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PhD THESIS
SUMMARY

OBTAINING FOODS WITH HIGH NUTRITIVE VALUE AND INCREASED SAFETY AGAINST FOOD POISONING USING VOLATILE OILS FROM VEGETABLE PRODUCTS

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SUMMARY

The PhD thesis entitled "Obtaining foods with high nutritive value and increased safety against food poisoning using volatile oils from vegetable products" includes 9 chapters, 165 figures, 20 tables and 162 bibliographic references. The experimental researches took place in the period 2018-2021, and the results obtained were structured in two main parts: the documentary part and the experimental part.

The documentary part includes 4 chapters which are presented as it follows:

- previous research on food with high nutritional value and increased safety against food poisoning
- the importance of volatile oils extracted from different medicinal plants and their main characteristics and benefits
- bioactive principles of different dairy products

The experimental part includes 5 chapters in which are presented:

- Materials and methods used
- Results and discussions
- Partial and final conclusions
- Personal contributions
- Perspectives for further research

The experimental part took place at the "Lucian Blaga" University of Sibiu, in the laboratories of the Faculty of Agricultural Sciences, Food Industry and Environmental Protection and in the Physical-Chemical Laboratory within the company Solina Romania in Alba Iulia.

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INTRODUCTION

The last decades and especially the last year have shown us that without a healthy lifestyle it is very difficult to cope with an extreme situation, especially the one created by a pandemic. Both physical and mental health must be in harmony and reach the highest possible level so that we can withstand many factors such as pollution, stress and an unhealthy lifestyle.

The diet of each individual is a very important factor in managing health because, in addition to the beneficial and healthy role, it can prevent various diseases. Even though there are still many people who believe that the food we use does not directly affect our health, research in recent years has denied this and even promoted more and more healthy and organic foods and their labelling. It is becoming more and more common in the sales stores.

The consumer must be increasingly oriented into choosing quality foods with a high nutritional content that offers the possibility of a healthier diet.

This work aims to obtain foods with high nutritional value and increased safety against food poisoning using volatile oils from vegetable products.

To achieve this goal we have set the following objectives:

• characterization of the main ingredient of the food product;
• extraction and characterization of volatile oil;
• making capsules with volatile oil;
• obtaining the food product with the addition of encapsulated volatile oil;
• physico-chemical and sensorial characterization of the newly obtained product;
• determination by specific analyzes of the values of the nutrient components in volatile oils and from food products obtained through their use;
• comparative analysis between samples obtained without addition and those with the addition of volatile oils.

Keywords: volatile oils, antioxidants, dairy products, bioactive compounds, plants.

DOCUMENTARY PART

1. DOCUMENTARY STUDY ON OBTAINING FOOD PRODUCTS WITH HIGH NUTRITIVE VALUE AND INCREASED SAFETY AGAINST FOOD POISONING

1.1. ANALYSIS OF THE EXISTING SITUATION AT THE INTERNATIONAL AND NATIONAL LEVEL ABOUT OBTAINING HIGH NUTRITIVE VALUE AND INCREASED SAFETY AGAINST FOOD POISONING

The demand for healthy and nutritious food is currently growing worldwide. It is desired to make food products that, in addition to satisfying the need for food, also bring numerous nutritional contributions to the consumer's health (Jeyakumari et al., 2016). However, in 2019 the FAO (Food and Agriculture Organization) of the United States of America stated that world agri-food production will increase by about 70% in the coming decades. This is necessary to keep up with the growing population. Due to the intensification of food production, many changes will take place in terms of the quality and safety of these products (Ben Said et al., 2019). It is necessary for food processors to be aware of this and to produce food products that prevent consumers from becoming ill, helping to improve their physical and mental health (Jeyakumari et al., 2016).

1.2.ANALYSIS OF THE EXISTING INTERNATIONAL SITUATION ABOUT OBTAINING HIGHLY NUTRITIVE AND INCREASED SAFETY PRODUCTS AGAINST FOOD POISONING

Milk is a very complex chemical and physico-chemical system, and its perfect knowledge is indispensable for understanding the principles of its preservation and transformation into derived products. Cow milk is most commonly used in human nutrition because it closely resembles breast milk (Tița, 2001).

Numerous studies conducted in recent years have shown that regular consumption of dairy products can have a protective effect against the development of obesity and cardiovascular diseases (Iglesia et al., 2020). Fermented dairy products are highly valued for their health benefits to consumers. They can be consumed from an early age, and the best-known dairy product in this category is yoghurt (Tiţa et al., 2019).

2. PRESENTATION OF VOLATILE OILS OBTAINED FROM VEGETABLE PRODUCTS USED TO INCREASE SAFETY AGAINST FOOD POISONING AND OBTAINING HIGH NUTRITIVE FOOD PRODUCTS

2.1. BASIL VOLATILE OIL

Basil (*Ocimum basilicum* L.) is part of the *Lamiaceae* family and is a very important plant and often used in medicine, aromatherapy and gastronomy. Due to its composition and the presence of volatile oil, this plant has a specific aroma and taste (Imeri et al., 2014). According to studies, it has been shown that volatile basil oil has antimicrobial, antifungal, anticancer properties (Bayala et al., 2014).

2.2. FENNEL VOLATILE OIL

Fennel (*Foeniculum vulgare* L.) is part of the *Umbeliferae* family and is an aromatic plant being considered one of the oldest cultivated medicinal plants in the world (Sayed-Ahmad et al., 2017). Volatile fennel oil has an antioxidant and antimicrobial capacity (Al-Okbi et al., 2018).

2.3. LAVENDER VOLATILE OIL

Lavender (*Lavandula angustifolia*) is part of the *Lamiaceae* family and is an aromatic plant used in folk medicine to relieve stress and anxiety. Lavender volatile oil is recognized for being used in the treatment of anxiety, migraines, stress, irritability, exhaustion, depression, headaches, digestion, colds, flatulence, insomnia, loss of appetite, stomach upset, liver disease, nervousness and also in aromatherapy (Benny și Thomas, 2019).

2.4. DILL VOLATILE OIL

Dill *(Anethum graveolens)* is an annual plant used as a vegetable and belongs to the *Apiaceae* family. It grows up to 40-60 cm with thin hollow stems. It is used in cosmetics and in various medicinal preparations. Dill has antimicrobial, antioxidant and antispasmodic properties (Kumar et al., 2021).

2.5. MINT VOLATILE OIL

Mint (*Mentha piperita* L.) belongs to the *Lamiaceae* family and is a perennial plant, with a characteristic taste and smell, 40-120 cm high, with a branched stem, light purple or white to pink inflorescence in the form of an ear cultivated worldwide for the production of volatile oil. Numerous specialized studies have been performed over the years to demonstrate the antimicrobial and antioxidant activity of mint volatile oil. (Ramos et al., 2017).

2.6. OREGANO VOLATILE OIL

Oregano (*Origanum vulgare*) is part of the *Lamiaceae* family and is one of the most traded plant species. Traditionally, oregano is used in the culinary arts due to the specific aroma offered by the volatile oil (Marcial et al., 2016). Oregano volatile oil has antioxidant properties due to the presence of two phenolic compounds, carvacrol and thymol (Migliorini et al., 2019). Oregano volatile oil also has antimicrobial properties, according to studies, especially on the fungi *Aspergillus* sp., *Fusarium* sp. and *Penicillium* sp. (Bedoya-Serna et al., 2018).

3. THE MAIN COMPOUNDS OF VOLATILE OILS GIVE THEM ANTIMICROBIAL AND ANTIOXIDANT ACTIVITY

3.1. PINENE

α-pinene is a natural and active monoterpene, which is very often used as a flavouring and pharmaceutical agent (Niu et al., 2019).

3.2. β-MIRCENE

β-Mircene is a monoterpene hydrocarbon that has various bioactivities, such as antimicrobials, antioxidants (Falowo et al., 2019).

3.3. EUCALYPTOL

Eucalyptol is very often used in medicine, perfumery and flavuor preparation and it has been reported that this compound has various tumour inhibitory properties (Almeid et al., 2018).

3.4. CITRAL

Citral is a monoterpene aldehyde consisting of geranium and neural combination of isomers (Nordin et al., 2019).

3.5. EUGENOL

Eugenol has three functional groups, namely hydroxyl, methoxyl and allyl groups so that eugenol can be modified into different derivative compounds (Golkar și Moattar, 2019).

3.6. NEROLIDOL

Nerolidol is sesquiterpene alcohol that is found naturally in the essential oil of many floral plants (Cazella et al., 2019).

3.7. THYMOL

Thymol has a high antimicrobial capacity inhibiting the growth of *Enterobacter cloacae* and *Escherichia coli* bacteria (Berthold-Pluta et al., 2019) and antioxidant properties that prevented 95% -100% inhibition of hexanal for 30 days at a concentration of 5 ug / ml (Gedikoğlu et al., 2019).

4. PRESENTATION OF THE BIOACTIVE PRINCIPLES OF THE DIFFERENT DAIRY PRODUCTS

Milk is a white-yellow liquid, with a sweet taste and characteristic odour, secreted by the mammary gland of mammals, with a complex chemical composition that varies depending on the species, breed, diet, age and health (Galatanu, 2014). The nutritional characteristics of fermented dairy products are determined by the nutrients present in the milk, those from other ingredients and those resulting as metabolites generated by the fermentation produced by the lactic acid batteries (Segal, 2005).

EXPERIMENTAL PART

5. MATERIALS USED TO OBTAIN FOOD PRODUCTS WITH HIGH NUTRITIVE VALUES AND INCREASED SAFETY AGAINST FOOD POISONING

5.1. MATERIALS USED TO OBTAIN KEFIR SAMPLES FROM COW MILK WITH THE ADDITION OF VOLATILE OILS ENCAPSULATED IN SODIUM ALGINATE

The following ingredients were used to obtain the kefir samples:

1. Cow's milk from a farm in Sibiu county.
2. Starter culture - a mix of LYOFAST cultures, MS 059 DT, manufacturer SACCO was used to make kefir
3. Sodium alginate capsules with lavender volatile oil, sodium alginate capsules with mint volatile oil and sodium alginate capsules with fennel volatile oil.

5.2. MATERIALS USED TO OBTAIN SAMPLES OF FRESH CHEESE WITH THE ADDITION OF VOLATILE OILS ENCAPSULATED IN SODIUM ALGINATE

The following ingredients were used to obtain the samples of fresh cheese::

1. Cow's milk from a farm in Sibiu county.
2. Rennet - IDEAL liquid rennet was used for the manufacture of fresh cheese, producer IDEAL STILL EXIM SRL.
3. Sodium alginate capsules with dill volatile oil, sodium alginate capsules with oregano volatile oil and sodium alginate capsules with basil volatile oil.

6. ANALYSIS OF VOLATILE OILS FOR THE DETERMINATION OF ANTIOXIDANT AND ANTIMICROBIAL PROPERTIES

6.1. METHODS OF ANALYSIS

6.1.1. Determination of antimicrobial activity

The technique used to determine the antibacterial activity was Kirby Bauer which focuses on the quality of antimicrobial compounds to diffuse on culture media on which a culture of microorganisms is seeded in order to be tested.

6.1.2. Determination of antioxidant activity

A method adapted from the method applied by Tylkowski et al. Was used to determine the antioxidant activity in the samples of volatile oils. (2011) for ethanolic extracts of *Sideritis ssp*. L.

6.1.3. Statistical analysis

All data that has been obtained in the process for determining the antimicrobial and antioxidant activity of volatile oils were expressed according to the following statistical indicators: mean value, standard error of the mean, median, standard deviation.

6.2. RESULTS AND DISCUSSIONS

6.2.1. Determination of antimicrobial activity

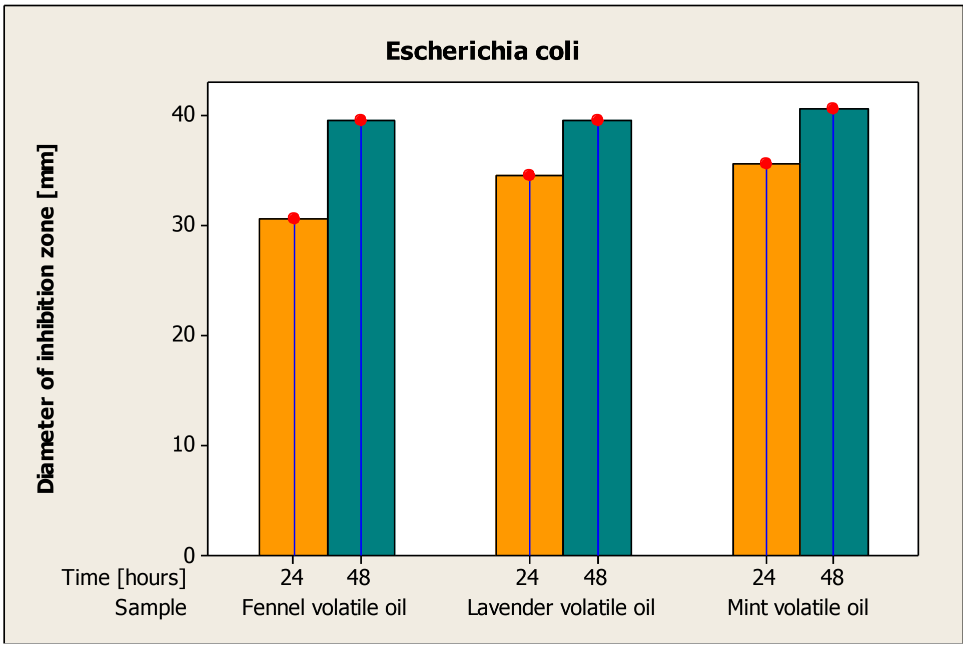

Figure 1. Inhibition of volatile oils of fennel, lavender and mint against *Echerichia coli*

Figure 1 shows the inhibition action of the volatile oils of fennel, lavender and mint against *Echerichia coli*. In the case of fennel volatile oil, after 24 hours, the average value of the diameter of the inhibition zone is 30.5 and the standard deviation is 0.707, the grade being sensitive. After 48 hours, the average value is 39.5 and the standard deviation is 0.707, the grade being sensitive. For lavender volatile oil, after 24 hours, the average value of the diameter of the inhibition zone is 34.5 and the standard deviation is 0.707, the grade being sensitive. After 48 hours, the average value is 39.5 and the standard deviation is 0.707, the grade being sensitive. Regarding mint volatile oil, after 24 hours, the average value is 35.5 and the standard deviation is 0.707, the grade being sensitive. After 48 hours, the average value is 40.5 and the standard deviation is 0.707, the grade being sensitive. All three types of volatile oils have an increase in inhibitory action between 24 and 48 hours. *Escherichia coli* is sensitive to all three types of volatile oils, both after 24 hours and after 48 hours. It has the highest sensitivity to mint volatile oil and the lowest to fennel volatile oil.

6.2.2. Determination of antioxidant activity

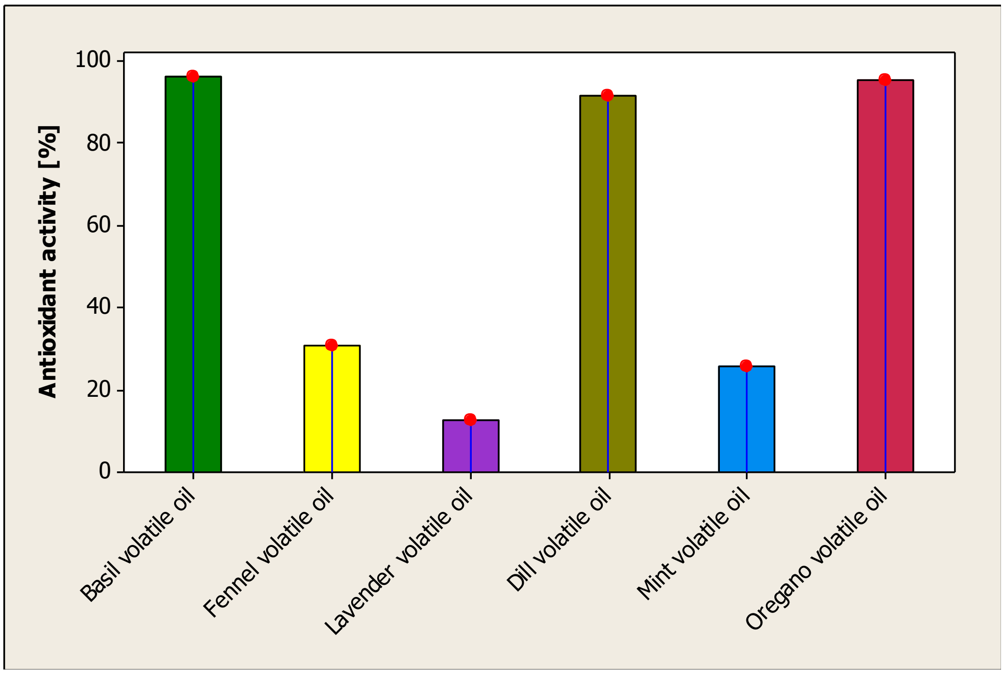

Figure 2. Antioxidant activity for the six assortments of volatile oils used in encapsulation

Figure 2 shows the antioxidant activity for the six assortments of volatile oils used in encapsulation. Basil volatile oil has an average antioxidant activity value of 96,373 and a standard deviation of 0.012. The median value is 96.38 and the skewness is -1.73, the histogram being oriented to the left. Fennel volatile oil has an average value of 30.623 and a standard deviation of 0.012. The median is 30.63 and the histogram is inclined to the left, the skewness is -1.73. The average value for the antioxidant activity of lavender volatile oil is 12,757 and the standard deviation is 0.015. The skewness is -0.9, the histogram is tilted to the left, and the median value is 12.76. The dill volatile oil has an average value of 91.713 ± 0.006, the median is 91.71, and the skewness has a positive value, the histogram being thus inclined to the right. The average value of antioxidant activity for mint volatile oil is 25.62 and the standard deviation is 0.01. The median is 25.62 and the histogram is perfectly symmetrical because the skewness is 0. Oregano volatile oil has an average value of 95.337 and a standard deviation of 0.012. The median value is 95.33 and the skewness is 1.73, the histogram being oriented to the right.

6.3. PARTIAL CONCLUSIONS

Following the antimicrobial determination, the mint volatile oil has the highest antimicrobial action against the chosen microorganisms, the only microorganism that showed resistance to it being *Aspergillus niger*. *Echerichia coli* has the highest sensitivity to this type of oil, the same sensitivity was shown in the case of *Penicillium expansum* and *Geotrichum candidum*.

The lavender and fennel volatile oil have a high antimicrobial action against *Escherichia coli*. Lavender volatile oil has antimicrobial action intermediate to *Geotrichum candidum* and *Penicillium expansum* and low to *Aspergillus niger*. Fennel volatile oil has a low antimicrobial action compared to other selected microorganisms

In terms of antioxidant activity, basil volatile oil has the highest value. It is followed by the oregano and dill volatile oil. Fennel and dill oils have similar antioxidant activities, and the lowest value is lavender volatile oil.

7. ANALYSIS OF KEFIR'S CHARACTERISTICS

7.1. METHODS OF ANALYSIS

This chapter presents the analysis performed to determine the main characteristics of kefir enriched with encapsulated volatile oils:

- Sensorial analysis using a non-numerical method based on several multi personal approval criteria
- Determination of acidity by the Thörner method
- Determination of lactose content by polarimetric method II
- Determination of dry matter content using the ML-50 moisture analyzer
- Determination of water activity using the "Novasina" device
- Determination of water retention capacity using the centrifugation test
- Determination of syneresis by centrifugation and drainage
- Determination of pH using the Orion 2 Star pH meter
- Texture profile analysis using the TA.XTpulsC- texture analyzer
- Determination of lactose and D-galactose content by an enzymatic method
- Determination of D-glucose content by an enzymatic method
- Determination of L-Glutamic acid content by an enzymatic method
- Determination of acetic acid content by an enzymatic method
- Determination of ethanol content by an enzymatic method
- Determination of L-lactic acid content by an enzymatic method
- Determination of antioxidant activity

7.2. RESULTS AND DISCUSSIONS

7.2.1. Sensory analysis

Table 1. Kefir sensory analysis results summary using a non-numerical method based on multiple multi personal approval criteria

Alternative	**Decision**		
	Day 1	**Day 10**	**Day 20**
Cow milk kefir enriched with encapsulated lavender volatile oil	Satisfying	Good	Satisfying
Cow milk kefir enriched with encapsulated mint volatile oil	Satisfying	Good	Satisfying
Cow milk kefir enriched with encapsulated fennel volatile oil	Satisfying	Good	Satisfying
Control sample	Satisfying	Satisfying	Acceptable

As can be seen in Table 1, the best results obtained from the sensory analysis of the kefir samples were obtained on day 10. On this day, the kefir samples enriched with volatile oils obtained the grade "Good", and the control sample obtained the grade " Satisfying ". On day 1, all kefir samples analyzed sensory obtained the grade "Satisfying ". On day 20, the kefir samples enriched with volatile oils obtained the grade "Satisfying" and the control sample obtained the grade "Acceptable".

7.2.2. Determination of acidity - Thörner method

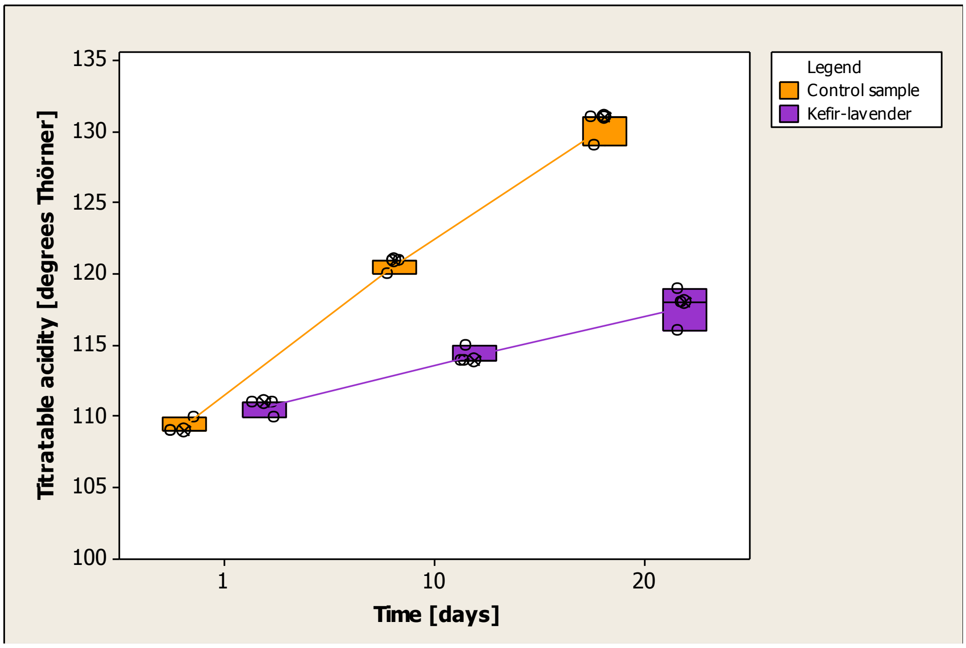

Figure 3. Comparative variation of titratable acidity in the sample of kefir enriched with encapsulated lavender volatile oil and the control sample

Figure 3 shows the comparative variation of the titratable acidity for the kefir sample of cow's milk enriched with encapsulated lavender volatile oil and the control sample during the 20 days of storage. On the first day, the sample of kefir with lavender volatile oil has an average acidity value of 110.67 degrees Thörner and a standard deviation of ± 0.577. The median value is 110, and the skewness is -1.73, which means that the histogram is tilted to the left. The control sample has an average acidity of 109.33 ± 0.577, the median is equal to 109, and the skewness is positive thus indicating a histogram inclined to the right. On the 10th day of storage, the kefir sample with volatile oil has an average acidity value of 114,33 and a standard deviation of ± 0,577. The value of the skewness is 1.73, so the histogram is tilted to the right. The control sample has an average acidity of 120.67 with a standard deviation of 0.577, the median value is 121, and the skewness is -1.73, the histogram being thus oriented to the left. On the 20th day of storage, the mean acidity value of the kefir sample with lavender volatile oil is 117.67 with a standard deviation of 1.53, the median value is 116, and the histogram is tilted to the left because the skewness is -0.94. In the case of the control sample, the mean acidity is equal to 130.33 ± 1.15, the median value is 131, and the skewness is -1.73, the histogram being thus oriented to the left. In the case of the Pearson correlation between Sample 1 and Sample 4, on the first day, the coefficient is equal to 0.5, which indicates a moderately positive association between the two variables. On the 10th day, the coefficient is equal to -1 which indicates a strong negative association between the two variables, and on the 20th day, the association between the two variables is strongly negative because the coefficient is equal to -0.756.

7.2.3. Determination of lactose content by polarimetric method II

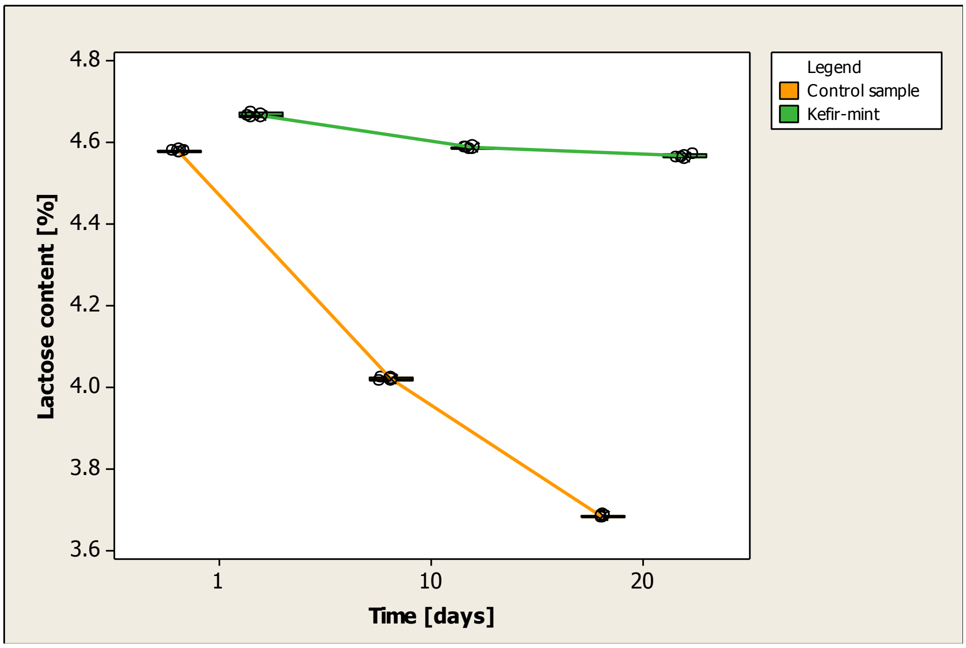

Figure 4. Comparative variation of the lactose content of the kefir sample enriched with encapsulated mint volatile oil and the control sample

Figure 4 shows the comparative variation of the lactose content of the kefir sample enriched with encapsulated mint volatile oil and the control sample. On day 1 of storage, the average lactose content of the kefir sample with mint volatile oil is 4,666 with a standard deviation of 0.006. The median is equal to 4,664, and the skewness is 1.51, the histogram being oriented to the right. The control sample has a lactose content of 4.577 ± 0.003, the median is equal to 4.578, and the histogram is inclined to the left because the skewness is -1.46. On day 10 of storage, the kefir sample with volatile oil has a lactose content of 4,587 and a standard deviation of 0.002. The value of the median is 4.588, and the skewness is negative. The control sample has an average lactose content of 4.021 ± 0.004, the median is equal to 4.021, and the skewness is negative, the histogram being oriented to the left. On the 20th day of storage, the lactose content of the kefir sample with mint volatile oil is 4,566 ± 0,006, the median value is 4,564 and the skewness is 1,510, the histogram being to the right. The control sample has an average lactose content of 3,684 ± 0.003, and the skewness is -1.460, the histogram being oriented to the left. For the correlation between Sample 2 and Sample 4, the coefficient from day 1 is 0.161, the association being weakly positive. On day 10 the coefficient is equal to -0.319, the association between the two variables being moderately negative, and on day 20 the coefficient is equal to 0.516, the association between the two variables being moderately positive.

7.2.4. Determination of dry matter content

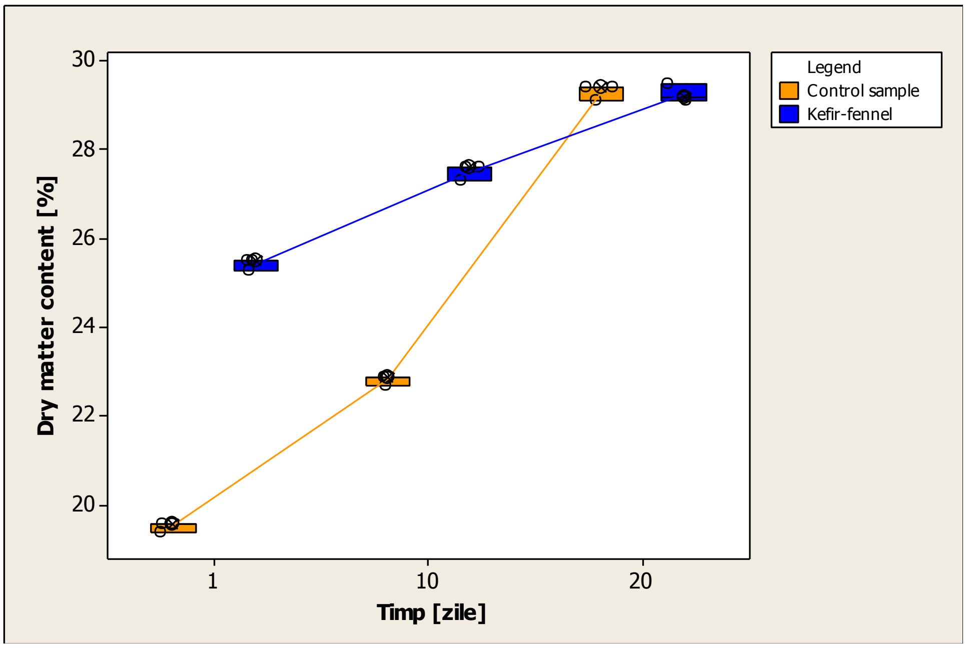

Figure 5. Comparative variation of the dry matter content of the kefir sample enriched with encapsulated fennel volatile oil and the control sample

Figure 5 shows the comparative variation of the dry matter content of the kefir sample enriched with encapsulated fennel volatile oil and the control sample. On the first day of storage, the sample of kefir with volatile fennel oil has an average dry matter content of 25,433 and a standard deviation of 0,115. The median value is 25.5, and the skewness is -1.73, the histogram being oriented to the left. In the case of the control sample, the average value of the dry matter content is 19,533 and the standard deviation is 0.115. The median value is 19.6, and the skewness is -1.73, the histogram being oriented to the left. On the 10th day of storage, the kefir sample with fennel volatile oil has an average dry matter content of 27.5 ± 0.173, and the asymmetry index is -1.73, the histogram being oriented to the left. The control sample has an average dry matter value of 22.833 ± 0.115, and the skewness value is negative, the histogram being oriented to the left. On the 20th day, the sample of kefir with fennel volatile oil has an average dry matter value of 29.267 ± 0.208, and the skewness is 1,290, the histogram being oriented to the right. The mean value of the dry matter content of the control sample is 29.3 ± 0.173 and the value of the skewness is -1.73. In the case of Sample 3 and Sample 4, the correlation coefficient is 1 on the first day, the association being strongly positive. On the 10th day, the correlation coefficient is 1, the association being strongly positive, and on the 20th day, the correlation coefficient is 0.693, the association being strongly positive between the two variables.

7.3. PARTIAL CONCLUSIONS

Following the sensory analysis, the results obtained show that for the kefir samples with volatile oils the sensory characteristics are highlighted during storage, on day 10 obtaining the highest ratings.

On the first day of storage, the highest acidity is in the kefir sample with lavender volatile oil, and the lowest in the kefir sample with mint volatile oil. The lowest lactose values are recorded in the control sample, and the highest is recorded in the case of the kefir sample with encapsulated lavender volatile oil. The dry matter content increases during the 20 days of storage. On day 1 of storage, the highest dry matter content is the kefir sample with mint volatile oil, and the lowest in the control sample.

8. ANALYSIS OF THE CHARACTERISTICS OF FRESH CHEESE

8.1. METHODS OF ANALYSIS

This chapter presents the analysis performed to determine the main characteristics of fresh cheese enriched with encapsulated volatile oils.:

- Sensorial analysis using a non-numerical method based on several multi personal approval criteria
- Determination of acidity by the Thörner method
- Determination of lactose content by polarimetric method II
- Determination of dry matter content using the ML-50 moisture analyzer
- Determination of water activity using the "Novasina" device
- Determination of water retention capacity using the centrifugation test
- Determination of syneresis by centrifugation and drainage
- Determination of pH using the Orion 2 Star pH meter
- Texture profile analysis using the TA.XTpulsC- texture analyzer
- Determination of lactose and D-galactose content by an enzymatic method
- Determination of D-glucose content by an enzymatic method
- Determination of L-Glutamic acid content by an enzymatic method
- Determination of acetic acid content by an enzymatic method
- Determination of L-lactic acid content by an enzymatic method
- Determination of antioxidant activity

8.2. RESULTS AND DISCUSSIONS

8.2.1. Determination of water activity

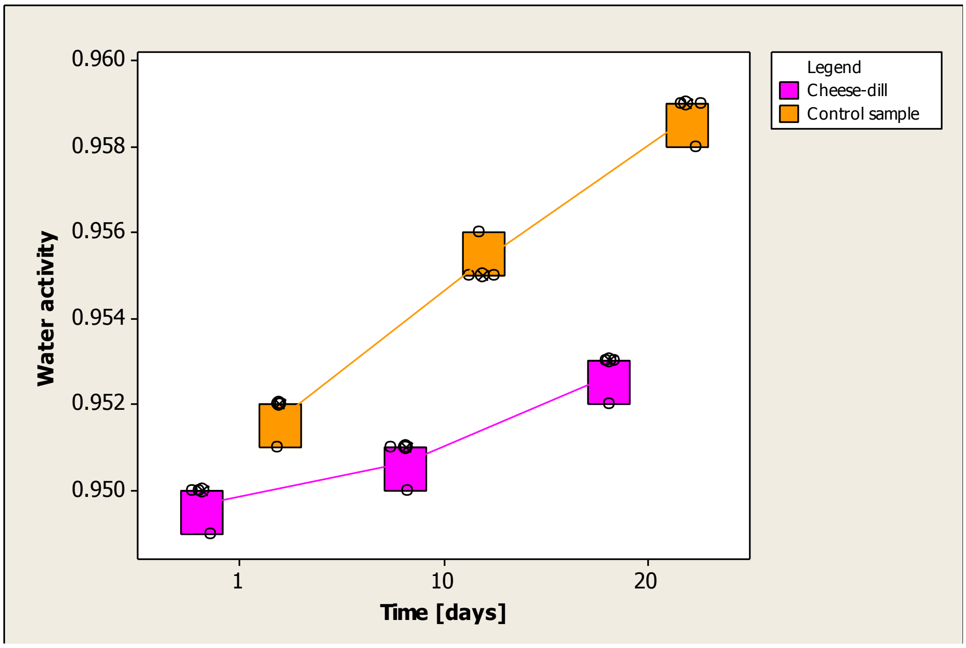

Figure 6. Comparative variation of water activity from fresh cheese sample enriched with encapsulated dill volatile oil and control sample

Figure 6 shows the comparative variation of water activity in the sample of fresh cheese enriched with encapsulated dill volatile oil and the control sample. On the first day of storage, the sample of fresh cheese with dill volatile oil has an average water activity value of 0.950 and a standard deviation of 0.0006. The median value is 0.950 and the skewness is -1.73, the histogram being oriented to the left. The control sample has an average value of water activity of 0.952 and a standard deviation of 0.0006. The median value is 0.952 and the skewness is -1.73, the histogram being oriented to the left. On the 10th day of storage, the sample of fresh cheese with dill volatile oil has an average water activity value of 0.951 and a standard deviation is 0.0006. The median value is 0.951 and the skewness is -1.73, the histogram being oriented to the left. The control sample has an average water activity of 0.955 and a standard deviation of 0.0006. The median value is 0.955 and the histogram is oriented to the right because the skewness is 1.73. On the 20th day of storage, the cheese sample with volatile oil has an average value of water activity of 0.953 ± 0.0006, and the skewness is -1.73, the histogram being oriented to the left. The control sample has an average value of water activity of 0.959 and a standard deviation of 0.0006. The median value is 0.959, and the skewness is -1.73, the histogram being oriented to the left. In the case of the Pearson correlation between Sample 1 and Sample 4, on the first day, the coefficient is equal to 1, which indicates a strong positive association between the two variables. On the 10th day, the coefficient is equal to -1 which indicates a strong negative association between the two variables, and on the 20th day, the association between the two variables is strongly positive because the coefficient is equal to 1.

8.2.2. Determination of water retention capacity

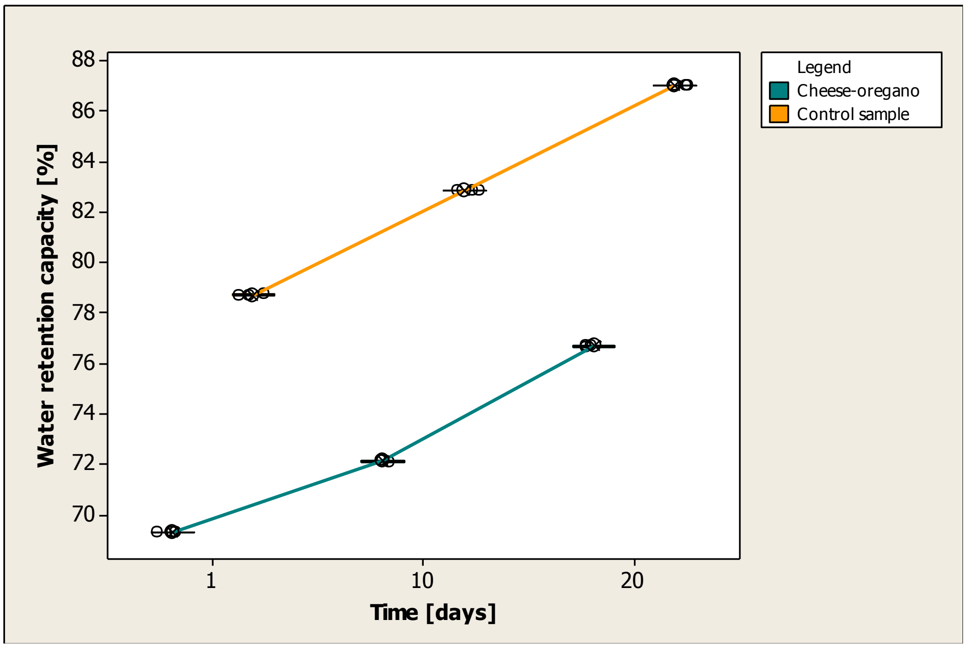

Figure 7. Comparative variation of water retention capacity from fresh cheese sample enriched with encapsulated oregano volatile oil and control sample

Figure 7 shows the comparative variation of the water retention capacity of the fresh cheese sample enriched with encapsulated oregano volatile oil and the control sample. On the first day of storage, the sample of fresh cheese with oregano volatile oil has an average water retention capacity of 69.34 and a standard deviation of 0.01. The value of the median is 69.34, and the skewness is 0, the histogram being perfectly symmetrical. The control sample has an average water retention capacity of 78,733 and the standard deviation is 0.006. The median value is 78.73, and the skewness is 1.73, the histogram being oriented to the right. On the 10th day of storage, the sample of fresh cheese with volatile oil has an average water retention capacity of 72.14 and a standard deviation of 0.01. The value of the median is 72.14, and the skewness is 0, the histogram being perfectly symmetrical. The control sample has an average value of water retention capacity of 82.86 and a standard deviation of 0.017. The median value is 82.87 and the skewness is -1.73, the histogram being oriented to the left. On the 20th day of storage, the sample of fresh cheese with volatile oil has an average water retention capacity of 76.7 and the standard deviation is 0.01. The median value is 76.71, and the skewness is -1.73, the histogram being inclined to the left. The control sample has an average water activity capacity of 87,043 and a standard deviation of 0.012. The median value is 87.05 and the histogram is oriented to the left because the skewness is -1.73. For the correlation between Sample 2 and Sample 4, the Pearson coefficient from the first day is -0.866, the association being strongly negative. On the 10th day, the coefficient is equal to 0.184, the association between the two variables being weakly positive, and on the 20th day, the coefficient is equal to 1, the association between the two variables being strongly positive.

8.2.3. Determination of pH

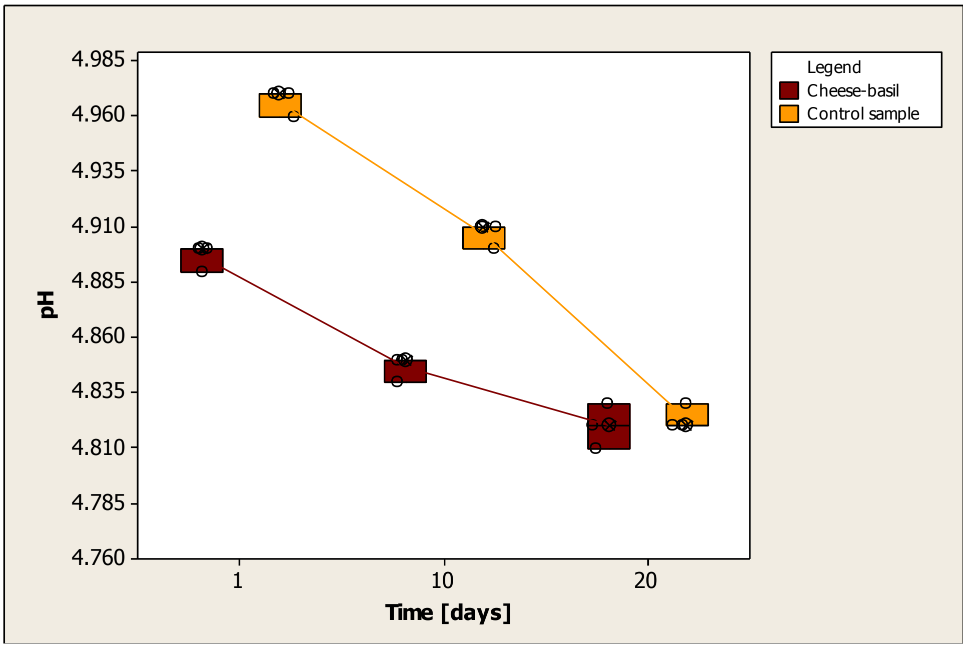

Figure 8. Comparative pH variation of fresh cheese sample enriched with encapsulated basil volatile oil and control sample

Figure 8 shows the comparative variation of the pH of the fresh cheese sample enriched with encapsulated basil volatile oil and the control sample. On the first day of storage, the cheese sample with basil volatile oil has an average pH value of 4.897 ± 0.006, and the asymmetry index is -1.73, the histogram being oriented to the left. The control sample has an average pH value of 4.967 ± 0.006, and the skewness is -1.73, the histogram being oriented to the left. On the 10th day of storage, the sample of fresh cheese with basil volatile oil has an average pH value of 4,847 ± 0.006. The median value is 4.85 and the skewness is -1.73, the histogram being oriented to the left. The control sample has a mean pH value of 4.907 ± 0.006. The median value is 4.91 and the histogram is oriented to the left because the skewness is -1.73. On the 20th day of storage, the sample of fresh cheese with basil volatile oil has an average pH value of 4.82 ± 0.01. The value of the median is 4.82 and the skewness is 0, the histogram being perfectly symmetrical. The control sample has a mean pH value of 4.823 ± 0.006. The median value is 4.82 and the asymmetry index is 1.73, the histogram being oriented to the right. In the case of the Pearson correlation between Sample 3 and Sample 4, the association from the first day and the 10th day is moderately negative because the correlation coefficient is -0.5. On the 20th day, the association is strongly positive with a coefficient of 0.866.

8.2.4. Determination of antioxidant activity

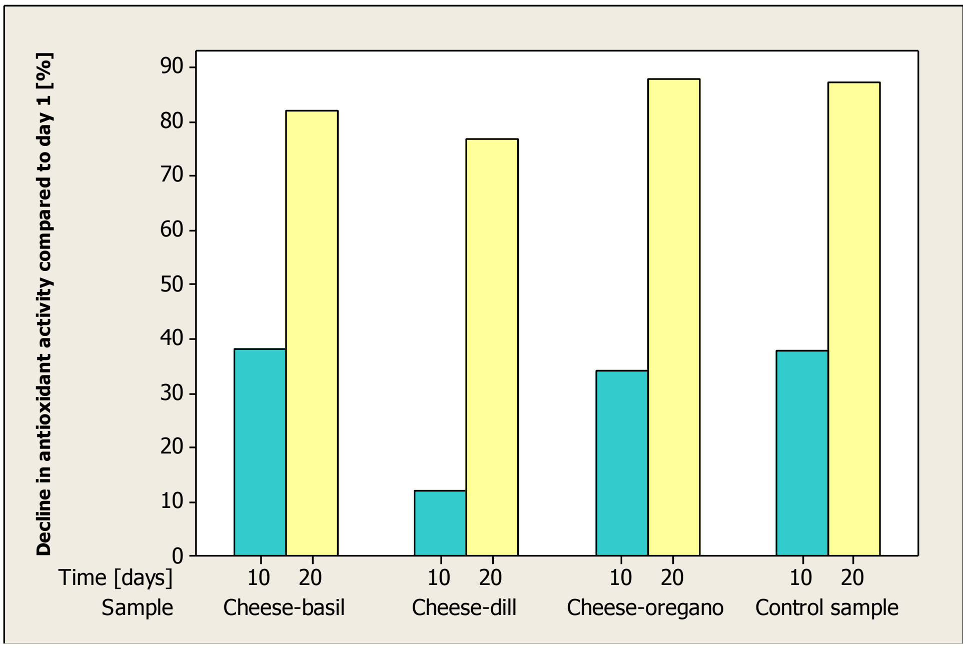

Figure 9. Decline in antioxidant activity on day 10 and day 20 of storage for fresh cheese samples compared to day 1 of storage

Figure 9 shows the decline in antioxidant activity on day 10 and day 20 of storage for fresh cheese samples compared to day 1 of storage. In the case of the sample of fresh cheese with dill volatile oil, the decline on day 10 compared to day 1 is 12.12% and that on day 20 is 76.96%. In the case of the sample of fresh cheese with oregano volatile oil, the decline on day 10 compared to day 1 is 33.97% and that on day 20 is 87.8%. The decline on day 10 in the case of the sample of fresh cheese with the addition of basil volatile oil is 38.22% and on day 20 is 82%. For the control sample, the decline on day 10 is 37.8% and on day 20 is 87.15%. We can conclude that the sample of fresh cheese with dill volatile oil is the most stable in terms of antioxidant activity because it has the lowest value of decline compared to day 1. In the case of the other three cheese samples, the value of the decline on day 10 is approximately equal. The largest decrease in antioxidant activity is recorded between day 10 and day 20 of storage, this being visible by the high value of the decline from day 20 compared to day 1 in the case of all four cheese samples.

8.3. PARTIAL CONCLUSIONS

During storage, the water activity in fresh cheese samples increases. On the first day of storage, the highest water activity has the control sample, and the cheese samples with volatile oils have the same water activity. On the 10th and 20th day of storage, the highest water activity has the control sample, and the lowest water activity has the cheese sample with basil volatile oil.

Throughout the storage period, the highest water retention capacity has the control sample, and the lowest water retention capacity has the fresh cheese sample with oregano volatile oil.

During the twenty days of storage, the pH of the samples of fresh cheese decreases. On day 1 of storage, the highest pH is the control sample, and the lowest in the sample of fresh cheese with oregano volatile oil. On days 10 and 20 of storage, the control sample has the highest pH, and the lowest in the cheese sample with dill volatile oil.

During the twenty days of storage, the antioxidant activity of fresh cheese samples decreases. On the first day of storage, the highest value of the antioxidant activity is the sample of fresh cheese with basil volatile oil, and the lowest in the control sample. On the 10th and 20th day of storage, the highest antioxidant activity is the cheese sample with dill volatile oil, and the lowest in the control sample.

9. FINAL CONCLUSIONS

Following numerous studies, it has been concluded that regular consumption of dairy products can prevent many cardiovascular diseases and obesity-related diseases. The most consumed dairy products at the moment are sour dairy products and cheese (Tița et al., 2020). Kefir is a fermented milk product, traditionally produced with kefir grains that have a specific combination of bacteria and yeast (Bellikci-Koyu et al., 2019).

The realization of a fermented dairy product with high nutritional value was considered, and for this purpose, kefir enriched with three types of volatile oils (lavender volatile oil, mint volatile oil and fennel volatile oil) was made. Due to the sensitivity of volatile oils to various factors, they were encapsulated in the sodium alginate and introduced as spherical capsules into the dairy product. According to studies, these volatile oils have a high antimicrobial and antioxidant capacity.

The kefir samples were analyzed from a physico-chemical point of view, highlighting the variation of acidity, pH, lactose content, dry matter, water activity, water retention capacity and syneresis and also from an enzymatic point of view, the content of lactose, D-galactose, D-glucose, L-Glutamic acid, acetic acid, ethanol and L-lactic acid. All data were expressed according to the following statistical indicators: mean value, standard error of the mean, median, standard deviation, maximum value, minimum value and skewness. All statistical analyzes were performed using the Minitab version 14 program.

Another dairy product with high nutritional value was considered, therefore, we enreached fresh cheese with three types of volatile oils, dill volatile oil, oregano volatile oil and basil volatile oil.

The sensory analysis was performed under the same conditions as in the case of kefir samples. For the interpretation of the obtained results, a non-numerical method based on several described multi-person approval criteria was used.

Physico-chemical analysis performed for fresh cow's cheese samples focused on the variation of acidity, pH, lactose content, dry matter, water activity, water retention capacity and syneresis. Enzymatic analyzes revealed the variation of the content of lactose, D-galactose, D-glucose, L-Glutamic acid, acetic acid and L-lactic acid. All data were expressed according to the following statistical indicators: mean value, standard error of the mean, median, standard deviation, maximum value, minimum value and skewness. All statistical analyzes were performed using the Minitab version 14 program.

As a conclusion, we can say that the volatile oils added in both kefir and fresh cheese have positively influenced the sensory, physico-chemical and enzymatic characteristics of the finished product. Samples enriched with encapsulated volatile oils obtained superior results compared to the control sample in all determinations made.

All these aspects show that the analyzed products fit perfectly in the current trend due to the benefits on the health of the consumer, as well as to increase the shelf life of the product by incorporating bioactive components.

9.1. PERSONAL CONTRIBUTIONS

The personal contributions found in this paper are the following:

- Characterization of volatile oils in terms of antimicrobial and antioxidant activity.
- Encapsulation of these volatile oils in sodium alginate to use them in the manufacture of foods with high nutritional value and increased effect against food poisoning.

- Performing sensory, physico-chemical and enzymatic analysis for kefir and fresh cheese to establish a high nutritional potential.
- Offering an alternative dairy product enriched with bioactive compounds that can prevent or treat digestive diseases that occur mainly due to an unbalanced diet.
- Providing an external source of antioxidant compounds needed by the body to withstand periods of high stress, especially in the context created by the pandemic.
- Obtaining two optimal and unique dairy products through their nutritional value.

9.2. RESEARCH DEVELOPMENT PERSPECTIVES

To continue the research included in this paper, I propose the following actions:

- The development of new dairy products in which to use volatile oils encapsulated with antimicrobial and antioxidant potential.
- Create of food products enreached with volatile oils from other industries such us: meat products, sweets, etc.
- Application of other methods of analysis to highlight the nutritional characteristics and bioactive potential of the products of this study, as well as other food products obtained.
- Analysis and use of other types of volatile oils in food, as well as highlighting the importance of harnessing the nutritional potential.
- Promoting functional foods and including them on the food market.

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