their milk all contribute to the variety of styles and flavors.

In this study we aim to analyze how the composition of different types of cheese affects the production, quality and shelf life of cheese snacks, for this we use 3 different types of cheese and subject them to a drying process by microwave energy which will give rise to our snacks.

1.4 PRODUCTION AND CONSUMPTION OF CHEESE IN THE WORLD

Cheese is one of the main livestock products in the world (Ávila et al., 2022) . According to the data of the Food and Agriculture Organization (FAO) of the United Nations, in 2018 more than 22 million tons of cheese were produced in the world. This amount is higher than the annual production of coffee beans, tea leaves, cocoa beans and tobacco combined. The largest producer of cheese is the United States, which accounts for 30 percent of world production, followed by Germany and France.

Regarding exports, the country with the highest monetary value of them is Germany, followed by the Netherlands and Italy, which is the largest in terms of quantity.

In consumption per person, Greece is in first place in the world ranking, with an average of 27.3 kg consumed per inhabitant; France is the second world consumer, with about 24 kg per person; Italy is in third position, with 22.9kg per person. (QUESOS.ES,n.d)

Table 2 shows the data, as of 2019, of the largest producers, largest exporters and largest consumers of cheese in the world.

Table 2. Producers, Exporters and consumers of cheese in the world (2019) (QUESOS.ES,n.d).

World producers in 2019 (tons)		Exporting countries in 2019 (US dollar)		Biggest consumer in 2019 (kg per habitant)	
UNITED STATES	6.315.293	GERMANY	4.575.815	DENNMARK	28.1
GERMANY	2.297.400	NETHERLANDS	4.156.537	ICELAND	27.7
FRANCE	1.938.600	ITALY	3.574.498	FINLAND	27.3
ITALY	1.327.300	FRANCE	3.513.872	FRANCE	27.2
NETHERLANDS	953.260	DENNMARK	1.123.706	CYPRUS	26.7
POLAND	867.950	UNITED STATES	1.615.437	GERMANY	24.7
RUSSIA	702.318	NEW ZELAND	1.571.465	SWITZERLAND	22.2
TURKEY	607.202	IRELAND	1.324.819	NETHERLANDS	21.6
EGIPT	593.078	BELGUIM	1.164.046	ITALY	21.5

Where it can be observed that United States together with numerous European countries are the largest producers. The largest exporters in this case would be the mostly central European countries. And as for the largest consumers of cheese in the world, it can be seen that the countries of Northern Europe are the ones that are consolidated with the highest percentage.

There is a great variety of cheese in the world depending on the type of milk used and depending on the geographical area in which it is found. According to the web wisconsincheese.com, more than 1,800 different types of cheese in the world can be found , and there are a lot of ways to classify them.

1.5 CONSUMPTION OF DIFFERENT TYPES OF CHEESE IN SPAIN

Cheese is one of the most consumed products in Spain since together with Spain being one of the World's largest producers of cheese, this product is of great importance in the Mediterranean diet. There are many varieties of cheese in the country, as shown in the **figure 4**, and their consumption is quite distributed and, above all, depends on the geographical area in which you live and where the cheese is produced.

In **Fig 4** it can be seen both, the consumption and the expenditure of different types of cheese in Spain.

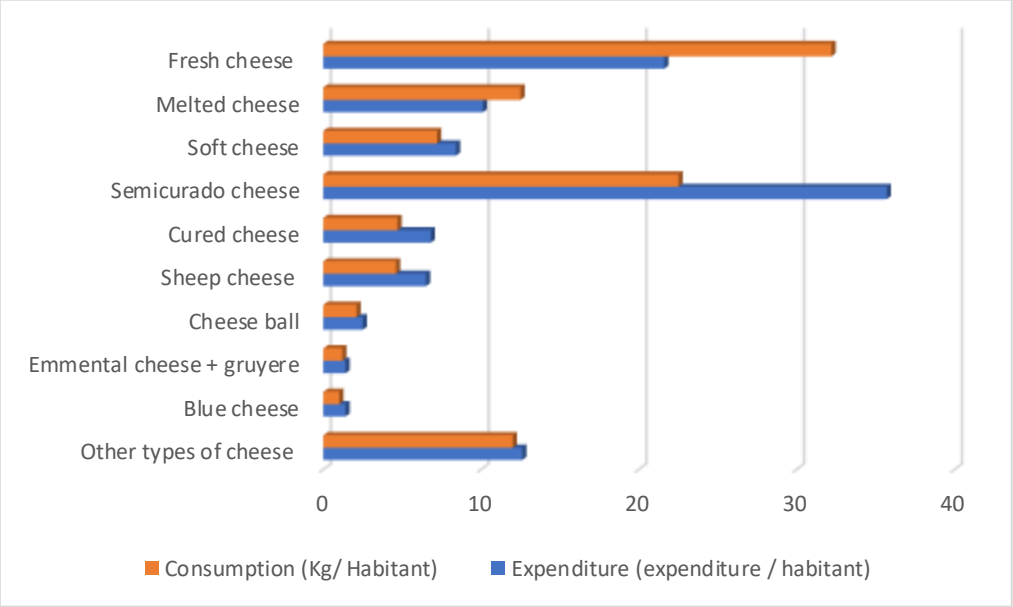

Fig 4. Consumption of different types of cheese in Spain (Cerdeño and Gráfico,n.d).

As we can see, one of the most consumed cheeses is *Queso semicurado*, and the other two types of cheese that we are going to use to make our snacks, which are Queso de bola (Edam cheese) and Emmental + Gruyère cheese, do not they are widely consumed in Spain because in this country they are not produced as much and they are not typical of it.

1.6 EDAM CHEESE USED IN THE STUDY

Edam cheese is a typical Dutch cheese that is prepared in the shape of red or yellow paraffin-coated balls or spheres. Edam, in the region of North Holland, is whence this cheese gets its name. It's known as ball cheese because of its spherical shape. This cheese is particularly popular

in Northern European nations such as the Czech Republic and Slovakia, as well as in Mexico's Yucatan Peninsula. (YOURTRIPAGENT,2022)

Rennet or other approved coagulating enzymes are used to coagulate the milk for this cheese. With or without the use of hot water, the curd is heated. Lactic fermentation is the most common type of fermentation. Ripening takes place during storage at a temperature of 10 to 12 degrees Celsius. After manufacturing, it is brine salted. It's a pasteurized cow's milk cheese with a dry matter fat content of at least 40%.

To make a one-kilogram piece of Edam cheese, about 10 litters of pasteurized and partially skimmed cow's milk are needed.

Edam is a semi-hard cheese with a firm rind that is frequently covered with paraffin, wax, plastic, or a layer of vegetable oil, all of which are yellowish in color; the coatings are yellow or red. It can also appear as a prismatic block without bark, with square or rectangular faces. Spherical shapes weigh between 1.7 and 2.5 kilograms, while blocks weigh roughly 20 kilograms.

The paste is firm in texture, cuts easily and is yellowfish in colour. It has few eyes regularly of irregularly distributed, inside the cheese, more or less round and variable in size from that of a grain of rice to that of a pea.

Its flavour is milky and very little salty.

Mild Edam is traditionally eaten with so-called "cheese fruits" such as peaches, melons, apricots and cherries. Old or aged Edam is usually eaten with pears or apples.

Like most cheeses, it is also common to eat it with crackers or with bread in the form of a sandwich, and it is also widely used in desserts such as cheesecakes. (WISCONSIN CHEESE, n.d)

It is also a great melting cheese so it can be eaten grated on pasta, in potato dishes and in dishes where the cheese is used as a filling.

Fig 5. Picture of Edam cheese

Table 3. Chemical composition of Edam cheese

Chemical Composition of Edam cheese (Composition,%)	
Water	42,5 ± 0,87
Fat Content	27,51 ± 0,38
Salt	1,49 ±0,07

1.7 EMMENTAL CHEESE USED IN THE STUDY

Emmental is a type of Swiss cheese manufactured from cow's milk that has distinctive eyes. It's a cheese from the Emme river region in the Alps.

Emmental is a general term that refers to this sort of cheese regardless of where it is produced. To set itself apart from the competition, the original cheese is known as Emmentaler AOC.

Since its birthplace in Switzerland, Emmental is now produced - under the general name of Emmental - in Germany, Austria, France, Finland, Denmark, and Ireland.

The total production in Europe reaches 490,000 tons and represents more or less 6% of the milk collection of those countries. France is the first producer of Emmental in the form of wheels. (BEDRI.ES,n.d)

Rennet or other approved coagulating enzymes are used to coagulate it. After chopping the curd into wheat grain-sized pieces, the grains are scalded to a minimum temperature of 50 degrees Celsius.

It is made in the form of big wheels that are covered in brine and aged for 3 to 6 months. Three bacterial species (including Propionibacterium *freudenreichii* subsp. *shermanii*) are required to manufacture this sort of cheese, each of which has a specific role, thus the proportions must be carefully calculated to ensure the desired level of acidity and flavor.

It can also be given in a cylindrical form. The bark is firm and dry, with a golden yellow to brown tint. There are also prismatic ones

In terms of the paste, it's ivory to pale yellow in color, delicate to the touch, and easy to cut. It is distinguished by its peculiar spherical eyes, which are formed from carbon dioxide produced by fermentation and trapped during production. They are found in varying numbers and are evenly dispersed, with sizes ranging from 1 to 3 centimeters.

Its flavor and aroma are mild, like that of walnuts. The maturation requires a minimum of sixty days from its manufacture. Normally, the Emmental cheese must keep its characteristics at a temperature of 18 °C for at least one month, from the moment it is ready for consumption.

Emmental cheese is one of the most widely used cheeses in the world for gratin due to its good melting properties and is usually used in dishes that require melted cheese such as gratins or casseroles and in sandwiches with melted cheese, and in this case, it is also one of the most important components of the foundes. Although its main use is as melting cheese, Emmental cheese can also be consumed cold, between sandwich breads or served on a plate with different types of fruit. (Alfaro et al., 2016)

Table 4. Chemical Composition of Emmental cheese

Chemical Composition of Emmental cheese (Composition,%)	
Water	37,5± 0,84
Fat Content	42,8 ± 0,63
Salt	2,1 ± 0,09

Fig 6. Emmental cheese used in study

1.8 "QUESO MEZCLA SEMICURADO" SPANISH CHEESE USED IN THE STUDY

This cheese *"Queso mezcla semicurado"* is made with a mixture of pasteurized cow's milk (60% minimum), sheep's milk (20% minimum) and goat's milk (6% minimum) and sheep rennet is used in its production. It has a two-month ripening in the cellar. It is presented with a natural rind, obtained from the development of molds on the surface of the cheese, which is combined with olive oil baths.

It is a cheese with a fine and tasty flavor, with a pleasant and delicate aroma. Pale ivory in color with a firm texture, it has small, well-spaced eyes.

The texture of this food's paste is determined by the curing process; it can be semi-hard, firm, soft, buttery, or melt in the mouth. A lactic flavor is detected, as well as acidic touches.

Semi-cured cheese is commonly used in a variety of dishes due to its well-balanced flavor, which is neither as soft as fresh or soft cheese nor as powerful as mature or aged cheese.

It takes anywhere from 30 days to three months to mature.

The cheese must be treated to the traditional curing procedure, which entails putting it in airtight chambers for 2 to 3 months, in order to produce the features of this product.

In the scale of types of cheese, we can point out that this is drier than fresh, but not more than cured, since they still have a percentage of whey inside.

The *Queso mezcla semicurado* may not have the same popularity with those cheeses that have matured for years, however, various producers express that in the authentic sub-dairy products of this category, the quality of the milk that has been used in its production can be better perceived, because as having less maturation time, the flavor of the milk will be more present in the food and more in those made with raw milk.

The *Queso Mezcla Semicurado* is a cheese that has a wide variety of uses, since it can be eaten alone; with cherry tomatoes, fresh basil, salt and extra virgin olive oil; also accompanied by a good fruit jam as an appetizer; accompanying a pasta dish or together with minced meat.

Fig 7. *Semicurado* cheese used in the study

Table 5. Chemical composition of *Semicurado* cheese

Chemical Composition of semicurado cheese (Composition, %)	
Water	37,3 ± 0,66
Fat content (in so	48,7 ± 0,7
Salt	2,1 ± 0,09

INGREDIENTS: Pasteurized cow's milk (min 82%), sheep (min 3%), Lactic Ferments, Rennet, Calcium Chloride (E-509), Salt. Contains: Preservatives and dyes: E-235, E-202 and E- 172. (May contain traces of egg). Origin of milk: Spain

1.9 NEW TENDENCIES IN CHEESE PRODUCTION AND SNACKS PRODUCTION

The cheese has helped consumers in a wide variety of ways, from snack making, to cheese pods, to establishing cheese as one of today's favorite and most convenient foods.

Even though cheese sales have fallen due to the problem related to Covid19 (restaurant closures, shortages in supermarkets and confinement), these facts have made us realize how important cheese is for us.

According to data from Mintel, cheese category sales grew 15% in 2021 COVID food trends, such as the rise in home cooking, the craving for comfort foods, and the need to keep convenient, healthy snacks on-hand for remote workers (and their kids), have highlighted the versatility of cheese. (MINTEL, 2020)

As a very healthy protein snack, cheese can compete with other ways of ingesting protein such as protein bars, protein shakes and it is even beginning to develop as an alternative to meat, since kebabs are beginning to be seen of cheese in barbecue concept. (MINTEL, 2020)

These products, due to their high protein content, provide great satiety to users of the fitness world and to nutritionists' clients.

In addition, the innovation of cheese when used in different ways as an ingredient, with different production processes and sustainability is showing that the cheese category is able to respond quickly to consumer's envolving needs. Here it is some trends in cheese production .

Shredded cheese

Due to the quarantine and because people have decided to spend more time at home and prepare their own dishes due to covid, grated cheeses have gained a lot of fame due to their use in some meals prepared collectively, such as pizzas or tacos.

According to a study carried out (MINTEL, 2020) 82% of the people interviewed use cheese in one of their meals and choose grated cheese as one of their favorite options. The great variety of existing cheeses has meant that this trend is expected to develop over the coming year as well.

Single-Serve Specialty cheese

The consumption of cheese in single-dose form has increased over the years, since it is a very easy and very accessible way to take cheese as a snack, and the consumption and marketing of premium cheeses is becoming fashionable in small monodoses since due to the pandemic it was not possible to go to restaurants

Functional cheeses

Another of the food trends derived from Covid is people's concern for their health and the health of their immune system, and in this field several measures have been taken, such as the introduction to the market by the macro babybel of a product that is enriched contains live, active cultures of LGG probiotic strains, vitamins A and B12 and it is called Babybel plus+ (MINTEL, 2020).

Crunchy cheese bars

The development of cheese-based snacks such as balls, bites or chips, is a recent innovation in the food industry and thanks to the current trend of eating away from home or eating at odd

hours, these products have become very popular since the vast majority have very suitable nutritional values and are a great option to ingest the recommended amount of daily protein. Among these products, the great variety of cheese bars that we can find in the market stand out, from matured cheddar cheese to jalapeño cheese; Also noteworthy are cheese-based snacks that are made using microwave energy, which are also on the rise.

2. OBJECTIVES AND WORK PLAN

2.1 OBJECTIVES

The aim of this work is to analyze the composition of different types of cheese affects the production, quality and shelf life of cheese snacks. For achieving of the aim, the following tasks are set:

1) To evaluate cheese composition used in the studies.
2) To make microwave drying experiment for setting the influence of cheese composition on cheese snacks quality and consumer perception
3) To analyse the changes of cheese snacks quality during the storage

2.2 WORK PLAN

The work plan followed to achieve the main objective was as follows (Fig.8):

-Analysis of raw materials (Edam cheese, Emmental cheese and *Queso Mezcla Semicurado*)

- Snack processing using a microwave energy dryer

- Packaging of the snacks in their corresponding containers

- Analysis of the different parameters (moisture content, peroxide value, firmness) over time.

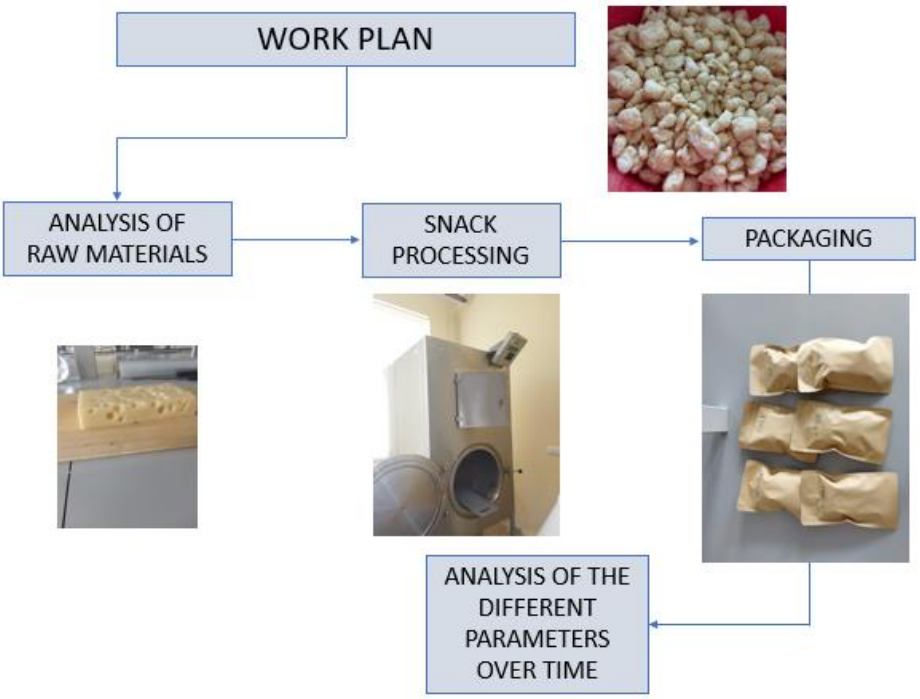

Fig.8 Outline of Workplan

3. MATERIALS AND METHODS

3.1 CHARACTERISTICS OF CHEESE USED IN THE STUDY

To produce cheese snacks, 3 types of cheese were used, which are: Emmental cheese bought in a local supermarket, Edam cheese made in the same university by another group of students and *"Queso mezcla semicurado"* cheese bought in the central market of Riga. Cheeses are from different parts of Europe. Specifically, from Switzerland, Netherlands and Spain.

These cheeses have different characteristics (fat, water, and salt content) (see **Table 5)**. So that is the reason why we have chosen them, because we wanted to have cheeses with different characteristics to see how each type of cheese affects the quality and acceptance of our final product.

Cheeses were, firstly, analyzed for their chemical composition (fat content, salt content and moisture content) and, secondly, cutted into cubes 1 cm wide and high for cheese drying in microwave drier. (Musson-1 ingredient microwave dryer)

Once these parameters in each of the types of cheese were measured, the final product, which are the ball-shaped cheese snacks, was produced. **(see Figure 2)**

To produce the snacks, drying process was carried out , in this case carried out a first drying experiment in the first week of study, in which a considerable number of snacks were produced, in this case snacks of the three different types of cheese was produced (Edam, Emmental and *Mezcla Semicurado* cheese). The cheese balls had initially a moisture content of 10%. Later, another batch of snacks were made , in this case only Edam and Emmental cheeses were used, and in this session, we carried out the drying process to see how adjusted final water content of the snacks influences quality and durability indicates

After the drying process, once the snacks are formed and it has been verified that there have not been any problems in production, proceed to let the snacks cool down for about 10 or 15 minutes and proceed to pack them in a large container. A sample of about 50 g of product is taken to put it in the container of cardboard bags with a layer of aluminum inside, this type of packaging was used because is the most typical for this type of product and we want to try to reproduce reality as accurately as possible.

Once you have had these snacks (first experiment) will be kept them for a total of 3 weeks (approximately a total of 40 days), after the production of the second batch we have repeated the same process mentioned above.

The samples have been preserved in containers and kept them in a place away from sunlight and at an ambient temperature of about 25ºC.

In the following sessions, will be evaluated how different characteristics evolved over time (firmness, peroxide content and moisture) five different sessions of measurements each approximately 10-15 days apart has been made.

3.2 EQUIPMENT USED IN DRYING PROCESS

To carry out the production process of cheese snacks, once you have the product cut into cubes of 1 cm on each side, enough wheat flour is added , this flour will help during the drying process because it will work as a carrier material to prevent the stickiness of the cubes. Once that the parameters for the drying experiment were calculated **(see 2.3)**, the cheese is placed into the dryer, specifically the "Musson-1 ingredient microwave dryer" has been used.

To produce our snacks, these parameters have been used:

Table 6. Parameters of drying process

Parameters of drying process	
Pressure (mm Hg)	56-70
Rotation speed (rpm)	6
Temperature (ºC)	50

Although it is a very suitable and optimal process for food processing, should be borne in mind that if a large amount of product is not produced, problems may arise such as the cheese melting due to the increase in temperature, since all the heat is not distributed equally throughout the product and it will become a paste that will have to be separated later in order to obtain the final product, the snacks.

Fig 9 Equipment used in drying process

Fig 10 & 11 Edam (10) and Emmental (11) cheese prior drying experiment

3.3 OPERATION AND CALCULATIONS FOR THE DRYING PROCESS

The drying process using this equipment (Musson-1 ingredient microwave dryer) is carried out through a series of calculations and equations for an iteration, with all this we calculate the amount of microwave energy (magnetrons) needed to obtain the snacks in an optimal way is calculated.

The equations are the following:

$$M_2 = M_1 \cdot \frac{100 - W_1}{100 - W_2},$$

This is the first equation that we used, and it will gave us the mass of cheese that we will obtain after the drying process. Where:

-M1= mass of cheese before drying process

-M2= mass of cheese after the drying process

-W1= initial humidity of the cheese

-W2= final humidity of the cheese (%)

Once we have calculated the mass of cheese that we will have after the drying process, we can calculate the evaporated moisture amount after the drying process with the following formula

$$\Delta M = M_1 - M_2,$$

Where: -M1=mass of cheese before drying

M2= mass of cheese after drying

ΔM=evaporated moisture amount

The amount of microwave energy (number of doses of magnetrons) required for drying process was calculated using the following formula:

$$X = \frac{\Delta M}{k},$$

Where:

- ΔM is evaporated moisture amount (%)

-K is a constant value that has a value of 16 since it is the amount of water that we can evaporate during the drying process with a magnetron per minute, in the same way with 42 kJ we can evaporate that amount of water.

So, once we have the value of X, we proceed to the iteration, in which we will divide the process into 4 stages, in the first stage we will put the highest number, that is, more energy since there is a greater amount of water, and in the following stages we will be lowering the number of magnetrons and therefore the energy.

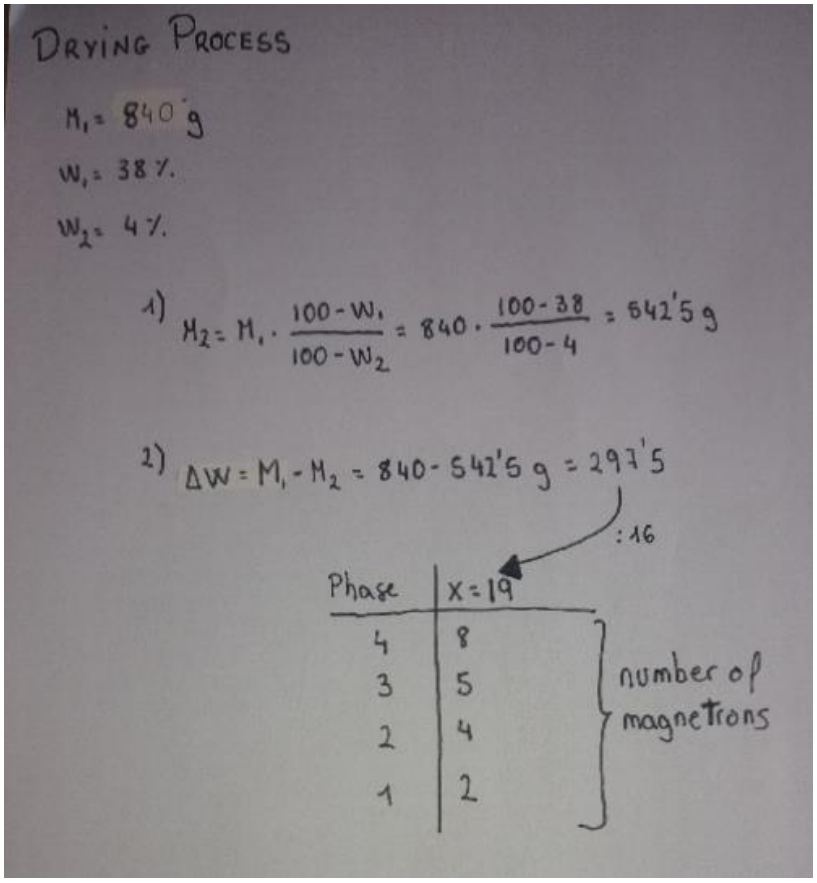

Fig 12. Example of magnetrons calculation

3.4 METHODS OF ANALYSIS

3.4.1 PROPERTIES MEASURED IN RAW MATERIAL

3.4.1.1 FAT CONTENT DETERMINATION

The determination of the fat in the cheese has been carried out following the method established by ISO 1735-2004, which specifies the reference method for the determination of the fat content of all types of cheese and processed cheese products having lactose contents below 5 %.

For this method, 10 ml of sulphuric acid are added (density 1.50-1.55 g/cm^3) to the milk butyrometer, then add 2 g of grated cheese are added to the followed 10 ml of sulphuric acid.

Next add 1 ml of amyl alcohol insert stopper and shake the butyrometer carefully until the cheese dissolves and no white particles can be seen. Place the butyrometer in the water bath at 70ºC and keep it there around 1 hour until the cheese is dissolved. The butyrometer must be placed in the centrifuge with the stem (scale) pointing towards the center of centrifuge.

Spin for 5 min 100 rpm in the centrifuge. Remove the butyrometer from the centrifuge. Put the butyrometers in a water bath maintained at 75 ºC for 5 min. before taking the reading

The fat column should be read from the lowest point of the meniscus of the interface of the acid-fat to the 0-mark of the scale and read butterfat percentage.

The fat content in cheese should be calculated according to the following equitation:

$$T = \frac{x * 11}{m}$$

where T- fat content %

X- reading of the butyrometer

M- cheese weight, g

11- experimentally determined coefficient

Fat content in cheese dry matter should be calculated according to the following equation:

$$Ts = \frac{(T * 100)}{(100 - W)}$$

where: T_s – fat content in dry matter, %

W – Water content in cheese, %

Fig 13. Determination of fat content using butyrometer

3.4.1.2 DETERMINATION OF MOISTURE CONTENT

The determination of the moisture in cheese has been carried out following the method established by ISO 5534:1985, which specifies the reference method for the determination of the moisture content of all cheese and processed cheese.

For this method a foil 100*100 mm must be weighed, then weight 4 g of grated cheese (with precision of 0.01 g), close with one foil and return the 10 mm edges, then for smooth sample dispersion press cheese, the open the package and put to the oven 130ºC, after 40 min take out the package and put to the desiccator.

Water content should be calculated according to the following equation:

$$W = \frac{(g - \mathrm{g1})}{(g - g0)} * 100$$

where: w- water content in cheese, %

g- mass of foil and cheese before drying, g

g_1- mass of foil and cheese after drying, g

g_0- mass of foil

3.4.1.3 DETERMINATION OF SALT CONTENT

The determination of the salt content in the 3 types of cheese has been carried out following the method established by ISO5943:2006, which specifies the reference method for the determination of the chloride content, specifically the chloride content in milk, milk products, infant formula and adult nutritionals by potentiometry.

First of all, 2 or 3 grated cheese should be added and weighed into a Erlenmeyer flask. Then added 25mL of 0,1 M $AgNO_3$ and 25 mL of HNO_3. the mixture is heated to boiling point and then when it is boiling, add 10 ml of $KMnO_4$ and during the solution is boiling and decolorizing, add another portion of $KMnO_4$ until the dark brown colour of solution remains. The excess of glucose

has been removed by the addition of point of the knife of glucose. To finish, the sample is diluted with 100 mL of water and 5 mL of $NH_4 Fe (SO_4)_2$ as a titration indicator. Finally the excess of $AgNO_3$ is titrated with $NH_4 SCN$ until the red-brown colour.

3.4.2 PROPERITES MEASURED IN CHEESE SNACKS

3.4.2.1 DETERMINATION OF FIRMNESS

Firmness was analyzed for the original product and the snacks. A device called TA HD plus Texture analyzer is used for this determination.

The TA HDplus Texture analyzer offers a maximum force capacity of 750 kg (7.5kN), and a family of intelligent, factory calibrated loadcells down to 0.5kg. It can perform precision testing to a few grams without compromising accuracy, whilst providing the required rigidity to accommodate measurements of considerably higher force for heavy duty applications. The greater testing bed area and height range offer the ability to test much larger samples within a twin column frame, making this instrument the obvious choice for users testing a wide range of products, or for those who have an uncertain future product testing requirement. (SCANCOTEC,2018).

In this case, a 5 mm tip was used , while measuring the cheese compression force, a test speed of 2 mm^{-1} was used ,a depth of press of 35 mm and a force applied of 0.0493N

This device can be used for:

-determine the effect of formulation or processing variable on product acceptability

-assess changes during storage or transportation

-compare with competitive product.

-determine the physical properties of your" gold standard" product for future consistent quality control.

An auxiliary equipment is required to use this texture analyzer, in this case is a computer which has the program provided by the company installed.

This program provides a series of graphs that shows the force profile that is applied to each sample of our snacks, which help to better understand the firmness of each test.

In this case this device has been used for determine the effect of formulation or processing variable on product.

5 sessions of analysis of the firmness have been carried out, in the 5 sessions was intented to carry out 3 replications for each product (*Mezcla Semicurado* cheese, edam cheese and Emmental cheese), but sometimes a problem has arisen with certain samples and we have had to carry out a higher number of samples.

Fig 14 Device used for firmness analysis

3.4.2.2 DETERMINATION OF PEROXIDE VALUE

The peroxide value in a product that contains a large amount of fat, is very important since it indicates the degree of oxidation of fats over time and is a great indicator of the quality of the product. Product since this oxidation of fats largely influences the degree of rancidity of the product.

For this determination of the peroxide value, we have carried out two replications for each type of cheese.

In this determination, the first step to be taken is to add 5 grams of cheese, which must have been previously crumbled, in an Erlenmeyer flask and then add 30 ml of acetic acid-chloroform and with the help of a fish magnet dissolve the sample until the cheese is almost dissolved. In the next step are added 0.5 ml of saturated potassium iodine solution and stir the mixture again so that it dissolves completely, once the sample has been dissolved, add 30 ml of distilled water and then add 1 ml of starch solution as indicator and the color will become lighter and we continue to titrate with $Na_2S_2O_3$ solution until the greyish-blue color disappears and then note the volume of sodium thiosulfate consumed.

$$\mathbf{PS} = \frac{(V1-V2)*C}{Weight\ of\ the\ sample} * 1000$$

V_1= Volume of $Na_2S_2O_3$ used for titration of sample, ml.

V_2= Volume of $Na_2S_2O_3$ used for titration of blank sample, ml

C= Molality of $Na_2S_2O_3$

3.4.2.3 DETERMINATION OF MOISTURE CONTENT IN CHEESE SNACKS

The determination of the moisture in cheese has been carried out by the oven drying method at 130ºC, it is a standard method for the vast majority of foods and is one of the most used in this world. We have done 3 replications for each type of cheese.

The first step that must be carried out is to weigh the container using a precision scale, immediately afterwards tare and weigh an amount of around 5 grams of our sample of cheese snacks, with the snacks of known mass and with the containers with the corresponding snack samples, are put into the drying oven for a total of 30 minutes at 130 ºC, after this time, containers are taken to a desiccator for about 10 minutes and then weigh them all together again (the container and the dried sample)

Water content should be calculated according to the following equation:

$$W = \frac{(g - \mathrm{g1})}{(g - g0)} * 100$$

where: w- water content in cheese, %

g- mass of recipient and cheese before drying, g

g_1- mass of recipient and cheese after drying, g

g_0- mass of recipient

4- RESULTS

4.1 RESULTS OF CHEESES USED IN THE STUDY (RAW MATERIALS)

For moisture content, we have made a total of 3 replicates for each type of cheese, from which we have obtained the mean and standard deviation, in the case of fat content we have made a total of 2 replicates of which we have made an average, and in the case of salt we have made only one replicate.

In **Table 7** is shown the results of the analysis that we have done the first day of laboratory, in this case we have analysed the moisture content, the fat content in dry matter and the salt content.

TABLE 7. Results of analysis of raw material

ANALYSED CHEESES	MOISTURE,%	FAT CONTENT (DRY MATTER)	SALT, %
QUESO MEZCLA SEMICURADO	37,24 ± 0,63	49,3	2,22
EMMENTAL CHEESE	38,07 ± 0,32	43,72	0,6
EDAM CHEESE	41,31 ± 0,79	39,1	1,6

As can be seen in the table, the cheese with the highest moisture content is Edam (41.31 ± 0.79), the cheese with the highest fat content in dry matter is the Semicurado Cheese from Spain (49.3) and relative to the salt content the cheese that has a higher value is the Semicurado cheese from Spain (2.22%)

Based on the information obtained through the composition of each of the cheeses that we have used for our study, we can observe that in all three cases they have a moisture content very similar to the standard composition that we have found. In the case of the fat content, we can observe that it is very similar to the chemical composition that we have found, and related to the salt content, is very similar too.

In the case of fats, it is expected that their content in our product will decrease since a partial function occurs during the drying process and this can be seen reflected in the fact that after the drying process part of the fats remain embedded in the walls of the plastic cylinder.

4.2 RESULTS OF CHEESE SNACKS

4.2.1RESULT OF MOISTURE CONTENT

After having carried out the drying experiment, we have proceeded to measure the moisture content of our snacks using the oven drying method, we have repeated this method in a total of 4 sessions, over the weeks. In all sessions, for each type of cheese we have made 3 replications, which has helped us to extract data on the mean and standard deviation.

In **Table 8** is shown the results of the moisture content analysis for analyzed cheese snacks. The data corresponds to the moisture content after production and after 1, 2 and 3 weeks of storage.

Table 8. Results of moisture content in cheese snacks

ANALYSED CHEESES	MOISTURE, % AFTER PRODUCTION	MOISTURE,% AFTER 1 WEEK OF STORAGE	MOISTURE,% AFTER 2 WEEKS OF STORAGE	MOISTURE,% AFTER 3 WEEKS OF STORAGE
Queso mezcla SEMICURADO	5,47± 0,09	5,91 ± 0,20	5,67 ± 0,38	7,76 ± 0,21
EMMENTAL CHEESE	9,20 ± 0,34	9,96 ± 0,83	9,53 ± 0,30	9,98 ± 0,35
EDAM CHEESE	9,29 ± 0,46	10,07 ± 0,24	9,28 ± 0,27	10,36 ± 0,62

In view of the results, we can see that the snacks with the highest moisture content are those based on Edam cheese.

We can also observe that the results in the second session are greater than in the third session, this is because in the first session our snacks were in cardboard containers with aluminium inside, and for the measurement of the second session we had to take the sample from the big bags which are not so optimal for storage, therefore, it is expected that they have a somewhat higher moisture content

Generally, we can observe that the moisture content increases over the weeks, which is to be expected in a product as dry as our snacks, the moisture generally increased due to the conditions of storage, because our product has a very low moisture content and tends to gain water from the environment.

4.2.2 RESULTS OF MOISTURE CONTENT IN NEW BATCH OF CHEESE SNACKS

In the 4th week, we have made another batch of snacks (2^{ND} experiment), therefore, in order to obtain more data and be able to have more evidence about them, we have also carried out the moisture content analysis on these snacks, where we tried to decrease the initial moisture content in snack samples.

In **table 9** we can see the moisture content results of second experiment cheese snacks. The data correspond to moisture content before storage and after one week of storage.

Table 9. Results of moisture content in new cheese snacks

ANALYSED CHEESES	MOISTURE ,% BEFORE STORAGE	MOISTURE,% AFTER 1 WEEK OF STORAGE
EMMENTAL	7,18 ± 0,04	7,75 ± 0,10
EDAM	5,79 ± 1,28	6,93 ± 0,12

We can observe that as in the case of the first experiment of snacks that were produced, the moisture content of the product rises with the sessions, which is to be expected since our product is a snack made by drying and therefore very dry and with high capacity to absorb water, due to storage conditions and exposure to moisture.

To alleviate this situation, another container could be found that would better maintain the humidity of the product or seek more optimal storage conditions with controlled temperature and moisture content in the air.

4.2.3 RESULTS OF PEROXIDE VALUE

After having carried out the drying process, and having obtained our snacks, we have proceeded to measure the peroxide values.

We have carried out 3 sessions to measure this value, in three different weeks.

In all the sessions we have made 2 replicates for each type of cheese, and we have obtained the average of both.

In **Table 10** we can observe the results from the three sessions of analysis of peroxide value of our product. Concretely we can observe the corresponding data of the peroxide value after production, and 1 and 2 weeks of storage.

TABLE 10. Results of peroxide value on cheese snacks

ANALYSED CHEESES	PEROXIDE AFTER PRODUCTION , mmol O^2/kg	PEROXIDE AFTER 1 WEEK OF STORAGE , mmol O^2/kg	PEROXIDE AFTER 2 WEEKS OF STORAGE , mmol O^2/kg
Queso Mezcla SEMICURADO	4,75	4,77	5,02
EMMENTAL	2,85	2,89	2,99
EDAM	1,95	1,98	2,03

We can observe that, as expected, that the peroxide value goes up during the storage, since this is mainly associated with the degree of oxidation of fats, therefore, since snacks are products with a high level of fats, these products tend to oxidize during storage, therefore, it would be necessary to look for a more suitable container so that this oxidation of fats does not occur to a greater degree, such as one that does not allow sunlight to enter and that does not have a lot of oxygen inside, since this is what promotes the oxidation of fats and therefore of the product

In the second experiment, we reduced the amount of water in the final cheese snacks (see table 8). Also peroxide value was measured of newly developed snacks and snacks after 10 days of storage (see table 10).

4.2.4 RESULTS OF PEROXIDE VALUE IN 2ND EXPERIMENT OF CHEESE SNACKS

In the 4th session, we have made another batch of snacks (2nd experiment), therefore, in order to obtain more data and be able to have more evidence about them, we have also carried out the peroxide value analysis on these snacks.

We have made, as in the previous case, 2 replicates for each of the samples and we have obtained the mean of both

Table 11 shows the results for the determination of the peroxide value in the second experiment. Specifically, the results after production and after one week of storage of the snacks.

TABLE 11. Results of peroxide value in 2ND EXPERIMENT

ANALYSED CHEESES	PEROXIDE AFTER PRODUCTION ,mmol O^2 /kg	PEROXIDE AFTER 1 WEEK OF STORAGE , mmol O^2/kg
EMMENTAL	4,92	4,95
EDAM	1,94	4,97

In this table we can see the results of the peroxide value in our new samples. As we can see, the same rule applies as in the case of the first experiment, the peroxide value increases with the passing of the sessions, this is because the cheese has a high fat content and with storage and as the sessions go by, these fats oxidize.

Microwave energy affects the stability of fats, as it contributes to their oxidation. This energy also affects the TBA index, which has a great relationship with the stability of fats since it is a measure of the degree of oxidation of fats during the microwave heating process, if we subject the sample to the temperature for a longer time. microwave energy, the TBA value is higher, therefore the degree of oxidation is higher and its level of stability is lower (Jittrepotch et al., 2010)

4.2.5 RESULTS OF FIRMNESS ANALYSIS

After having carried out our drying process, we have proceeded to measure the firmness of our product, in this case, we have carried out a total of 5 weeks, all of them with a total of 3 replicates for each type of snack and obtaining both the mean and the standard deviation of said data.

In **Table 12** we can see the results of the snacks that have been produced on the first experiment. Specifically, we can observe the firmness data after the production of snacks and after 2,3,4 and 5 week of storage.

Table 12. Results of firmness analysis in cheese snacks 1st experiment

ANALYSED CHEESES	EDAM CHEESE	EMMENTAL CHEESE	QUESO MEZCLA SEMCIURADO
FIRMNESS (1st EXPERIMENT) AFTER PRODUCTION ,N	39,53 ± 17,57	36,68 ± 7,12	52,54 ± 9,74
FIRMNESS (1ST EXPERIMENT)AFTER 2 WEEKS,N	43,18 ± 1,84	37,22 ± 18,59	65,16 ± 10,,78
FIRMNESS (1st EXPERIMENT) AFTER 3 WEEKS ,N	46,50 ± 13,81	49,66 ± 11,78	77,24 ± 15,53
FIRMNESS (1st EXPERIMENT) AFTER 4 WEEKS ,N	47,876 ± 0,60	51,91 ± 2,68	79,87 ± 4,25
FIRMNESS (1st EXPERIMENT) AFTER 5 WEEKS,N	49,48 ± 15,91	56,91 ± 12,30	80,75 ± 2,92

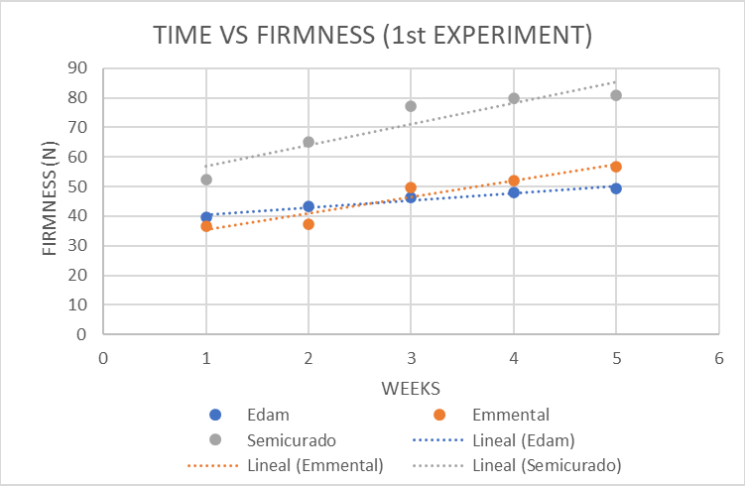

FIGURE 12. Time vs firmness (1st EXPERIMENT)

In **table 12,** we can see the results of the first experiment, based on the average values, we can see that generally for the three types of cheese, the firmness increases Over time, due to storage, where product absorbs the water from the environment, which causes it the loos of its characteristic crispness.

In **figure 15** we can see in a more graphic way what was previously described that the firmness of the product increases over time (and the value of the force to which the product must be subjected to pierce it increased too). In the axis Y we have the firmness, which has been measured with the equipment (TA HD plus Texture analyzer) and has units of newtons, and in the axis X there are the different weeks which firmness was measured (1,2,3,4 & 5)

It can also be seen that there is a deviation in the first datum of the Emmental cheese series.

In **table 13** we can see the results of firmness analysis from the second experiment of cheese snacks. Specifically we can observe the firmness data after the production and after 1 week of storage.

TABLE 13 Results of firmness analysis of second experiment

ANALYSED CHEESE	EDAM CHEESE	EMMENTAL CHEESE
FIRMNESS (2nd EXPERIMENT), AFTER PRODUCTION,N	43,15 ± 2,94	42,95 ± 6,74
FIRMNESS (2nd EXPERIMENT), AFTER 1 WEEK,N	58,30 ± 4,08	88,30 ± 1,49

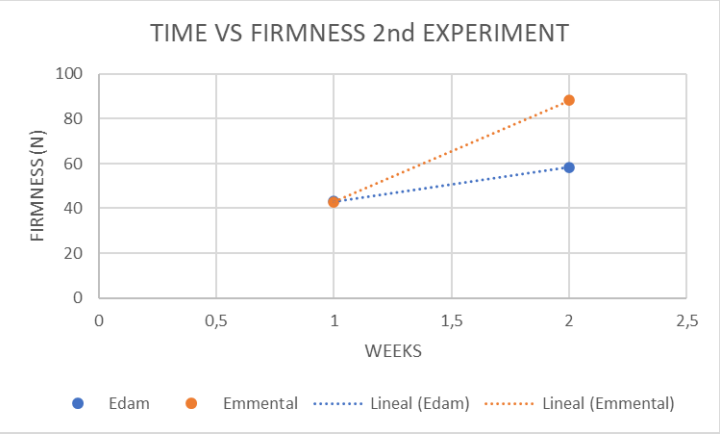

Figure 16. Time vs Firmness (2nd Experiment)

In Table 13 and Figure 13We can observe that as before, the firmness value normally increases with the passing of the sessions, and this is due to the gain of water due to storage.

The crispness and crunchiness are related to water activity, so it is found that scores of crispness for crackers, extruded snacks, and potato chips decreased with moisture content in a straight

line, because during the storage, the water activity of our snacks will increase considerably. (Tunick et al., 2013)

5. CONCLUSIONS

1. Once all the analyzes have been completed, based on the firmness during storage, it increases 10 N in the Edam type, 20 N in Emmental type and 30 N in Mezcla Semicurado.

2. In the peroxide value analysis we can see that due to its high fat content, Mezcla Semicurado cheese has the highest peroxide value.

3. Regarding the moisture content, the snacks produced from Mezcla Semicurado, despite having the lowest water content, gain a lot of moisture very quickly compared the other two cheeses.

4. From my point of view, I could say so, since after having tried the snacks several times, I can say that those that have a more different texture and flavor and are not as acceptable among the public are those that have been made with edam cheese as raw material.

5. Once we have seen how the characteristics of the product evolve, we can affirm that our container is not entirely acceptable and it would be more suitable to use a plastic container, specifically polypropylene.

6. The number of magnetrons that we must use in our drying process, depends on the product and water activity, but it will always be better to go higher number of magnetrons to less since at the beginning we have a greater amount of water.

7. We can try to do another experiment to lower the moisture content of our final product so that the crispness is not affected as much during storage.

8. After the study, we have concluded that the best storage conditions for our product are to store them in a cool and dry place, away from sunlight and at room temperature. And once opened, try to find a container as hermetic as possible to store them.

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