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(*) Corresponding author
Peer review method: Double-blind
Original research article
DOI: 10.20544/HORIZONS.1.1.23.P07



SENSORY AND PH EVALUATIONS OF NOVEL VARIETIES OF KEFIR

Elena Damjanovska Gavriloska*

UKLO, Faculty of Technology and Technical Science -Veles
elena3dam@gmail.com

Tatjana Kalevska

UKLO, Faculty of Technology and Technical Science -Veles
tatjana.kalevska@uklo.edu.mk

Gordana Dimitrovska

UKLO, Faculty of Biotechnical Science -Bitola
gordana.dimitrovska@uklo.edu.mk

Jasenka Gajdoš Kljusurić

University of Zagreb, Faculty of Food Technology and Biotechnology
jasenka.gajdos@pbf.unizg.hr

ABSTRACT

The paper aims to assess the sensory attributes and pH changes in newly formulated varieties of kefir with the purpose of exploring customer acceptance of a novel dairy beverage.

Sensory evaluation of novel variations of kefir incorporating dietary fibers and flavors: strawberry-CKS, vanilla-CKV and peach-CKP. The evaluation encompasses appearance, color, aroma, consistency, and taste, providing a comprehensive understanding of the sensory profiles of these kefir variants.

The methods employed in this study involved, the technological method of obtaining these industrial kefir; sensory analysis of three varieties functional kefir and classic kefir (CK) using scoring and ranking methods; t-tests for assessing statistical significance ($p < 0.05$, $p < 0.01$, $p < 0.001$) between functional kefir and classic kefir (with two repeated samples) and time intervals (1-7-14, 21 days); and comparison of dynamic changes in pH value in kefir.

The results revealed significant sensory variations among kefir variants. On the first day, CKS showed higher consistency and aroma scores, while CKV excelled in appearance, color, and aroma. On the 7th day, CKS scored higher in consistency and aroma, whereas CKV achieved better scores in appearance, color, and aroma. However, t-tests showed no statistically significant difference between control kefir and strawberry functional kefir. CK kefirs maintained consistent quality, while functional kefirs displayed unique patterns. Additionally, pH analysis confirmed that all kefir variants maintained acceptable pH levels.

The results of those analyses of kefir variations are a measure of their appeal to consumers as a tasty and healthy functional food on the Macedonian market, particularly to the younger demographic population.

KEY WORDS: kefir variations; functional foods; statistical analysis; sensory analysis; dietary fibers;

1. INTRODUCTION

A probiotic is a living microbial food supplement that positively influences the host by improving microbial balance. One of the natural functional food products considered a natural probiotic is kefir (Semih & Cagindi, 2003). Kefir is an ancient fermented beverage associated with the Caucasus region. The traditional production of kefir among the Caucasus population spread to other parts of the world by the end of the 19th century, integrating its nutritional and therapeutic indications into the daily food choices of populations (Güzel-Seydim et al., 2011; Farnworth, 2003). Kefir contains a large number of beneficial microorganisms and bioactive compounds, making it a product with great potential as a functional food. In Russia, the USA, Japan, and Central and Northern Europe, kefir is used to manage various diseases due to its nutritional and therapeutic aspects. In countries formerly part of the Soviet Union, kefir is informally recommended to healthy individuals to reduce the risk of chronic diseases, and also to patients with gastrointestinal and metabolic disorders, hypertension, weight control, and allergies (Stoma et al., 2016). Kefir is a symbiotic medium of microorganisms characterized by a matrix composed of proteins, lipids, and a soluble polysaccharide called "kefiran," harboring a spectrum of lactic acid bacteria, yeasts, and acetic acid bacteria. The microflora of kefir grains is formed by microorganisms that ferment sugar and produce lactic acid, alcohol, CO₂, B-complex vitamins, and other organic acids (Gao & Li, 2016). The multitude of microorganisms present in kefir, their microbiological interactions, and the bioactive compounds resulting from microbial metabolism are benefits associated with the consumption of this fermented beverage, granting it the status of a natural probiotic, referred to as the beverage of the 21st century (de Oliveira Leite et al., 2013). A study conducted by Georgetown University Medical Center evaluated the impact of kefir on reducing antibiotic-induced diarrhea in children (Smolyansky, 2009). This research indicated a potential positive effect, especially for children experiencing health issues and undergoing antibiotic treatment. Recent research has highlighted the significance of dietary components in the progression of certain health conditions. For instance, studies by Gavrilovska et al. (2022) and Gligorova Damjanovska et al. (2018) have explored the role of a low-protein diet in the context of chronic kidney disease, where patients have been controlled by taking 0.8 grams of protein per day. On the low-protein diet menu, it was allowed kefir, yogurt, eggs, etc. A review article by Bourrie et al. (2020) examines the potential role of kefir in the prevention and treatment of obesity and metabolic syndrome, as well as its impact on the gut microbiota. Furthermore, Knights et al. (2023) have demonstrated the keto diet's effectiveness through modeling and optimization with artificial intelligence in nutrition. Among these products, probiotics positively affect intestinal functions by optimizing the immune system's ability to prevent certain diseases due to the presence of live microorganisms (Damián et al., 2022). The addition of dietary fibers improves the physical, microbiological, and sensory properties of kefir, depending on the rate of added dietary fibers (Aiello et al., 2020; Goncu et al., 20217). Fiber-rich diets have a positive impact on human health, correlating with a reduced incidence of several diseases, including cardiovascular diseases, diabetes, obesity, digestive tract cancer, constipation, and other disorders with negative effects on human health (Lattimer & Haub 2010; He et al., 2022).

In addition to dietary fibers, various additives can be incorporated into fermented dairy products to enhance flavor, taste, aroma, appearance, etc. The addition of banana, guava, and lemon flavors to kefir for ice cream preparation resulted in products with improved sensory characteristics appealing to consumers (Januário et al., 2018). Fruit flavors, pleasant fruit aromas, and colors have proven to be highly interesting and popular among yogurt consumers, especially the younger ones (Teshomeet al., 2017).

Regardless of the health-promoting benefits of a product, consumer taste preferences are most often the determining factor in accepting a new food as a regular part of the diet (Aggarwal et al., 2016). Fermented dairy foods typically score high in sensory tests, but most consumers prefer samples with the lowest acidity (Bayarri et al., 2011). Still, many enjoy the pronounced acidity and complex flavor profile associated with traditional kefir. The objective of this study was to explore the acceptance of a novel dairy beverage made from kefir with a flavor of fruit and vanilla with natural ingredients and dietary fibers.

2. MATERIAL AND METHODS

For the production of the three new varieties of kefir with the addition of dietary fibers and flavors (strawberry-CKP, vanilla-CKV, peach-CKP), a technology designed for the production of classic kefir (CK) is employed, as practiced at the VEMILK dairy (IMV - Milk Industry Velkovski, village of Kravari, Bitola) (VEMILK Dairy).

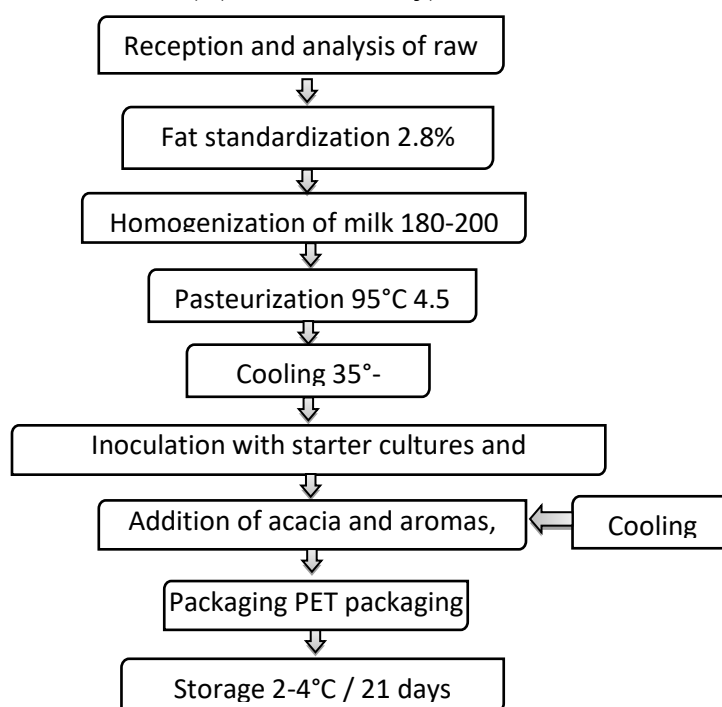


Figure 1. The process of technology for industrial production of kefir

The technological process for kefir production starts with receiving raw milk and collecting samples for analysis of the physical-chemical and microbiological quality of the milk. It continues with the separation and automatic standardization of milk fat to 2.8%.

Homogenization of milk fat globules is carried out in a two-stage homogenizer at a pressure of 180-200 bar. The heat treatment of milk occurs in an automatic system at a temperature of 95°C for 4.5 minutes. After pasteurization, the milk is cooled to 35-37°C, where inoculation with kefir starter cultures takes place. Kefir fermentation continues until a pH value of 4.5-4.6 is reached. After achieving the desired acidity with constant stirring and cooling a temperature of 12°C, are add 0.25% aroma and 2%-4% plant fibers (Fiber Gum). Subsequently, the kefir is cooled and homogenized to obtain a creamy texture. The kefir is then filled into 0.5 L PET packaging. The kefir is stored and kept at a temperature of 2-4°C for 21 days (Figure 1).

Samples for analysis from the three kefir variants are taken in aseptic plastic containers after the kefir has been cooled. Sensory and pH evaluation were conducted on days 1, 7, 14, and 21 of cooling storage.

The representative sensory properties of the three kefir formulations are evaluated using the corrected five-point score system and the ranking method (Radovanovic & Popov-Raljac, 2001/2002). The sensory evaluation will cover attributes like aroma, taste, flavor, color, and consistency. Each evaluated attribute is assigned an importance coefficient. The evaluated properties are scored from 1 to 5. The score for each property is multiplied by the importance coefficient, and their sum expressed in percentages indicate the percentage of the maximum possible quality. When this sum is divided by the sum of importance coefficients ($\Sigma=20$), a weighted average value is obtained, representing the overall quality assessment of the tested kefirs.

The sensory assessment of the four kefir formulations was conducted by 15 assessors with diverse backgrounds. The assessor group includes various profiles (professors and technologists directly and indirectly involved in production) as well as citizens with different genders and age structures. The obtained results from the sensory analysis of kefir will be presented in the Results and Discussion section.

The pH values of raw milk and other products were determined using a pH meter. Statistical analysis of the data is performed based on calculating mean values and their standard deviations. Testing for statistical differences in the mean values of the tested parameters between the control and functional kefir is done using a t-test ($p < 0.05$) with two repeated samples. The obtained results are presented in tabular and graphical formats. Statistical analysis of the results will be conducted using an appropriate software package.

3. RESULTS AND DISCUSSION

3.1 Sensory Analysis of Functional Kefirs

The sensory analysis of kefirs from the CK series during storage yielded the following results on the 1st day: for appearance, the average score was 4.25 ± 0.87 ; for color, the average score was also 4.25 ± 0.87 ; for aroma, 3.75 ± 1.42 ; for consistency, 3.75 ± 0.87 ; and for the most important sensory property - taste, the average score was 3.75 ± 0.97 (Figure 1). The kefirs from the CKS series on the first day of storage were evaluated as follows: for appearance, the average score

was 4.5 ± 0.80 ; for color, 4.16 ± 0.83 ; for aroma, 3.75 ± 1.36 ; for consistency (texture), 3.75 ± 1.14 ; and for taste, the most important property, the average score was 4.0 ± 1.35 .

During the 7th day of storage, the sensory analysis of kefir from the CK series yielded the following results: for appearance, the average score was 3.8 ± 1.41 ; for color, 4.2 ± 1.17 ; for aroma, 4.0 ± 1.15 ; for consistency, the average sensory score was 3.9 ± 0.86 ; and for taste, the most important quality property, the average score was 3.5 ± 1.33 . The kefir from the CKS series on the 7th day of storage were evaluated as follows: for appearance, the average result was 3.9 ± 1.32 ; for color, 3.8 ± 0.41 ; for aroma, the average score was 4.4 ± 1.04 ; for consistency, the average score was 4.3 ± 0.95 ; and for taste, the most important property, the average score was 3.8 ± 1.03 . Kefir from CKS received higher scores in consistency on the 7th day.

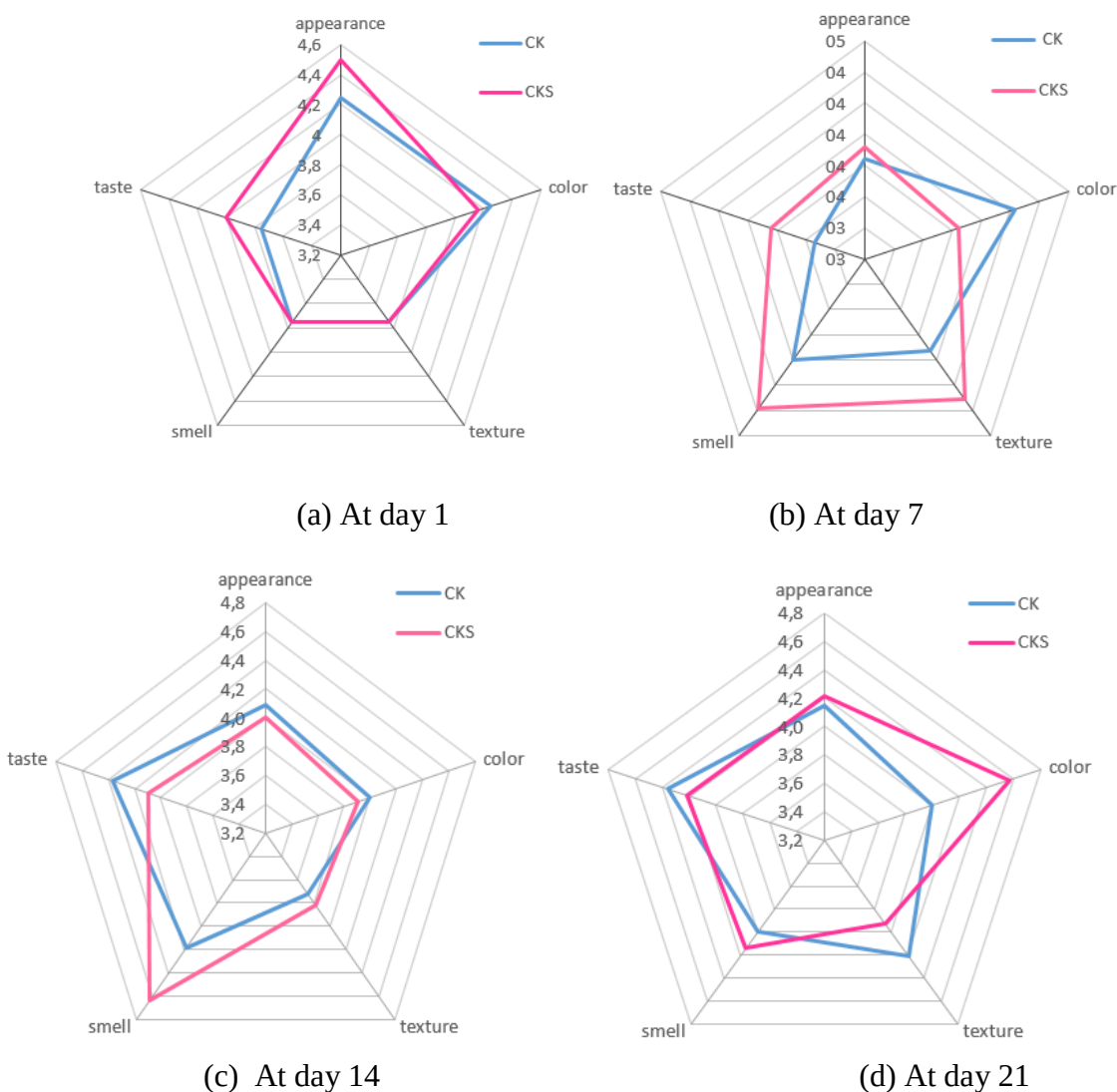
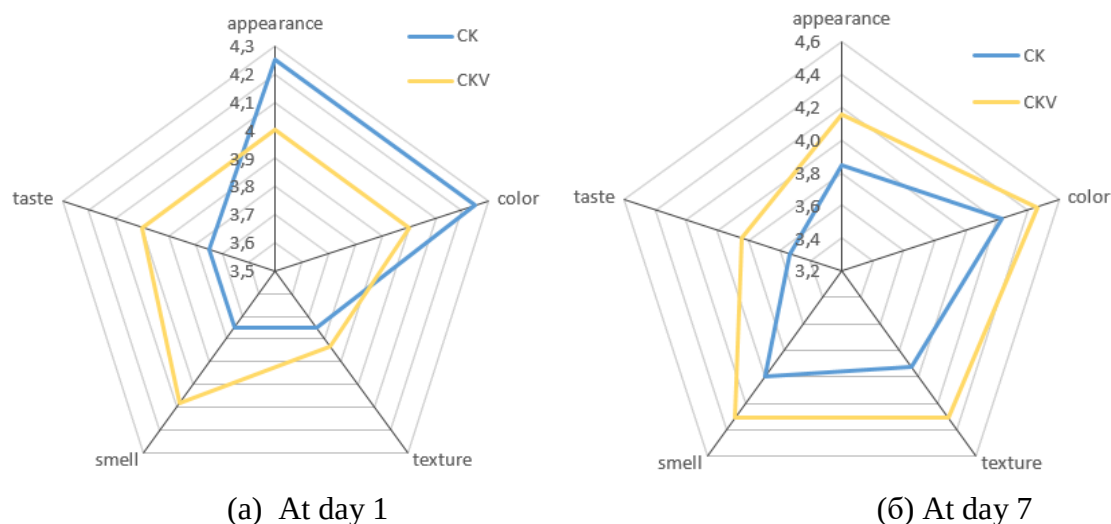


Figure 1. Sensory analysis of the CK and CKS kefir series during storage

The CKS kefir series obtained higher scores in consistency and aroma on the first day, consistency, aroma, and taste on the seventh day, consistency and aroma on the 14th day, and appearance, color, and aroma on the 21st day. During the conducted t-tests on different days of sensory analysis, no statistically significant difference ($p > 0.05$) in sensory parameters was observed between the control kefir and strawberry functional kefir.

3.2 Score Evaluation of Control Kefir and Functional Vanilla Kefir

The sensory analysis of the CKV kefir series during storage yielded the following results for the first day: for appearance, the average score was 4.0 ± 0.95 ; for color, 4.0 ± 1.13 ; for aroma, 4.08 ± 0.79 ; for consistency, 3.83 ± 0.83 ; and for taste, the most important property, the average score was 4.0 ± 0.95 (Figure 2). The sensory analysis of the CKV kefir series during storage on the seventh day yielded the following results: for appearance, the average score was 4.2 ± 1.21 ; for color, 4.5 ± 0.96 ; for aroma, 4.3 ± 0.95 ; for consistency, the average sensory score was 4.3 ± 0.75 ; and for taste, the most important property, the average score was 3.8 ± 1.4 . On the 14th day, the sensory analysis of the CKV kefir series during storage yielded the following results: for appearance, the average score was 4.0 ± 1.34 ; for color, 3.6 ± 1.17 ; for aroma, 4.5 ± 0.93 ; for consistency, the average sensory score was 3.8 ± 1.43 ; and for taste, the most important property, the average score was 3.7 ± 2.1 .



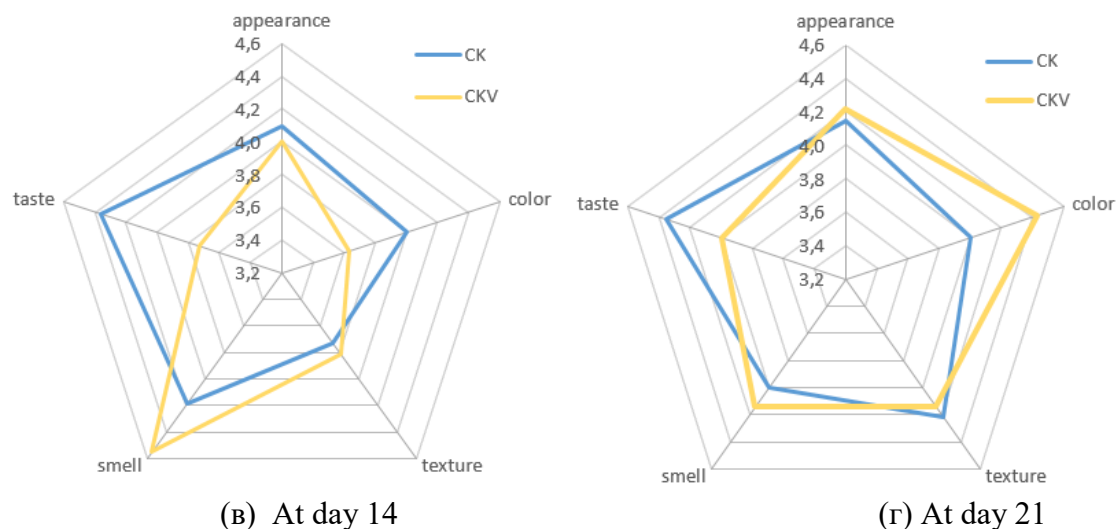


Figure 2. Sensory analysis of the CK and CKV kefir series during storage

Sensory analysis for kefir of the CKV series during storage obtained the following results for the 21st day: for appearance, the average score was 4.21 ± 1.25 ; for color the average score was 4.43 ± 1.09 ; for the quality attribute smell the average score was 4.14 ± 1.17 , for consistency 4.14 ± 0.77 and for the most important quality attribute - taste, the average score was 4.0 ± 1.47 .

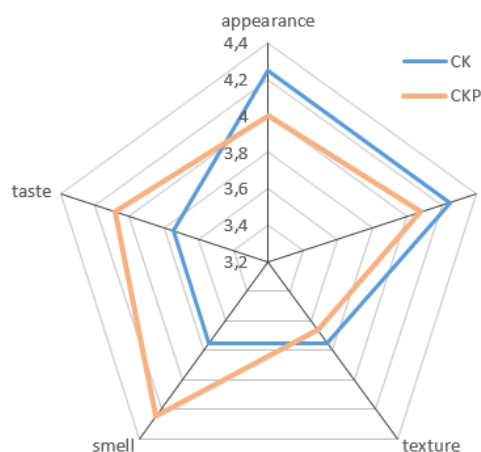
Kefirs from the CKV series received higher marks in consistency and smell, on days 1, 7 and 14, on days 1 and 7 they had a higher mark for taste, and it is interesting that on day 21 this kefir still had a higher mark for appearance, color, and smell, but the consistency was lower.

Probiotic vanilla kefir based on the results of time-dependent variables on day 7 showed that with the addition of flavor and dietary fiber compared to the control kefir, the five parameters of the sensory analysis of vanilla kefir showed a statistically highly significant difference ($p < 0.01$), where $t = -12.65$, $p = 0.00011$. While for the rest of the days, no statistically significant difference ($p > 0.05$) was shown in the parameters of the sensory analysis of the control kefir in relation to the functional vanilla kefir.

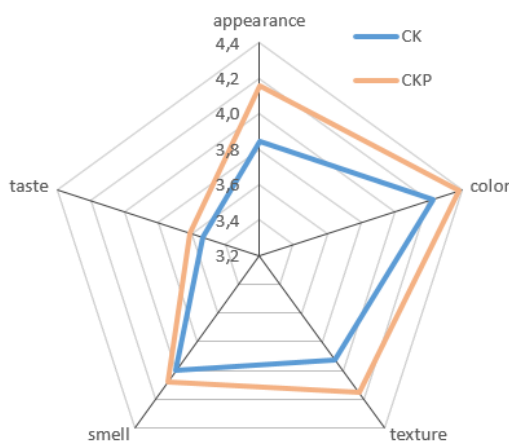
3.3 Score Evaluation of Control Kefir and Functional Peach Kefir

From the sensory analysis of the kefir from the series of functional CKP during storage, we obtained the following results for the first day: for the appearance of the kefir, the average score was 4.00 ± 0.85 ; for color 4.08 ± 0.90 ; for smell 4.25 ± 0.87 , for consistency 3.66 ± 0.89 and for the most important quality property - taste, the average score was 4.08 ± 1.0 (Figure 3).

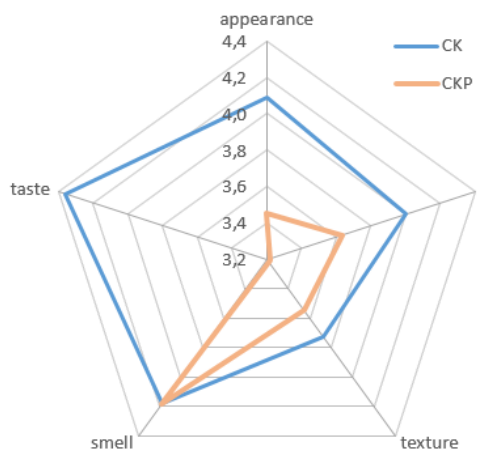
Sensory analysis of functional kefir of the CKP series during storage obtained the following results for the 7th day: appearance, average score of 4.2 ± 1.34 ; for color 4.4 ± 1.04 ; for smell 4.1 ± 1.12 , for texture, the average sensory score was 4.2 ± 0.89 and for the most important quality attribute - taste, the average score was 3.6 ± 1.51 .



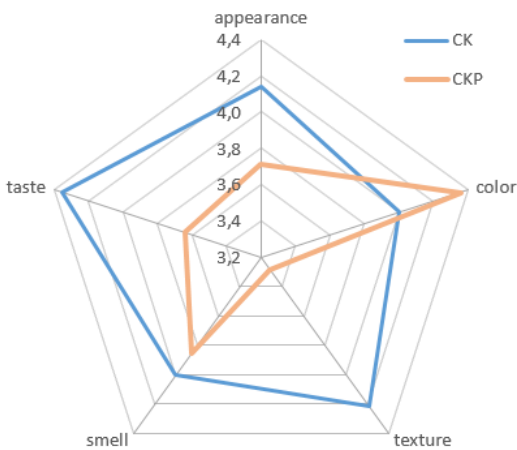
(a) At day 1



(b) At day 7



(c) At day 14



(d) At day 21

Figure 3. Sensory analysis of production series CK and CKP during storage

Sensory analysis of the CKP kefir series during storage obtained the following results for the 14th day: for appearance, the average score was 3.5 ± 1.57 ; for color 3.6 ± 1.13 ; for smell 4.2 ± 1.54 , for texture, the average sensory score was 3.5 ± 1.36 and for the most important quality attribute - taste, the average score was 3.2 ± 2.04 .

Sensory analysis of kefirs of the CKP series during storage obtained the following results for the 21st day: for appearance, the high score was 3.71 ± 1.54 ; for the quality property - color, the average score was 4.36 ± 1.22 ; for the quality attribute the average score was 3.86 ± 1.35 , for consistency/texture high sensory value was 3.29 ± 0.91 and for the particular quality attribute - taste, the average score was 3.64 ± 1.60 .

In our research, the CKP series of kefirs received higher scores in consistency and smell, appearance, color, and taste on day 7, kefir, where the five parameters of the sensory analysis of peach kefir showed a statistically highly significant difference ($p < 0.01$), where $t = -3.77$.

On the 14th day, unfortunately, the five sensory parameters for the peach kefir had a lower rating, which when calculating the t-test showed a statistically significant difference ($p < 0.05$), where $t = 2.29$. Also, on day 21, the sensory analysis parameters of the peach kefir were lower than the control kefir but did not show a statistically significant difference.

3.4 Comparison of Weighted Value and Maximum Possible Quality Rating in Evaluating Functional Kefirs

The average value, or weighted overall quality rating of kefir, is obtained by dividing the maximum possible quality by the sum of the importance coefficient ($\Sigma = 20$) shown in Figure 4. The percentage (%) of the maximum possible quality is presented in Figure 5.

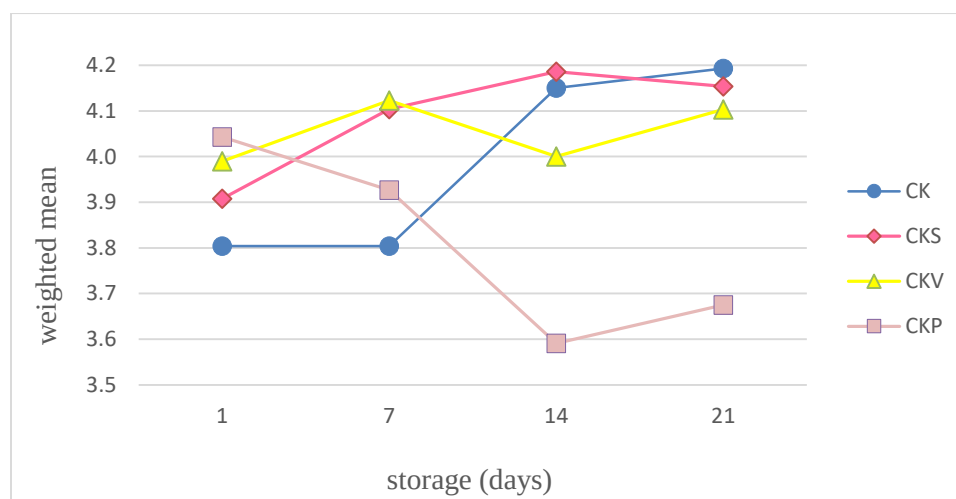


Figure 4. Weighted mean of kefir during storage

The weighted overall rating for CK kefir was 3.8 ± 0.27 on the 1st day, 3.8 ± 0.25 on the 7th day, 4.2 ± 0.24 on the 14th day, and 4.19 ± 0.15 on the 21st day. The percentage of the maximum possible quality for CK kefir on the 1st day was 76 ± 11.32 ; on the 7th day, 76.1 ± 11.17 ; on the 14th day, 83.0 ± 13.47 ; and on the 21st day, 83.86 ± 13.25 .

The weighted overall rating for CKS kefir was 3.91 ± 0.31 on the 1st day, 4.1 ± 0.26 on the 7th day, 4.2 ± 0.32 on the 14th day, and 4.15 ± 0.23 on the 21st day. The percentage of the maximum possible quality for the CKS series on the 1st, 7th, 14th, and 21st day was: 78.16 ± 11.95 , 82.1 ± 12.44 , 83.7 ± 13.30 , and 83.07 ± 12.84 , respectively.

The weighted overall rating for the CKV kefir series was 3.99 ± 0.09 on the 1st day, 4.1 ± 0.23 on the 7th day, 4.0 ± 0.36 on the 14th day, and 4.1 ± 0.16 on the 21st day. The percentage of the maximum possible quality for the 11DC series on the 1st, 7th, 14th, and 21st day was: 79.81 ± 12.41 , 82.5 ± 12.13 , 80.0 ± 12.40 , and 82.07 ± 12.32 , respectively.

The weighted overall rating for the CKP kefir series was 4.0 ± 0.22 on the 1st day, 3.9 ± 0.28 on the 7th day, 3.6 ± 0.37 on the 14th day, and 3.68 ± 0.25 on the 21st day. The percentage of the maximum possible quality for the 12DP series on the 1st, 7th, 14th, and 21st day was: 80.86 ± 12.80 ; 78.5 ± 11.33 ; 71.8 ± 10.87 ; and 73.5 ± 11.29 , respectively.

The control kefir series based on the score was acceptable and received slightly higher scores during storage. The functional strawberry kefir based on the assessment had a weighted score in the increase up to 14 days, while the functional vanilla kefir had a sinusoidal type increase, at 7 days - an increase, then a decrease at 14 and an increase at 21 days. The weighted mean of functional peach kefir has a decline during storage.

The results for the percentage (%) of the maximum possible quality show that the percentage of the series of control kefir is lower 1 and 7 days compared to the series of functional kefir with flavor and dietary dirt which are closer to 100%, while the functional kefir has a 14-day log estimate from strawberry, and there is a significant decrease in functional peach kefir.

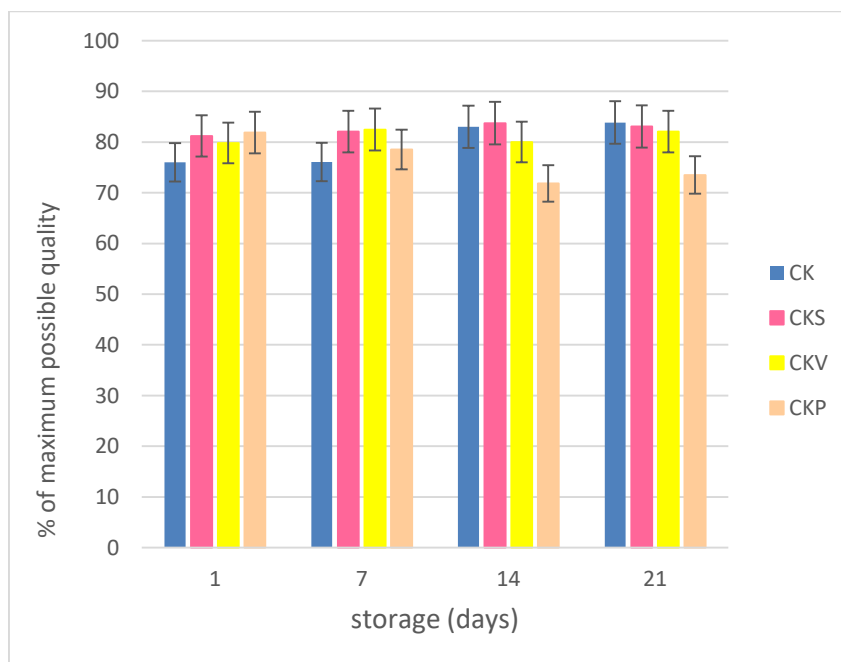


Figure 5. Percentage (%) of the maximum possible quality of kefir during storage
3.5 Comparison of Dynamic Changes in pH Value in Functional Kefir Series

Figure 6 illustrates a comparative analysis of pH values between the control and functional kefir series during storage. From the presented results, it can be concluded that there is a difference in pH values between the control and functional kefir series after the first day of storage. The series CKP displayed the highest pH value of 4.62, while the series CK and "CKV showed the lowest pH value of 4.5.

On the seventh day of storage, a decrease in pH values was observed in all kefir series (CK, CKS, CKV, CKP). The decrease in pH values for the "CK" and "CKJ" series was 4.40, while for "CKV" it was 4.36, and the lowest pH value of 4.34 was recorded in the "CKP" series.

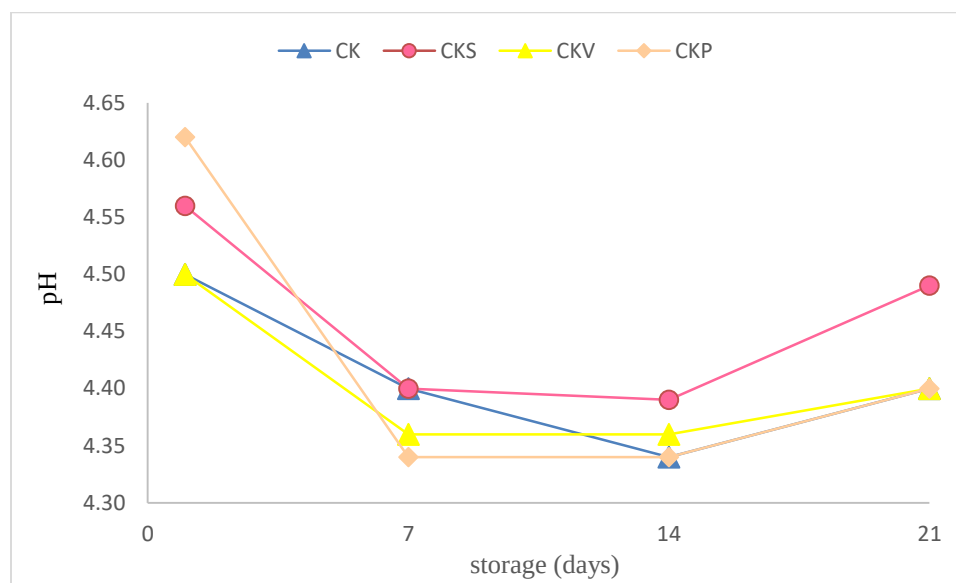


Figure 6. Comparison of the pH dynamics in production batches of control and functional kefir during storage

During long-term storage, the pH of kefir decreases due to the production of lactic acid by lactic acid bacteria, while the titration acidity gets higher values. During storage at 4°C, it was determined that there was no significant change in the pH value, that is, it always remained within the range of recommended values. The pH value shows stability on day 14 in all production batches.

The active acidity (pH) during 21 days of storage for production batches of kefir CK was $M=4.41$, $SD=0.0$, while for production batches of kefir CKS the active acidity (pH) was $M=4.46$, $SD= 0.0$.

The active acidity (pH) during storage of 21 days for the production batch of CKV kefir was $M=4.41$, $SD=0.0$, while for CKP kefir it was $M=4.43$, $SD=0.0$.

On the 21st day of storage, the active acidity (pH) of kefir from all production series showed slightly higher values for active acidity.

In conclusion, taking into account the 21st day of storage, the pH value of the products is in accordance with the provisions of Official Gazette of R. Macedonia, no. 96/2011; which states that the pH should not be lower than 4.0.

4. CONCLUSION

In this study, the formulation of new variations of kefir with the addition of dietary fibers and flavors (strawberry, vanilla, peach) was investigated to enhance nutritional value and sensory attributes, making them suitable as functional foods for the Macedonian market. The research aimed to examine the quality attributes and biochemical transformations during kefir storage.

The sensory analysis of the kefir formulations revealed important insights into their quality attributes. For the control kefir series, attributes such as appearance, color, aroma, consistency, and taste were evaluated, while for the functional kefir series (strawberry, vanilla, and peach), these attributes were also assessed. The sensory scores varied throughout storage, with some attributes showing significant differences between control and functional kefir. Functional kefir exhibited varying patterns of improvement and decline in sensory attributes over time, highlighting the complexity of flavor and quality changes during storage.

Furthermore, the pH values of the kefir products were monitored during storage. The pH values showed consistent trends, decreasing over time due to the production of lactic acid by microorganisms. All kefir series exhibited pH values within the recommended range, ensuring the products' safety and quality throughout the storage period.

The study demonstrated the potential of incorporating dietary fibers and flavors into kefir to enhance its nutritional and sensory properties. The research findings serve as a foundation for developing and producing new kefir variations that are more appealing to consumers, particularly the younger demographic. The results also contribute to the broader understanding of how additives can influence the quality attributes of fermented dairy products like kefir.

Overall, this research provides valuable insights into the formulation and quality assessment of functional kefir varieties, offering potential benefits for both consumers and the food industry.

ACKNOWLEDGEMENT

With heartfelt gratitude, we would like to acknowledge VEMILK dairy (IMV - Milk Industry Velkovski, village of Kravari, Bitola) for their generous assistance and cooperation throughout the duration of our research. Their unwavering support in providing access to their facilities and resources has played a crucial role in the successful execution of our study on kefir. We are thankful for their commitment to fostering academic exploration and contributing to the advancement of our scientific understanding in the realm of food production and analysis.

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