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Anna Lohinova,
Oksana Petrusha,
Larysa Arsenieva,
Galyna Polischuk,
Oksana Vasheka

DETERMINATION OF RELEVANT SENSORY CHARACTERISTICS OF BAKED DAIRY PRODUCTS

The paper considers approaches to increasing the objectivity of determining the organoleptic quality indicators of baked dairy products, in particular fermented baked milk, as one of the most common products in this segment. The main attention is paid to the analysis of key organoleptic parameters – color, appearance, consistency, taste and smell. Thus, the object of research is baked dairy products, in particular fermented baked milk, which are characterized by the spinning process, which involves prolonged heat treatment of the product. Such processes are accompanied by the Maillard reaction, which forms specific organoleptic characteristics. The problem being solved was to establish how the general choice of the consumer regarding a baked dairy product is formed based on the results of organoleptic evaluation, namely color, appearance, consistency, taste and smell. Since the consumer often only has an assessment of the color before purchasing the product, this parameter was considered in quite some detail. The fermented baked milk products available on the market differ in organoleptic indicators, both between manufacturers and between batches produced in different seasons.

The study applied a quantitative quality assessment method based on a total quality indicator (TQI), which takes into account the set of organoleptic characteristics. Color parameters were determined in the RGB and CIELab systems, which allows to objectively assess color – as the level of milk baking. A one-factor analysis of variance (ANOVA) was performed to assess the complex influence of individual organoleptic characteristics on others. This method was used to test hypotheses about the influence of individual organoleptic characteristics on the perception of other indicators.

Using a comprehensive approach to quality assessment allows not only to objectively determine the quality characteristics of the product, but also to establish the relationship between the technological parameters of production and its consumer properties. Focusing on consumer needs is an integral part of a successful, competitive market operator.

It is proposed to change the approaches in the technological control of baking by color characteristics to ensure stable quality of baked dairy products and optimize the parameters of the technological process.

Keywords: *sensory analysis, organoleptic indicators, baked dairy products, fermented baked milk, color, duo-trio, ANOVA.*

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1. Introduction

Color is an important indicator of the sensory evaluation of any food product, since it is the first visual signal by which 93 % of consumers visually perceive the product [1].

There are several main factors that show the importance of this indicator in sensory evaluation:

– *first impression* – color is usually the first criterion for assessing the quality of a product for those food products that are either not packaged or the packaging allows for an assessment [1]. The brightness and saturation of the color can affect the perception of freshness or ripeness of the product (greens, fruits/vegetables) [2];

– *taste expectations* – color can indicate a certain connection with taste [3]. For example, there is an opinion that red fruits are sweet, green ones are sour [4], and also – stimulate the appetite [5];

– *quality and safety assessment* – deviations in color from standardized characteristics may indicate deterioration in quality [6] or safety, especially of perishable products such as meat, milk [7] or fish;

– *differentiation among similar products* – color can be used to distinguish between similar products, such as certain grape or wine varieties [8] or different cheese varieties [9].

It is well known that consumer choice, purchase, repurchase, acceptability and preference are shaped, among other things, by the evaluation of organoleptic characteristics and the corresponding associative perception of a particular food product [10].

Appearance characteristics such as color, size, shape and visual texture often influence consumer purchasing decisions [11]. In many food categories, color conveys information to consumers about the sensory characteristics of the product (e. g. taste and aroma) or key brand attributes such as premium [12], naturalness or health benefits [13].

For example, when developing a new product, it is necessary to conduct a sensory evaluation, and based on this, a conclusion is made about whether the product will be in demand. The sensory evaluation criteria for each food product are different: appearance, texture, crunch, color, taste, smell, aroma, etc. But common to all products are such basic characteristics as: appearance, taste and smell and color. But for each product the most important indicator will be different [14, 15].

It is believed that the visual perception of a food product is of decisive importance in predicting the taste and even smell of a food product [16].

To quantitatively describe the color of products, researchers use various devices [17] and color models [18], designed specifically for selected food systems and tasks.

Color, as a characteristic of a food product, is a sensation that occurs when light energy from an object in the form of a visible spectrum (380–770 nm) falls on the retina of the eye of the researcher (consumer). The traditional method is to assess the color of a selected object by verbally describing its correspondence to a certain term inherent in a certain product [18].

Instrumental color measurements can be performed using conventional devices and computer vision systems. Minolta Chromameter and Hunter Lab colorimeters are commonly used. The quantitative expression of the color of a food product is quite often reflected in the color models of the International Commission on Illumination (CIE): CIELab, CIELu*v* and CIEXY, etc., each of which has its own distribution of color components. In addition to the value of the color coordinate itself, there are three additional characteristics: hue, brightness and chromaticity, the values of which are also quite often used to form similarities and differences in research [18].

Dairy products play an important role in the diet of the population, as they are rich in micro- and macronutrients, vitamins and, most importantly, calcium, so the consumption of these products is very important for ensuring the functioning of the human body [19].

Color assessment is important in the formation of dairy product characteristics [20–23]. For example, the color of cheese is associated, among other things, with the period of its maturation. As a rule, the longer the cheese is matured, the higher the level of volatile compounds that form the taste, and the darker its appearance. Therefore, the brightness of the cheese is a visible characteristic that affects the intentions of buyers depending on individual preferences [24]. This is illustrated by the research results. They, among other sensory and physicochemical characteristics, comprehensively evaluated the color of various young and mature Gouda cheeses, as a result of which they obtained different color brightness (L^* from 85 to 67) and linked these characteristics with consumer perception.

For other dairy products, such as milk-fruit drinks, vanilla ice cream [21], sour cream [22], milk and soy vanilla drinks [23], butter and cheese [24], the correspondence of color and appearance for consumer acceptability has also been demonstrated. The least color variability was found for sour cream. Therefore, the corresponding color characteristics of individual food groups indicate that they are manufactured using the same technology, using the same quality raw materials and in the same time.

There are a number of dairy products for which the formation of colors by spinning or pasteurization is desirable. These are products such as GHI butter [25], butter from fried cream [26], grilled cheeses, fried milk, condensed milk [27], fermented baked milk, toffee [28], fudge, dulce de leche [29], crème brûlée ice cream.

One of such popular lactic acid products in Ukraine is fermented baked milk – a traditional Ukrainian dairy product of cream color, which can be found in every grocery store. Fermented baked milk is made from fermented milk, and its fat content is from 2.5 to 4.0 %. The specific properties of this product are due to the baking process, during which the Mayllard reaction occurs, which partially forms the taste and aromatic properties of fermented baked milk. Thermal high-temperature treatment of milk is an energy-intensive technological operation that lasts over a wide range of time – from 2 to 4 hours. The end of the baking process is regulated not by the final properties of the product or semi-finished product, but by a subjective assessment of the color of fermented milk or cream, which leads to fluctuations in the quality indicators of finished products manufactured at different enterprises.

The issue of obtaining a product with stable characteristics is increasingly becoming important for market operators in economic activity.

The aim of research is to determine the influence of product characteristics on the organoleptic perception of baked dairy products, in particular, fermented baked milk, by consumers. In this study, the tasks were set to conduct a general assessment of the organoleptic characteristics of baked dairy products; to compare the color of baked dairy products of different production seasons and batches; to investigate the ability of consumers to distinguish between two similar products and to establish whether there is an interaction between the perception of some organoleptic characteristics on others.

2. Materials and Methods

2.1. Sample preparation

To conduct a comparative analysis of the sensory characteristics of fermented baked milk, six commercial samples of this product were examined. The tests were conducted in a training laboratory under natural lighting at a temperature of 20±2 °C. For the analysis, fermented baked milk produced in industrial conditions by various dairy processing enterprises was used: "Kagma" PrJSC, "Radyvylivmoloko" LLC, "Yuria" PrJSC, "Yagotynsky Maslozavod" SLC, "Lyustdorf" LLC and "Paryboche" farm. The temperature of the samples during tasting was 6±2 °C. The presented fermented baked milk samples had different fat contents: "Kagma" PrJSC, "Yuria" PrJSC, "Lyustdorf" LLC and "Paroboche" farm – with a fat content of 4.0 %; "Yagotinsky Maslozavod" SLC with a fat content of 3.2 % and "Radyvylivmoloko" LLC with a fat content of 2.5 %.

2.2. Formation of the group of participants

To conduct the sensory characterization of baked dairy products, 62 participants of different genders were selected. Sensory tests were conducted in the laboratory of the Department of Food Expertise of the National University of Food Technologies. The criteria for selecting participants included people aged 17 to 51 years without bad habits, lactose intolerance and aversion to dairy products.

2.3. Sensory evaluation procedure

2.3.1. Evaluation of general organoleptic characteristics

During the study, participants evaluated 6 samples of fermented baked milk using a standard scale for such indicators as: "appearance and consistency", "taste and smell" and "color" in accordance with DSTU 4565:2006 "Fermented baked milk and varenets. Technical conditions". Tasters evaluated the samples in turn, having sufficient time for this.

According to DSTU 5492:2006 "Sensory research. Glossary of terms", testers (n=62) participated in the assessment of the acceptability of fermented baked milk: women – 35, men – 27, with an age range from 17 to 51 years. No special conditions were imposed on the testers regarding previous experience in sensory research, but the main thing was that the individuals did not have an aversion to fermented baked milk. Six samples were randomly presented to consumers according to a randomized complete block design [30]. Between sample evaluations, tasters were offered water to minimize taste carryover from the previous sample [31]. Consumers rated their impressions on a nine-point hedonic scale from 1 (very disliked) to 9 (very liked) points according to ISO 22935-2:2009 "Milk and milk products – Sensory analysis – Part 2: Recommended methods for sensory evaluation".

2.3.2. Evaluation of organoleptic characteristics by the "duo-trio" method

The duo-trio method is used to identify significant differences between two samples. These differences can be associated with either one organoleptic characteristic or a set of such characteristics.

The "duo-trio" research procedure was carried out in accordance with the requirements of DSTU ISO 10399:2006 "Sensory research. Methodology. "Duo-trio" test".

2.4. Measurement of color characteristics of fermented baked milk

To measure the color of fermented baked milk, an LS171 colorimeter (China) was used, the settings and calibration of which were carried out in accordance with the instructions. The color of fermented baked

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milk was assessed in the CIE $L^* a^* b^*$ system. Further, the data obtained using mathematical transformations were presented in the form of indices: whiteness, yellowness and browning.

2.5. Processing of research results

2.5.1. Calculation of the generalized quality indicator

The calculation of the generalized quality indicator is carried out according to the formula:

$$Q = X_1 \cdot x + X_2 \cdot y + X_3 \cdot z, \quad (1)$$

where Q – the generalized quality indicator; X_1 – the expert's assessment of each individual quality indicator; x, y, z – the weighting factors of the individual quality indicator for appearance and consistency, taste and smell, and color, respectively.

The following weighting factors are proposed for fermented baked milk: appearance and consistency (z) – 0.3; taste and smell (y) – 0.3; color (x) – 0.4.

2.5.2. Calculation of color difference

The color difference of a food product is a quantitative characteristic of the change in the color of the product compared to the reference sample or initial state. The color difference was calculated by the formula:

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}, \quad (2)$$

where ΔE – the color difference; ΔL – the lightness coordinates of the first and second colors; Δa – the coordinates in the red-green spectrum; Δb – the coordinates in the yellow-blue spectrum.

2.5.3. Calculation of color tone

The color tone of a food product is one of the main color characteristics that determines what shade the product has (red, yellow, green, blue, etc.). The color tone was calculated using the formula [32]:

$$h_{ab} = tg^{-1}\left(\frac{b}{a}\right), \quad (3)$$

where h_{ab} – the color tone; a and b – the coordinates in the red-green spectrum and the yellow-blue spectrum, respectively.

2.5.4. Calculation of the whiteness and browning index

The whiteness index (WI) is a quantitative characteristic that determines the degree of whiteness of a food product.

The whiteness index was determined using ASTM E313–1973:

$$WI = 4 \cdot B - 3 \cdot G, \quad (4)$$

where WI – the whiteness index; B and G – the color coordinates of blue and green colors, respectively.

The browning index (BI) is a quantitative indicator that characterizes the intensity of the brown color of the food product.

The browning index was determined according to [33]:

$$BI = \frac{\left[\frac{0.31(a+1.75L)}{5.645L + a - 3.012b}\right]}{0.172}, \quad (5)$$

where BI – the browning index; L, a and b – the lightness coordinates, coordinates in the red-green and yellow-blue spectrum, respectively.

2.5.5. ANOVA statistical analysis

One-way analysis of variance (ANOVA) was used to examine the data and compare different samples related to the intensity of attributes and consumer acceptability. The criterion for determining a significant difference was set at a confidence level of $p < 0.05$. Duncan's multiple comparison of ranges was performed as a post hoc test when a significant difference was observed with ($\alpha = 0.05$).

The results are presented as mean ± standard deviation. Statistical analysis was performed using factorial analysis of variance (1-factorial analysis of variance) followed by Fisher's least significant difference (LSD) test to assess the main effects (adding and storing BP) as well as the effect of their interaction on all analyzed traits. PSPP software, a sample data analysis program version GNU PSPP 1.2.0-g0fb4db, was used to implement the statistical analysis.

3. Results and Discussion

3.1. Organoleptic evaluation of baked dairy products using the example of fermented baked milk

Since the organoleptic evaluation was carried out within the range from 1 to 9 points, it was decided to distribute the obtained data into 3 categories:

1–3 points – negative result, low scores;
4–6 points – average result, average scores;
7–9 points – high result, high scores.

Fig. 1 shows the results of the organoleptic evaluation of fermented baked milk from 6 commercial producers. Fig. 1, *a* shows the best sample according to the testers, namely – Sample 5. Fig. 1, *b* shows the average, according to the respondents, sample – Sample 4. And Fig. 1, *c* shows the worst sample – Sample 1.

Samples 2, 3 and 6 are also characterized by average results for all indicators, similar to sample 4.

From Fig. 1, *a*, it is possible to see that the indicators "color" and "appearance and consistency" were most liked by the evaluators, while the indicator "taste and smell" had a share of average (4–6 points) and high (7–9 points) ratings, which was equal to 44 %. Therefore, it can be assumed that the indicator "color" will also be influenced by the testers' impressions of "appearance and consistency".

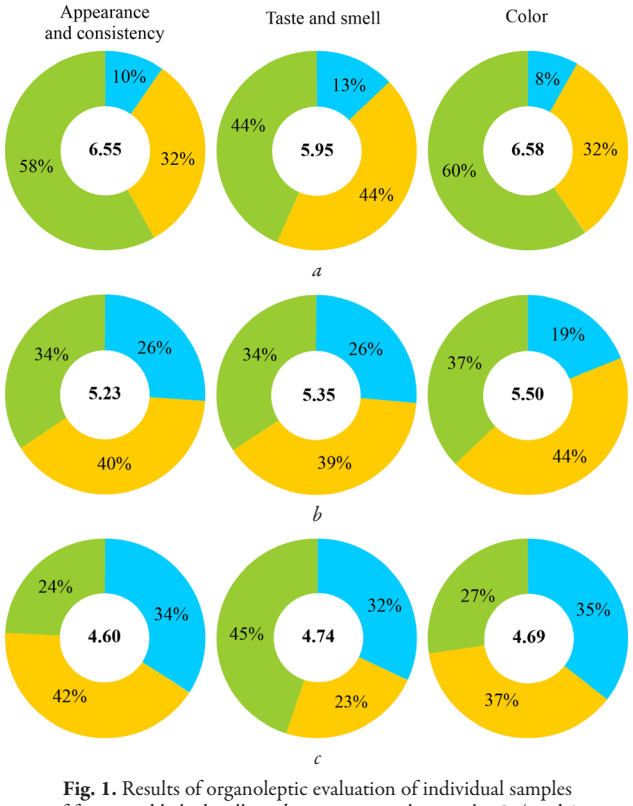

Fig. 1. Results of organoleptic evaluation of individual samples of fermented baked milk: *a*, *b*, *c* – respectively, samples 5, 4 and 1; 1–3 points; 4–6 points; 7–9 points

From Fig. 1, *b* it is clear that according to all criteria, the average scores were received by the largest number, which indicates the absence of significant differences in both the positive and negative directions, and in the opinion of the evaluators, this sample is included in the average results.

From Fig. 1, *c*, it is possible to see that according to all criteria, the obtained sample scored few high scores, and also that the indicator "taste and smell" scored a larger number of high scores. Therefore, it can be assumed that all three organoleptic indicators had an approximate distribution of ratings among respondents with a difference of up to 8 %.

It is known that American consumers prefer lighter colored Gouda cheese. According to the JustAboutLight (JAR) assessment, the appearance of some cheeses was clearly not liked, with some cheeses being rated as too light or too dark, indicating the importance of understanding the influence of color on consumer perception/preference [34]. Thus, although color is an important characteristic of cheese [35], in terms of overall taste, mouthfeel and aroma are more important than appearance [36].

Therefore, since it is about dairy products [20], it is quite plausible to state that the consumer's choice when purchasing fermented baked milk is influenced by its appearance and color.

3.2. Stability of fermented baked milk color characteristics

It is impossible to obtain a consistently uniform color of fermented baked milk in industrial conditions, since each batch will have different color characteristics. To verify this theory, 3 types of commercial fermented baked milk and 1 baked milk were tested in winter and summer. Measurements were made using a LS 171 colorimeter (China) in the CIELab color system (Fig. 2).

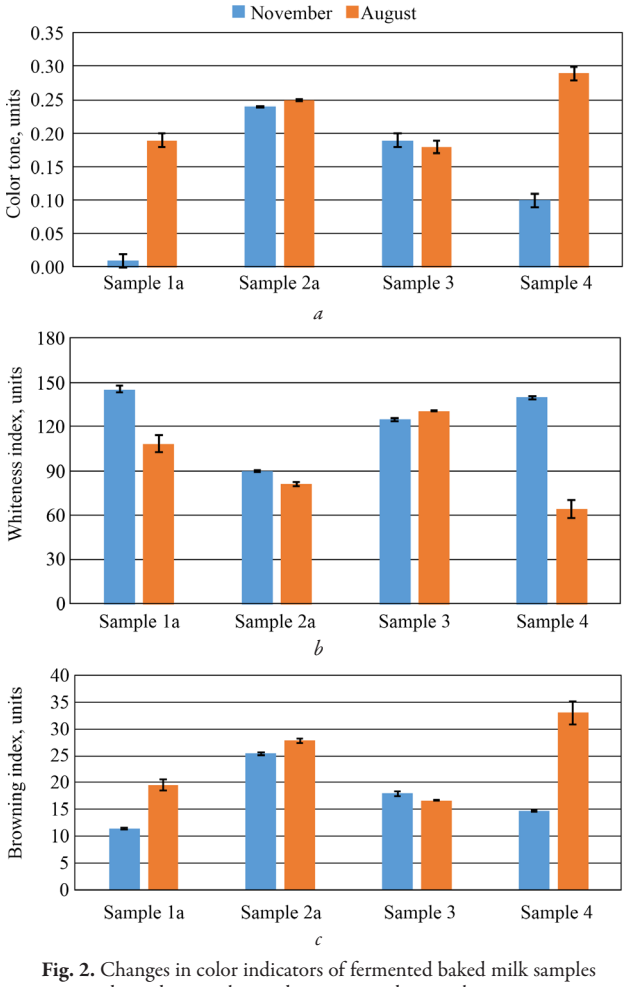

Fig. 2. Changes in color indicators of fermented baked milk samples depending on the production period: *a* – color tone; *b* – whiteness index; *c* – browning index

To characterize the color of the baked dairy product, the following indicators were selected: color tone, whiteness index and browning index, since these indicators best characterize changes in different batches of the product in the winter and summer periods.

Based on the results obtained, the ΔE indicator was also calculated – an indicator used to assess the difference in color between two samples. As can be seen from the results obtained (Table 1), the samples are very different from each other, from which it is possible to conclude that the color of baked dairy products, and most importantly, their stability, is influenced by a number of important factors.

Also, thanks to this, it is possible to check the individual sensitivity of respondents regarding their ability to distinguish this color difference or not.

Table 1

ΔE for the samples under study

Sample	ΔE value
Sample 1a	7.65
Sample 2a	14.37
Sample 3	1.38
Sample 4	7.41

Designation of samples: 1a and 2a – samples of fermented milk and fermented baked milk, respectively, from the same retail chain; 3 and 4 – samples of fermented baked milk from other commercial producers, $n = 6$, $p < 0.05$.

As can be seen from Fig. 2, *a*–*c*, two samples of fermented baked milk and one sample of fermented milk have clear differences in their color characteristics in the winter and summer production periods. Thus, Fig. 2, *a* and Fig. 2, *c* show that the indicators "color tone" and "browning index" have low values in winter and high in summer for three out of four samples studied. Fig. 2, *b* shows that the indicator, the whiteness index, on the contrary, has high values in winter and low values in summer, again for three out of four samples.

The effect found: the difference in the color of baked dairy products from the same manufacturer can be explained by the following factors: different feeds for feeding animals in the winter and summer periods. As is known, in winter the diet of cows consists mainly of dry grass and grains, and in summer – green grass, rich in chlorophylls, which, in turn, affect the color of the raw milk and, accordingly, the color of the final product [24]. It is also known that different durations of spinning of milk from which fermented milk is made affect its final sensory characteristics, in particular color, aroma and taste. Longer baking promotes a more intense Maillard reaction and caramelization, which gives the product a darker shade, a pronounced caramel aroma and a richer taste [7]. The process of milk baking does not have an exactly known baking duration. On average, this process lasts for a fairly wide range – from 3 to even 5 hours, depending on the fat content in the milk [37]. The final baking time is determined by the technologist visually and quite subjectively, which reduces the possibility of obtaining a product with stable quality indicators [38].

Another reason for the difference in the color of roasted dairy products is the possible replacement of equipment and non-compliance with the temperature regimes of this technological process.

3.3. Duo-trio

According to the duo-trio method, the study participants first carried out an organoleptic assessment of the obtained samples by appearance and consistency, taste, smell and color, according to DSTU 4565:2006.

Four samples (A, C, S and Y) combined into 6 groups were presented to the testers, however, both approximately similar and different samples were offered for evaluation. The results of the evaluation using the duo-trio method are presented in Table 2.

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Table 2

Results of testers' responses to samples of fermented baked milk using the "duo-trio" method

Study series	Sample codes	Number of correct answers	% correct answers
101	АкАС	20	100
201	СкАС	20	100
102	SкSY	20	100
202	YкSY	17	85
103	СкCS	17	85
203	SкCS	13	65

In the general characteristics, the difference in organoleptic characteristics of the samples was quite clearly revealed, however, it should be noted that the final decision was made after several evaluations of the samples. The color and smell of the samples did not give a clear discrepancy.

For fermented baked milk "A" and "C" in 100 % of cases, the testers were able to distinguish the samples, which is due to the difference in appearance and consistency and taste and smell (Table 2). The color difference was not visually identifiable, although the color coordinates were on average higher by ~1.0 units for product "C". When comparing sample "C" with sample "S", they had closer taste and smell characteristics. The color difference for products "C" and "S" was already approximately 2.0 units, which is not noticeable to the human eye. And for such a combination, the percentage of correct answers decreases. Fermented baked milk "S" and "Y", although they had a visually noticeable difference in color, for 3 testers this did not become the main criterion in making a decision when changing the combination with the control sample.

The above results show the complexity of the formation of neural mechanisms of consumers when evaluating a product [39], when both individual product characteristics and their complex effect on human sensors are important.

3.4. ANOVA analysis

Based on the data of the organoleptic evaluation of six samples of fermented baked milk, an ANOVA analysis was conducted in the PSPP program. As a result, 28 hypotheses of various dependencies between indicators were proposed. The connections between the "color" and "appearance" of the samples were investigated, as well as between "color" and "taste and smell". The dependence between "color" and the age group of tasters was considered separately.

The hypotheses concerned both the relationships within each sample and the relationships between different samples.

After testing the hypotheses, only 5 hypotheses were mathematically confirmed, the confirmation of which is given in Table 3.

The obtained data prompts reflections on the formation mechanism of human perception of color and factors influencing its assessment.

The first hypothesis suggests that there is a certain relationship between the perception of the color of fermented baked milk and the age group of respondents, which must be taken into account when forming the target audience. The significance of color in the perception of the product plays a more important role for the older age group. Here, too, most likely, the perception of the product will be influenced by their life experience when buying fermented baked milk and the desired color that they associate with fermented baked milk.

For the hypotheses of the connection of the three component organoleptic characteristics of fermented baked milk ("color", "taste and smell" and "appearance and consistency"), there is a certain regularity of the influence of "taste and smell" and "appearance and consistency" on the testers' assessment of "color".

Table 3

Results of confirmation of hypotheses by ANOVA method

Hypothesis	F	Value	$F_{standard}$	Standard value
Dependence of the color of fermented baked milk samples on the age of the surveyed respondents	3.63	0.000	3.99	0.05
Dependence of the color of fermented baked milk of "Radyvylivmoloko" LLC on its appearance and consistency	2.08	0.049	3.99	0.05
Dependence of the color of fermented baked milk of "Radyvylivmoloko" LLC on its taste and smell	2.08	0.049	3.99	0.05
Dependence of the color of fermented baked milk of "Yuriya" PrJSC on its taste and smell	2.12	0.036	3.99	0.05
Dependence of the color of fermented baked milk of "Paruboche" farm on its taste and smell	3.70	0.001	3.99	0.05

The second hypothesis suggests that the formation of the perception of the color of the second sample is influenced, in fact, by its appearance and consistency.

And from the third, fourth and fifth hypotheses, the formation of an opinion about the color of these samples is also influenced by their taste and smell.

There is a certain theory that the color of the product will be influenced primarily by the consumer's perception of its appearance and consistency [39], but as is possible to see, this hypothesis was not confirmed within the framework of this study (Table 3). At the same time, a complex formation of the indicator of the organoleptic properties of the product is clearly noted. The formation of such characteristics of fermented baked milk will depend mainly on the raw materials and proper technological practice of the process. Since the process of spinning milk is less clearly regulated by the defining characteristic – color, enterprises should introduce methods that will more accurately allow observing the conditions for the formation of the specified characteristics in the product.

Compared with the literature data, the obtained results indicate a larger range of variations in the color characteristics of the product, which may be due to differences in raw materials and heat treatment modes.

The practical significance of research lies in the possibility of using the method of objective color assessment to develop quality control standards for baked dairy products. This will allow manufacturers to ensure the stability of consumer characteristics and increase the competitiveness of products.

The limitations of this research are that, firstly, consumers were selected as the target group, not experts. Secondly, popular samples of fermented baked milk, which are presented in large stores, were selected for the study.

In the studies, consumers were selected as the target group, not experts, focusing on their assessment of the quality and differences of the samples.

The conditions of martial law in Ukraine did not affect the conduct of experimental studies. Although fermented milk products were not presented in retail chains at the beginning of the full-scale invasion, after a few months the offer of baked dairy products and fermented milk was restored.

Prospects for further research include the development of optimized milk spinning modes to standardize the organoleptic characteristics of baked dairy products and the introduction of digital color analysis methods into production quality control.

4. Conclusions

The paper presents the results of different approaches in the evaluation of organoleptic characteristics of baked dairy products. The obtained data demonstrate the complex formation of the general perception of the product by the consumer, which is mathematically confirmed by the ANOVA method.

Heat treatment of milk, accompanied by the Maillard reaction and lactose caramelization in the production of fermented baked milk, leads to the appearance of golden or brown shades, which, with a color difference of up to 6 units between the samples, is not a determining criterion for evaluating and selecting the product. At the same time, the differences in the values of the color coordinates of the samples of individual manufacturers in different periods of the year were ~75 units for the whiteness index and ~20 units for the browning index. This is due to the technological instructions for the process, which do not contain color control criteria.

Therefore, to ensure the stable quality of baked dairy products, it is necessary to develop a method for the operational determination of their color, which will also allow optimizing the parameters of the technological process.

Conflict of interest

The authors declare that they have no conflict of interest in this research, including financial, personal, authorial or other, that could influence the work and its results presented in this article.

Financing

The research was conducted without financial support.

Data availability

Data will be provided upon reasonable request.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies in creating the presented work.

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✉***Anna Lohinova,*** *Assistant, Department of Foodstuff Expertise, National University of Food Technologies, Kyiv, Ukraine, e-mail: anna.ol.logi@gmail.com, ORCID: https://orcid.org/0000-0002-3980-5768*

Oksana Petrusha, *PhD, Associate Professor, Department of Foodstuff Expertise, National University of Food Technologies, Kyiv, Ukraine, ORCID: https://orcid.org/0000-0002-6009-127X*

Larysa Arsenieva, *Doctor of Technical Sciences, Professor, Department of Foodstuff Expertise, National University of Food Technologies, Kyiv, Ukraine, ORCID: https://orcid.org/0000-0002-0976-7625*

Galyna Polischuk, *Doctor of Technical Sciences, Professor, Department of Milk and Dairy Products Technology, National University of Food Technologies, Kyiv, Ukraine, ORCID: https://orcid.org/0000-0003-3013-3245*

Oksana Vasheka, *PhD, Associate Professor, Department of Foodstuff Expertise, National University of Food Technologies, Kyiv, Ukraine, ORCID: https://orcid.org/0009-0004-9781-8243*

✉*Corresponding author*