Scifood
vol. 19, 2025, p. 17-29
https://doi.org/10.5219/scifood.2
ISSN: 2989-4034 online
https://scifood.eu

Received: 31.10.2024
Revised: 28.11.2024
Accepted: 1.12.2024
Published: 1.1.2025

Influence of selenium additives on butter quality and storage stability

Bagila Jetpisbayeva, Alma Katasheva, Sholpan Abzhanova, Ulzhan Nuraliyeva, Akylzhan Kozhabergenov, Ayazhan Kanatkyzy

ABSTRACT
The study's results showed that using Selenium preparations in butter production inhibited oxidative processes occurring during butter storage. In such a product, the oxidative changes of the butter were slowed down, resulting in the product's quality parameters being preserved longer. Before storage, the butter was evaluated in the 45 to 43 points range. After 15 days of storage, the taste and odour scores of the oil ranged from 44 to 40 points. The highest score was assigned to samples with high fat content stored at minus 5°C. The 62.5 per cent fat samples stored at 15°C had the lowest score for this storage period. When stored for more than 30 days, there was a further decrease in the taste and odour score of the oil. It scored between 41 and 37 points during this storage period. In addition, only sweet butter stored at minus temperature remained in the high grade. At the last storage stage (60 days), the butter scored from 38 to 35 points. Summarising the presented data, it should be noted that using selenium in butter production inhibits the development of oxidative processes and slows the deterioration of organoleptic characteristics during product storage. The rate of these processes depends on the storage temperature and the amount of oil in the butter. Due to the use of Selenium at the temperature of Minus 5 °C the shelf life of butter of the highest grade increases by 1.6-2.0 times, at 5 °C, by 1.8-2.4 times and at 15 °C, by 2.4-3.0 times. The non-infinite fatty acids in the milk fat of the cows we study are less than infinite acids, as indicated by the value of glyceride solid fractions and the amount of iodine. The iodine index in cows of the Alatau breed was 28.62, while for those in the third lactation and beyond, it was 28.45. The iodine index values for Holstein cows were 28.86 and 28.7, respectively.

Keywords: milk, vegetable oil, selenium, safety, nutritional value

INTRODUCTION
Modern industrial milk processing based on high-tech processes places increased demands on the quality of milk used as raw material for producing a wide range of dairy products **[1]**. Therefore, one of the main priority areas of dairy cattle breeding is the production of milk that meets sanitary and hygienic standards and the requirements of processing enterprises. The complexity of solving the problem of milk quality is associated with the fact that the sanitary and production culture used in most dairy farms and sanitary and production culture are not compatible with the conditions for obtaining high-quality and safe milk, and this requires revision of raw milk production technologies and preventive measures aimed at improving its quality **[2]**. Seasonality of milk production remains a significant problem in breeding dairy cattle. In some seasons of the year, the supply of milk of optimal quality is quite unstable, which creates substantial difficulties for technologists to produce the planned quantity of dairy products and forces them to periodically rearrange their work modes with an inevitable decrease in efficiency and profitability. In this regard, there is a need to improve the quality of milk **[3]**. This will allow the development of optimal parameters of technological processes, the fulfilment of which will provide milk of

guaranteed quality and increase the profitability of its production. One of such factors is seasonal changes in technological processes (feeding, housing methods, etc.).

Optimization of milk quality indicators at high productivity of cows (7000 kg of milk and more), industrialization of their maintenance processes, and the need to increase the 'manufacturability' of milk are urgent problems. Ensuring profitable operation of dairy complexes also largely depends on the quality of produced dairy raw materials **[4]**.

One of the most demanded products of milk processing is butter. The quality of raw materials is of crucial importance in the production of this milk product. To a large extent, the composition and technological properties of milk are determined by the season of the year, influencing them through feed, housing practices, and temperature regime. In particular, with increasing seasonality index, a decrease in the percentage of fat used for butter production from 24-37% to 15-27% is observed. To assess the quality of milk used in butter production, data on the quantitative content of milk fat and the dispersibility of the fat phase are needed. Fat is the most roughly dispersed phase of milk and is found in it as fat globules of 0.1 to 10 microns in size; their number in 1 ml varies from 1.5 to 6 billion. Depending on the number and size of fat globules, the technological properties of milk change when it is processed into butter. Only large fat globules are used in butter production, and globules with a diameter of less than 1 micron go into skimmed milk and buttermilk **[5]**.

Butter has a high nutritional value. Their qualitative and quantitative composition depends primarily on the quality of the milk used and changes significantly during butter production in spring-summer and autumn-winter periods **[6]**. For example, currently, there is such a trend abroad as increasing requirements to product quality. In recent years, the appearance of milk fat as a healthy product has improved significantly in many countries.

Selenium (Se), a trace element, restores human health in small amounts. It acts as an antioxidant and immunomodulator and controls various endocrine pathways **[7]**. The issue of selenium content in various foods and its effect on health is relevant and requires careful study.

Scientific Hypothesis

Adding Selenium during the butter production suppresses oxidative processes occurring during butter storage.

Objectives

Primary objectives: Study of technological properties of milk as a raw material for butter production to optimise its qualitative characteristics, increase the efficiency of processing and ensure the stability of production of finished products of high quality.

MATERIAL AND METHODS

Samples

Samples description: The following raw materials were used to produce experimental butter samples: milk of Holstein and Alatau cows, Republic of Kazakhstan. The milk was obtained from a tanker of the farming company Turar LLP located in Kostanay region, Kazakhstan.

Samples collection: To analyse and assess the quality of milk, samples were collected following the requirements of standards. The collection was carried out from the tanker of the farm of the company "Turar" LLP (Kostanay region, Kazakhstan). After collection, milk samples were stored at +2 to +4 °C and transported to the laboratory for further studies.

Samples preparation: Butter with selenium was produced from pasteurised cream converted into double cream following current technological recommendations. Milk reception and preparation: Milk is received, cleaned and cooled to a temperature of 4-6 °C. Normalisation and pasteurisation: The fat content of the milk is normalised to the required level (3.5-4.5%). Pasteurisation is performed at 85-90 °C for 15-20 seconds to kill pathogenic microflora. Cream maturation: Milk is separated to obtain cream with a mass fat percentage of 30-35%. The cream is cooled to a temperature of 4-6 °C and allowed to mature for 6-12 hours. Selenium enrichment: While the cream is ripening, a pre-prepared solution of organic selenium is added. The cream is mixed thoroughly to ensure an even distribution of the additive. Cream whipping: The ripened cream is whipped in a creamer until butter grains are formed. The butter is washed with cold water to remove any residual buttermilk. Forming and packing: Ready butter is formed into blocks or packed in containers (250 g, 500 g). Storage and transportation: The butter is stored at 0 to +4 °C. The shelf life of enriched oil is 30-45 days under observance of storage conditions. The selenium concentration is calculated so that the final product contains 10-20 μg of selenium per 100 g of oil (recommended rate). Control samples were analysed.

Number of samples analysed: 28

Chemicals

Calcium oxides CaO, methanol CH3OH, ethyl alcohol C_2H_6O, and sodium methylate CH3NaO were purchased from Sigma-Aldrich, Inc. (Merck KGaA, Darmstadt, Germany), which guarantees the high quality and reliability of the chemicals used in the experiments.

Animals, Plants and Biological Materials

Holstein and Alatau cows belong to the “Turar” LLP farm in Kostanay region, Kazakhstan.

Instruments

Gas chromatographs: Meta-chrome (Russia).

G10S titrators: Compact, Mettler Toledo (Russia).

Laboratory Methods

Method for determination of fatty acids. In a 500 cm^3 flask, weigh (30+1) g of calcium oxide, add 250 cm^3 of methanol, and boil with a refrigerator-type XSh (reverse) for 6-8 hours. Then methanol is distilled in a distillation apparatus at a temperature of 64.7 °C. In a flask of 500 cm^3 capacity, weigh (30±1) g of calcium oxide, add 250 cm^3 of ethyl alcohol, and boil with a refrigerator of XSH (reverse) type for 6-8 hrs. Then ethyl alcohol is distilled in a distillation apparatus at a temperature of 78.3°C. Preparation of a solution of sodium methylate in methanol (sodium ethylate in ethanol) of concentration 2 mol/dm^3 weighs 2.7 g of sodium methylate (3.4 g of sodium ethylate) or 1.15 g of metallic sodium into a weighing cup. The result shall be recorded in grams to the second decimal place. Pour 10-12 cm^3 of absolute methanol (absolute ethanol) into a measuring flask with a capacity of 25 cm^3, pour into it a suspension of sodium methylate, or throw small pieces of sodium. After stirring (dissolution), the solution is cooled to room temperature and topped up with absolute methanol (absolute ethanol) to mark. The solution is stored in the refrigerator. The test oil sample is mixed well. 2-3 drops of oil are pipetted into a glass tube and dissolved in 1.9 cm^3 of hexane. 0.1 cm^3 of sodium methylate in methanol (sodium ethylate in ethanol) solution of 2 mol/dm^3 concentration is added. After stirring vigorously for 2 min, the reaction mixture is allowed to stand for 5 min and filtered through a paper filter. The ready solution is stored in the refrigerator for over 2 days **[8]**.

Methods of iodine number determination according to GOST 5475-69 **[9]**.

Type of detector used: Mass Spectrometric (MS) (optional depending on configuration).

Injector: Split/no split injector.

Column: Fused quartz (glass column) or stainless steel. Dimensions: Length: 30 m. Inner diameter: 0.25-0.32 mm.Film thickness: 0.25 μm.

Stationary phase: Polar: DB-17 (50% phenylmethylpolysiloxane) for the analysis of complex mixtures. Non-polar: DB-5 or HP-1 (100% dimethylpolysiloxane) for general analysis.

Carrier Gas: Carrier gas type: Helium (basic) or hydrogen. Carrier gas purity: 99.999%. Flow/Pressure Parameters: Constant flow: 1.0 mL/min. Alternatively, 40 pounds per square inch (psi) pressure.

Description of the Experiment

Study flow: At the first stage of the experiment, we collected milk samples from cows of the farm “Turar” LLP located in the Kostanay region, Kazakhstan. The samples were collected in sterile containers and delivered to the laboratory at +4 °C for further processing. Then, we processed the samples for individual experiments and laboratory analyses. First, we determined the main milk characteristics: fat, protein and dry matter content; minerals (including selenium baseline); acidity level (pH); and number of microorganisms. The obtained results were processed and subjected to statistical analysis. We compared the indices of the oil enriched with selenium with control samples (without selenium addition). We tested the validity of our hypothesis about the influence of enrichment on the quality of the product.

Quality Assurance

Number of repeated analyses: 5

Number of experiment replications: 5

Reference materials: -

Calibration: -

Laboratory accreditation: The experiments were conducted in the laboratory “Food Safety” accredited in the accreditation system of the Republic of Kazakhstan for compliance with the requirements of GOST ISO/IEC 17025-2019 “General requirements for the competence of testing and calibration laboratories” (Accreditation Certificate № KZ.T.02.E 1158).

Data Access

No data sets are available.

Statistical Analysis

Statistical analysis was performed using the SPSS program (IBM SPSS Statistics 20). The methodology of analysis included one-factor analysis of variance (ANOVA). Comparisons were made at a significance level of $p < 0.05$. On the statistical evaluation were these parameters X1 (amount of selenium), X2 (shelf life) and Y (oil acidity).

RESULTS AND DISCUSSION

Moisture content, mass fraction of fat, mass fraction of carotene, and amount of iodine were determined in freshly prepared butter (Table 1).

Table 1 Chemical composition of butter.

Indicators	Alatau breed		Holstein breed	
	first lactation	Third lactation and high	first lactation	Third lactation and high
Amount of moisture	15.6	15.6	15.6	15.7
Mass fraction of fat, %	74.3	75.4	78.3	79.9
Mass fraction of carotene, %	0.04	0.04	0.03	0.04
Acidity, ° T	37.1	37.5	38.0	37.0
Quantity of iodine	28.6	28.5	28.9	28.7

The data of the table showed that the moisture content in the studied oil samples was within the range of 15.6-15.7. High moisture content of freshly prepared fat 15.7 was in Sako cows of Holstein breed, and in other groups it was 15.6. Acidity of milk fat ranged from 37.1 to 38.0. The fat prepared from milk of Tumsa Holstein cows had high acidity-38.0. This indicates that the fat contains a lot of free fatty acids. The fat content of freshly prepared butter was following the established standard. However, despite the high fat content in Holstein breed, there is little difference in Alatau cows.

Fat firmness assesses changes in butter composition depending on the time of year. Throughout the year, the iodine content of milk fat varies from 25 to 40. The amount of iodine starts to increase in March and reaches its peak in October. In combined milk, the minimum iodine content is observed in December-March, then it gradually increases and reaches its maximum in July-August. The iodine fraction expresses the amount of iodine, the value of which can be related to 100 grams of fat. The higher it is, the more unsaturated acids in the oil, and the more double bonds in these acids **[10]**.

The iodine index in cows of the Alatau breed was 28.62, while for those in the third lactation and beyond, it was 28.45. For Holstein cows, the iodine index values were 28.86 and 28.7, respectively.

Pleasant taste, smell and colour are essential in butter recipes. The type of butter primarily determines the flavour and odour of butter. There should be sweet butter with an excellent pronounced taste and smell of pasteurised cream. The taste and aroma of butter depend on the composition of cream, which, in turn, is determined by the season (the taste and smell of butter in winter is usually not expressed), biological maturity of cream, and storage period of products **[11]**. In our studies, fat from the milk of Holstein cows was characterised by pronounced flavour and aroma.

The consistency of butter is a consumer indicator related to its physical structure and composition **[12]**. In terms of consistency, butter should not be too hard, brittle, crumbly or soft; it should have elasticity and good spreading ability, retaining its shape even at temperatures of 20-25℃. In our study, the consistency of butter in all groups of cows was homogeneous and spreadable; the surface of fat on the cut was shiny with the tiniest drops of moisture.

Saturated fatty acids dominate milk fat, the total amount of which is about 65%. The primary saturated acids are palmitin, myristic acid and stearin. The results presented in Table 2 show that the total content of these three acids is 49%. The data also show that Holstein seed milk butter contains a low amount of stearic acid at 10.17 and a relatively high amount of volatile low molecular weight fatty acids (fatty, caproic, caprylic and lauric acids) at 11.26%.

The distribution of natural and artificially introduced Selenium between separate fractions of milk and its processed products was investigated.

Butter with selenium was produced from pasteurised cream by converting it into double cream following current technological recommendations. The product was enriched with selenium while whipping the double cream. Small amounts of selenium were detected in the tested milk. Their mean monthly content in milk ranged from 3.5 to 7.0 μg/kg and threshold values ranged from 3.0 to 9.0 μg/kg.

Of the 100% Selenium contained in milk, 4% was transferred to butter, 10% to whey, 43% to cheese and 43% to whey. This indicates that the natural selenium in milk is mainly bound to proteins. The selenium artificially introduced into milk was distributed among the latter fractions: butter 1, whey 4, cheese 5 and whey 90%. This indicates that the artificially introduced selenium preparation is mainly dissolved in the aqueous phase of milk and, during its further processing, passes with it into the final product.

Table 2 Fatty acid content in butter from Holstein seed milk.

Peak number	Name of the acid	Share of the total number, %
	Saturated	
1	$C_{4:0}$ Miles	2.42
2	$C_{6:0}$ Capron	3.80
3	$C_{8:0}$ Capril	2.29
4	$C_{12:0}$ Laurin	2.75
5	$C_{14:0}$ Miristin	16.45
6	$C_{16:0}$ Palmitin	22.48
7	$C_{18:0}$ Stearin	10.17
	Unsaturated	
8	$C_{18:1}$ Olein	28.58
9	$C_{18:2}$ Linol	2.79
10	$C_{18:3}$ Linolene	1.47

Therefore, this preparation can be used for the enrichment of liquid dairy products, while in the production of butter, cheese and other multi-component products, a part of the aqueous phase is released; for this reason, the preparation should be introduced at the final stage of production or in the finished product.

The dependence of butter flavour and odour on storage temperature (X1), amount of free volatile fatty acids (Y2), amount of fatty acids (V3) and peroxides (Y4), mass fraction of fat in butter (X2) and storage duration (X3) is expressed by the following regression equations:

The planning matrix of the experiment is shown in Table 3.

X1 selenium content, mg / kg

X2 shelf life, date

Y1 butter peroxide value (POV), 100 g x10-2 g I2

Y2 acid number (AV), oK

Y3 Reichert-Meissel number

Organoleptic evaluation Y4, score

Table 3 Experiment planning matrix.

№	Encoded values		Independent factors		Resulting factors			
	Z1	**Z2**	**X1**	**X2**	**Y1**	**Y2**	**Y3**	**Y4**
1	-1	-1	0	0	0.34	1.2	26	4.6
2	0	-1	5	0	0.34	1.2	26	4.6
3	1	-1	10	0	0.34	1.2	26	4.6
4	-1	0	0	15	0.63	1.8	64	4.2
5	0	0	5	15	0.46	1.5	34	4.35
6	1	0	10	15	0.44	1.5	31	4.4
7	-1	1	0	30	0.97	2.8	97	3.9
8	0	1	5	30	0.54	1.9	43	4.2
9	1	1	10	30	0.51	1.8	40	4.25

Table 4 Coordinates and values of critical points Y 1, Y 2, Y 3 and Y 4.

View	Coordinates of fixed points		Meaning of representation
	X1 – Amount of selenium	**X2 – Shelf life, days**	
Y_{1max}	0	30	0.97
Y_{1min}	10	0	0.34
Y_{2max}	0	30	2.8
Y_{2min}	10	0	1.2
Y_{3max}	0	30	97
Y_{3min}	10	0	26
Y_{4max}	10	0	4.6
Y_{4min}	0	30	3.9

Table 4 represents the response for the corresponding coordinates (X1 and X2). These points are used to analyze how changes in the amount of selenium and storage time affect the various parameters (Y1, Y2, Y3, Y4).

The study's results showed that using selenium preparations in butter production inhibited oxidative processes occurring during butter storage. In such a product, oxidative changes of butter were slowed down, resulting in the product's quality parameters being preserved longer. Similar phenomena were observed for all experimental butter samples. However, as the dose of selenium added to the oil increased (from 5 to 15 mg per kg of product), its antioxidant effect became more pronounced.

Before storage, the oil was evaluated between 45 and 43 points. After 15 days of storage, the taste and odor scores of the oil ranged from 44 to 40 points. The highest score was assigned to samples with high fat content stored at minus 5 °C. The 62.5 percent fat samples stored at 15 °C had the lowest score for this period. When stored for more than 30 days, there was a further decrease in the taste and odor score of the oil. It scored between 41 and 37 points during this storage period. In addition, only sweet butter stored at minus temperature remained in the high grade. At the last stage of storage (60 days), the butter scored from 38 to 35 points.

Extended multiple regression equations for peroxide value (Y1):

$$Y1\ POV = 0.3639 - 0.0353*x1 + 0.0192*X2 + 0.0037*x1*x1-0.0015*x1*X2-1.4815\ E\text{-}5 * X2 * X2$$

Regression analysis revealed a strong relationship between the change in butter shelf life and the amount of selenium by peroxide (POV) values (correlation index, 0.859; coefficient of determination, 0.738). The null hypothesis was rejected, and the regression coefficients and regression equations were statistically significant ($P<0.05$) (Table 5). Multiple R 0.859464739, r-squared 0.738679637.

Table 5 Regression analysis results of oil peroxide as a function of storage time and amount of selenium.

Variable name	Fisher's criterion (F-criterion)	F-probability of the null hypothesis for criterion (p)	regression equation coefficient	Student's criterion (t-test)	probability of the null hypothesis for the coefficient of the regression equation (P-level)
Initial value coefficient	8.480161	0.017845	0.44944444	5.702087	0.00125783
Selenium content			-0.0216667	-2.24442	0.06594501
Shelf life			0.01111111	3.452955	0.01358379

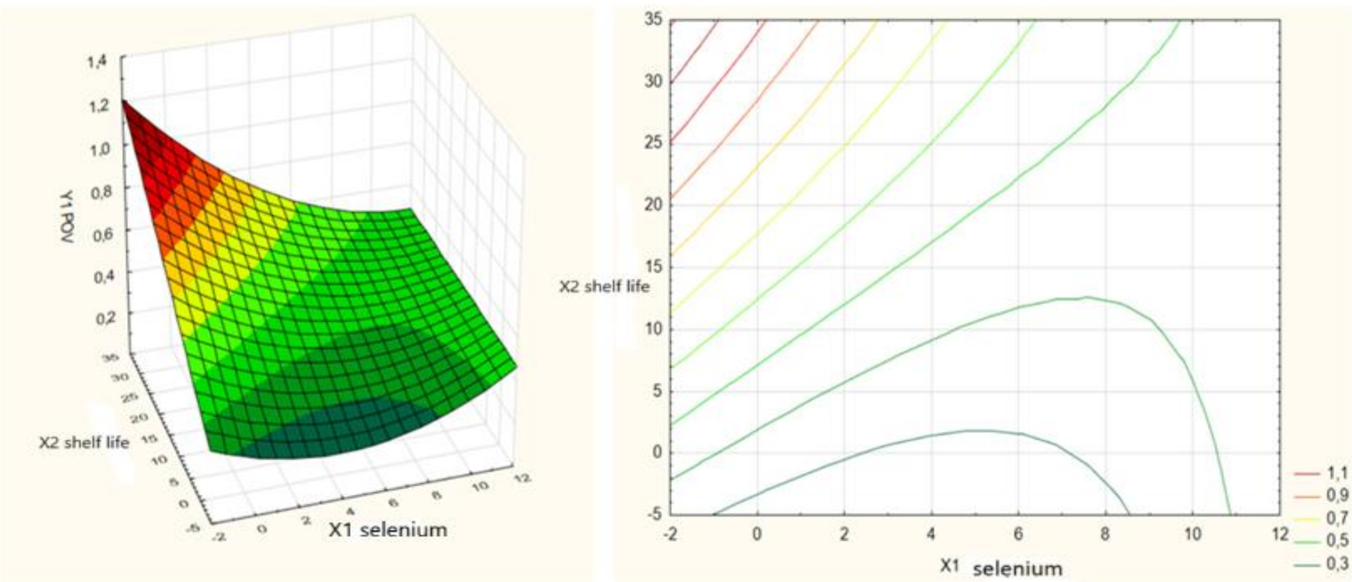

Figure 1 Butter peroxide (Y1) essentially, surface and lines representing equal levels of selenium content and storage time in butter.

Before storage, the butter peroxide value mainly depended on the type of butter and ranged from 0.35 to 0.44. After 15 days of storage, the distribution of oil peroxide took the following pattern. For oil with a fat content of 82.5% stored at Minus 5°C, the fat peroxide was 0.40, 5°C was 0.45 and 15°C was 0.53.

Over 30 days of storage, these values increased to 0.72; 0.77 and 0.83, and over 60 days, 0.80; 0.90 and 0.96, respectively.

Extended multiple regression equations for acid number (Y2):

Y2 AV = 1, 2278-0, 0667*x1+0, 0378*x2+0, 0073*x1*x1-0, 0033*x1 * x2+0, 0004 * X2 * X2

Regression analysis revealed a strong relationship between the change in butter shelf life and the amount of selenium as measured by acid number (AV) values (correlation index, 0.899; coefficient of determination, 0.808). The null hypothesis was rejected, and the regression coefficients and regression equations were statistically significant (P<0.05) (Table 6). R multiple 0.899128002, r-squared 0.808431163.

Table 6 Results of regression analysis of acidity value as a function of oil storage time and amount of selenium.

Variable name	Fisher's criterion (F-criterion)	F-probability of the null hypothesis for criterion (p)	regression equation coefficient	Student's criterion (t-test)	probability of the null hypothesis for the coefficient of the regression equation (P-level)
Initial value coefficient	12.66017	0.00703	1.388889	8.079945	0.000193
Selenium content			-0.04333	-2.05834	0.085252
Shelf life			0.032222	4.591684	0.003724

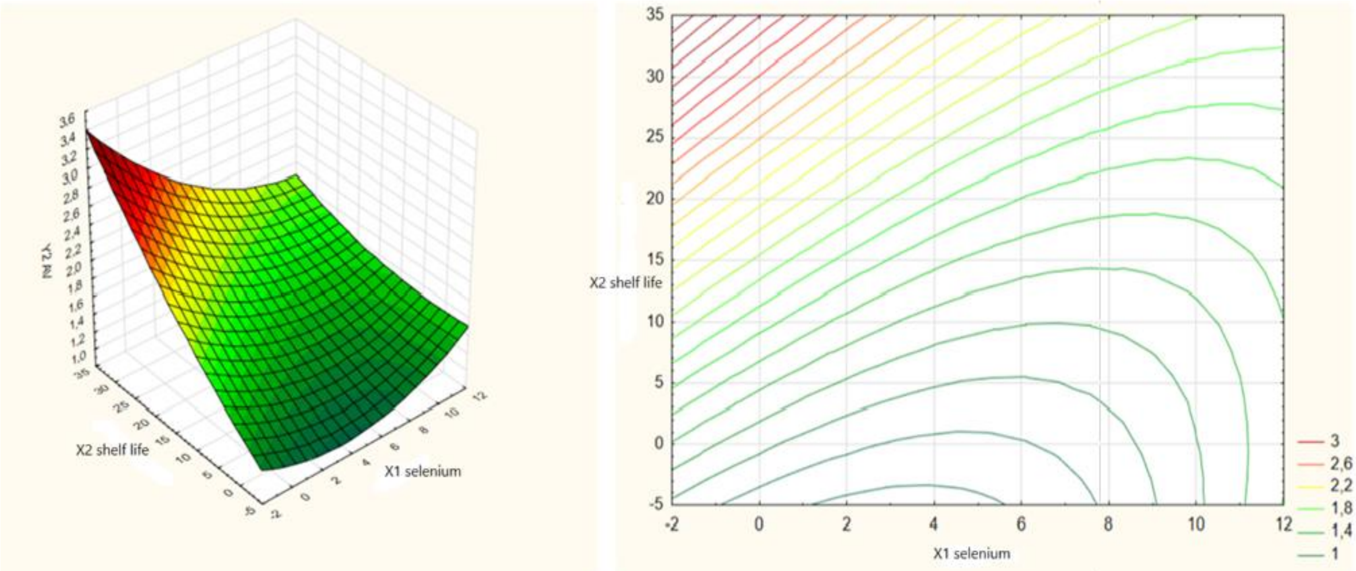

Figure 2 surface and lines of sight with equal storage time and amount of selenium in oil on the amount of oil acidity (Y2).

Extended multiple regression equations for Reichert-Meisel number (Y3):

Y3 = 31.0833-5.35*x1+2.0833*X2+0.52*x1*x1-0.19*x1*X2+2.047 E-16 * X2 * X2

Regression analysis revealed a strong relationship between the change in butter shelf life and the amount of selenium in the Reichert-Meisel number values (correlation index, 0.831; coefficient of determination, 0.691). The null hypothesis was rejected, the regression coefficients and regression equations were statistically significant (P<0.05) (Table 7). R multiple 0.831739166. R-squared 0.69179004.

Table 7 Results of regression analysis of Reichert-Meisel number as a function of oil storage time and amount of selenium.

Variable name	Fisher's criterion (F-criterion)	F-probability of the null hypothesis for criterion (p)	regression equation coefficient	Student's criterion (t-test)	probability of the null hypothesis for the coefficient of the regression equation (P-level)
Initial value coefficient	6.733624	0.029278	41	4.064034	0.00662
Selenium content			-3	-2.428	0.051302
Shelf life			1.133333	2.751736	0.033215

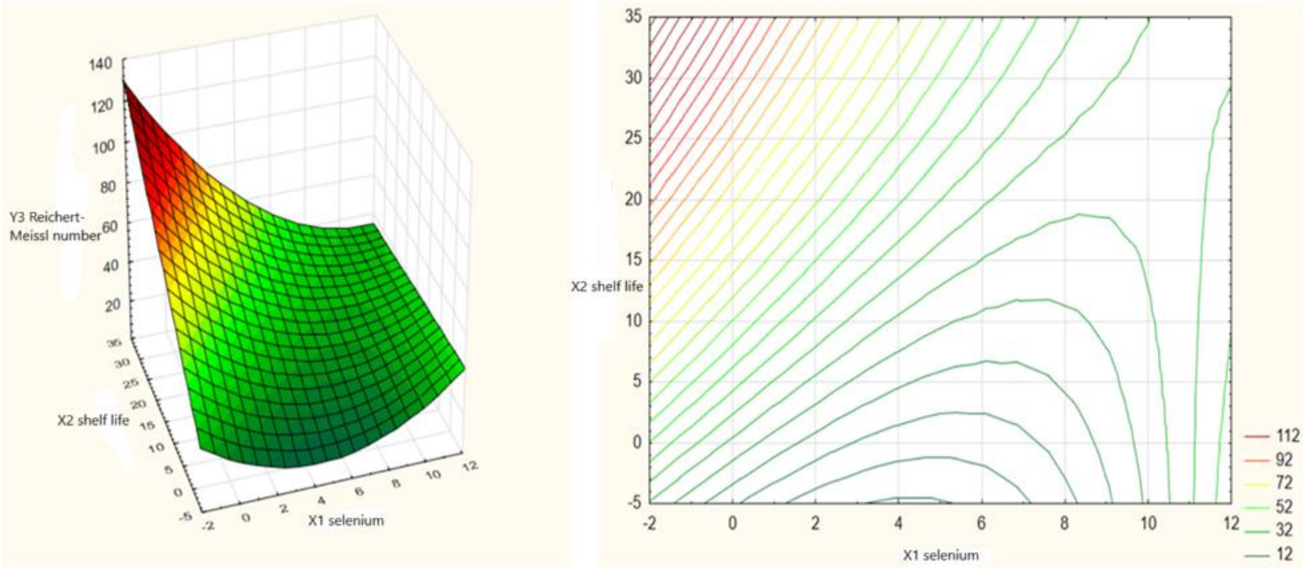

Figure 3 View surface and lines at equal levels of selenium content and storage time in oil by Reichert-Meisel number (Y3).

The maximum value of Reichert-Meisel number after 15 days of storage with a fat content of 62.5% was in oil stored at 15°C.

Extended multiple regression equations for organoleptic parameters (Y4):

$$Y4 = 4.5764+0.0264+0.0242*x1-0.0275*X2-0.0023*x1*x1+0.0012 * x1 * X2+0.0002 * X2 * X2$$

Regression analysis revealed a strong relationship between the change in butter shelf life and the amount of selenium in terms of organoleptic index values (correlation index, 0.946; coefficient of determination, 0.896). The null hypothesis was rejected, the regression coefficients and regression equations were statistically significant ($P<0.05$) (Table 8). Multiple R 0.946717113, r-squared 0.896273292.

Table 8 results of regression analysis of organoleptic indicators values depending on butter shelf life and amount of selenium

Variable name	Fisher's criterion (F-criterion)	F-probability of the null hypothesis for criterion (p)	regression equation coefficient	Student's criterion (t-test)	probability of the null hypothesis for the coefficient of the regression equation (P-level)
Initial value coefficient	25.92216	0.001116	4.494444	76.67185	3.31E-10
Selenium content			0.018333	2.553617	0.043279

Shelf life	-0.01611	-6.73226	0.000523

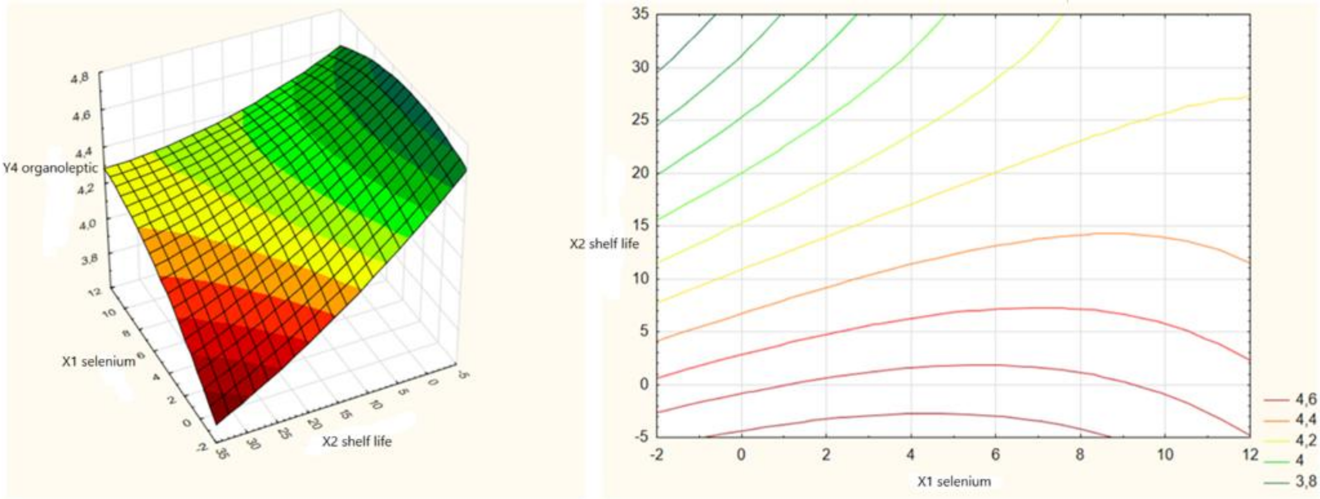

Figure 4 View surface and lines at the level of storage time and amount of selenium in oil by organoleptic oil parameters (Y4).

The presented results of production tests confirm the selenium's positive role in preserving butter's organoleptic properties.

Summarising the presented data, it should be noted that using selenium in butter production inhibits the development of oxidative processes and slows the deterioration of organoleptic characteristics during product storage. The rate of these processes depends on the storage temperature and the amount of oil in the butter. Due to the use of selenium at a temperature of Minus 5 °C, the shelf life of butter of the highest grade will increase by 1.6-2.0 times, at 5 °C by 1.8-2.4 times, and at 15 °C by 2.4-3.0 times.

A study shows that adding selenium and vegetable oil to broiler diets significantly improves body weight gain, final body weight and meat quality without increasing feed costs **[13]**, and selenium and vitamin E supplementation improved milk production. They provided higher levels of selenium and vitamin E in blood and milk **[14]**. High selenium levels in meat, eggs, poultry and seafood are essential for human health **[15]**. The study shows that 3% cinnamon extract **[16]** and carrot cake **[17]** can be used to create antioxidant-rich oil, and it can be used as a natural preservative in oil preparation. Sweet lime peel powder (SLPP) also improves the stability and quality of the oil at different storage times, with 6% SLPP showing the highest antioxidant activity and colour change **[18]**.

Adding 1.5% sea buckthorn to goat butter increases consumer appeal by 35%, giving it a sticky and sour taste but with a negative colour and fruity aroma **[19]**. Also, adding olein to butter produced a softer product with a more intense colour and possible nutritional benefits due to medium-chain triglycerides and higher levels of carotene **[20]**. In several scientific papers, scientists have investigated the technology of butter production with the addition of barberry **[21]**, dihydroquercetin **[22]**, and flaxseed **[23]**, which increases its nutritional value and calorie content while reducing bacterial contamination and saves raw milk. The positive effect of adding rosemary **[24]**, and thyme extracts was only observed when analysing the oxidative stability of milk fat of butter **[25]**.

Enrichment of butter with linseed oil and sesame oil improved vitamin E content, flavour and shelf life without compromising quality while adding antioxidant properties improved storage stability at 3-2 °C **[26]**. Also, the authors investigated the safety parameters of vegetable oils, and the rationality of using amaranth oil as a functional component of butter was established **[27]**.

Adding olein to butter resulted in a softer product with a more intense color and possible nutritional benefits due to medium chain triglycerides and higher levels of carotene **[28]**.

The concentration of 0.5% fucoidan in sour cream butter **[29]**, as well as the addition of 0.1% and 0.25% chia seed extract **[30]**, has been studied to increase shelf life and reduce acidity while preserving flavour, odour and colour during storage. Butter, ice cream and mayonnaise with lycopene supplementation extends their shelf life and maintain organoleptic properties while reducing extraneous flavours, odours and colour change during storage **[31]**.

Periodic monitoring during storage is crucial to preserve the organoleptic and physicochemical properties of the oil as they change with time **[32]**. Also, the physicochemical, microbiological and organoleptic characteristics and fatty acid composition of Turkish yak butter made from yoghurt were studied **[33]**. The effect of storage at 4

°C or 12 °C on cow butter produced without or with salt (2.1%) was studied **[34]**, and the physical and chemical characteristics of different types of butter made from pasteurised cream were determined during shelf life **[35]**.

CONCLUSION

The study results showed that using selenium preparations in butter production suppresses oxidative processes occurring during butter storage. As a result, oxidative changes in butter slowed down, and the quality parameters of the product were preserved longer. Similar phenomena were observed for all experimental butter samples. However, as the dose of selenium added to the butter increased (from 5 to 15 mg per kg of product), its antioxidant effect became more pronounced.

Before storage, the oil was evaluated between 45 and 43 points. After 15 days of storage, the taste and odour scores of the oil ranged from 44 to 40 points. The highest score was assigned to samples with high-fat content stored at minus 5 °C. The 62.5 percent fat samples stored at 15 °C had the lowest score for this period. When stored for more than 30 days, there was a further decrease in the taste and odour score of the oil. It scored between 41 and 37 points during this storage period. In addition, only sweet butter stored at minus temperature remained in the high grade. At the last storage stage (60 days), the butter scored from 38 to 35 points. Summarising the presented data, it should be noted that using selenium in butter production inhibits the development of oxidative processes and slows the deterioration of organoleptic characteristics during product storage. The rate of these processes depends on the storage temperature and the amount of oil in the butter. Due to the use of selenium at a temperature of minus 5 °C, the shelf life of butter of the highest grade increased by 1.6-2.0 times, at 5 °C by 1.8-2.4 times, and at 15 °C by 2.4-3.0 times.

REFERENCES

1. Pastukh, O. N., & Zhukova, E. V. (2021). To the issue of using secondary dairy raw materials. In IOP Conference Series: Earth and Environmental Science (Vol. 640, Issue 3, p. 032022). IOP Publishing. https://doi.org/10.1088/1755-1315/640/3/032022
2. Vélez-Terranova, M., Campos Gaona, R., Salamanca-Carreño, A., Velasco Daza, R. A., Arenas Rodríguez, B. A., & Chaparro Ortegón, J. S. (2023). Environmental Factors That Affect the Sanitary and Nutritional Variability of Raw Milk in Dual Purpose Livestock Systems of Colombian Orinoquia. In Animals (Vol. 13, Issue 8, p. 1385). MDPI AG. https://doi.org/10.3390/ani13081385
3. Mudavadi, O. P., Emmanuel, M. A., Charles, G., Namasake, M. F., & Bernard, L. A. (2020). Effects of Season Variation on Water, Feed, Milk Yield and Reproductive Performance of Dairy Cows in Smallholder Farms in Eastern Africa. In Journal of Agriculture and Ecology Research International (pp. 1–15). Sciencedomain International. https://doi.org/10.9734/jaeri/2020/v21i830157
4. Yudina, E., & Konovalov, S. (2020). Development Issues and Prospects of Milk Processing Enterprises. In Proceedings of the International Scientific Conference The Fifth Technological Order: Prospects for the Development and Modernization of the Russian Agro-Industrial Sector (TFTS 2019). Proceedings of the International Scientific Conference The Fifth Technological Order: Prospects for the Development and Modernization of the Russian Agro-Industrial Sector (TFTS 2019). Atlantis Press. https://doi.org/10.2991/assehr.k.200113.219
5. Señoráns, M., Gallo, V., Calvo, M. V., & Fontecha, J. (2023). Lipidomic and Proteomic Profiling of the Milk Fat Globule Membrane from Different Industrial By-Products of the Butter and Butter Oil Manufacturing Process. In Foods (Vol. 12, Issue 4, p. 750). MDPI AG. https://doi.org/10.3390/foods12040750
6. Staniewski, B., Ogrodowska, D., Staniewska, K., & Kowalik, J. (2021). The effect of triacylglycerol and fatty acid composition on the rheological properties of butter. In International Dairy Journal (Vol. 114, p. 104913). Elsevier BV. https://doi.org/10.1016/j.idairyj.2020.104913
7. Ullah, H., Liu, G., Yousaf, B., Ali, M. U., Abbas, Q., Munir, M. A. M., & Mian, M. M. (2018). Developmental selenium exposure and health risk in daily foodstuffs: A systematic review and meta-analysis. In Ecotoxicology and Environmental Safety (Vol. 149, pp. 291–306). Elsevier BV. https://doi.org/10.1016/j.ecoenv.2017.11.056
8. Narloch, I., & Wejnerowska, G. (2022). Comparison of the Effectiveness and Environmental Impact of Selected Methods for the Determination of Fatty Acids in Milk Samples. In Molecules (Vol. 27, Issue 23, p. 8242). MDPI AG. https://doi.org/10.3390/molecules27238242
9. Du, C., Liu, B., Hu, J., & Li, H. (2021). Determination of iodine number of activated carbon by the method of ultraviolet–visible spectroscopy. In Materials Letters (Vol. 285, p. 129137). Elsevier BV. https://doi.org/10.1016/j.matlet.2020.129137
10. Widodo, H., Adhani, L., Kustiyah, E., & Santoso, I. (2020). Studi Pengaruh Jenis Katalis, Waktu Reaksi dan Penurunan Bilangan IODINE pada Pembuatan Cocoa Butter Substitute dengan Proses Hidrogenasi Minyak

Kelapa. In Jurnal Jaring SainTek (Vol. 1, Issue 1, pp. 8–14). Universitas Bhayangkara Jakarta Raya. https://doi.org/10.31599/jaring-saintek.v1i1.183

11. Panchal, B., Truong, T., Prakash, S., Bansal, N., & Bhandari, B. (2021). Influence of fat globule size, emulsifiers, and cream-aging on microstructure and physical properties of butter. In International Dairy Journal (Vol. 117, p. 105003). Elsevier BV. https://doi.org/10.1016/j.idairyj.2021.105003
12. Pădureţ, S. (2021). The Effect of Fat Content and Fatty Acids Composition on Color and Textural Properties of Butter. In Molecules (Vol. 26, Issue 15, p. 4565). MDPI AG. https://doi.org/10.3390/molecules26154565
13. Ibrahim, M., Eljack, B., & Fadlalla, I. (2011). Selenium supplementation to broiler diets. Animal Science Journal, 2, 12-17.
14. Saran Netto, A., Silva, T. H., Martins, M. M., Vidal, A. M. C., Salles, M. S. V., Roma Júnior, L. C., & Zanetti, M. A. (2022). Inclusion of Sunflower Oil, Organic Selenium, and Vitamin E on Milk Production and Composition, and Blood Parameters of Lactating Cows. In Animals (Vol. 12, Issue 15, p. 1968). MDPI AG. https://doi.org/10.3390/ani12151968
15. Basta, A. H., El-Saied, H., Baraka, A. M., & Lotfy, V. F. (2016). Comparative evaluation of xerogel-based activated carbons synthesized from aliphatic aldehydes of different chain lengths. In Soft Materials (Vol. 14, Issue 4, pp. 297–308). Informa UK Limited. https://doi.org/10.1080/1539445x.2016.1212065
16. Vidanagamage, S. A., Pathiraje, P. M. H. D., & Perera, O. D. A. N. (2016). Effects of Cinnamon (Cinnamomum Verum) Extract on Functional Properties of Butter. In Procedia Food Science (Vol. 6, pp. 136–142). Elsevier BV. https://doi.org/10.1016/j.profoo.2016.02.033
17. Naurzbayeva, G., Smolnikova, F., Baytukenova, S., Kapshakbayeva, Z., Mustafayeva, A., Baytukenova, S., Smailova, Z., Dikhanbayeva, F., Temerbayeva, M., & Baybalinova, G. (2023). Incorporating carrot pomace-based emulsion to enhance the nutritional value and shelf life of butter. In International Journal of Food Properties (Vol. 26, Issue 1, pp. 2455–2475). Informa UK Limited. https://doi.org/10.1080/10942912.2023.2251718
18. Maqbool, Z., Tahir, H. S., Nadeem, M. T., Ahmad, R. S., Yasmin, A., Khalid, W., Asar, T. O., & Al-Sameen, M. A. (2023). Stability of Butter Using Spray Dried Sweet Lime Peel (SLP) Powder. In International Journal of Food Properties (Vol. 26, Issue 1, pp. 2627–2641). Informa UK Limited. https://doi.org/10.1080/10942912.2023.2241659
19. Chudy, S. (2021). Colour and textural typologies of goat cream butter with sea buckthorn (Hippophae rhamnoides L.) puree: instrumental, sensory, and consumer input for product development. In Mljekarstvo (Vol. 71, Issue 4, pp. 237–247). Croatian Dairy Union. https://doi.org/10.15567/mljekarstvo.2021.0403
20. Queirós, M. S., Grimaldi, R., & Gigante, M. L. (2016). Addition of olein from milk fat positively affects the firmness of butter. In Food Research International (Vol. 84, pp. 69–75). Elsevier BV. https://doi.org/10.1016/j.foodres.2016.03.017
21. Dolmatova, O. I., & Rogova, A. A. (2021). Dessert butter. In Proceedings of the Voronezh State University of Engineering Technologies (Vol. 83, Issue 2, pp. 148–153). FSBEI HE Voronezh State University of Engineering Technologies. https://doi.org/10.20914/2310-1202-2021-2-148-153
22. Ziablitseva, M. A., Bessonova, J. A., & Yershova, O. V. (2022). Production of butter paste with dihydroquercetin technology. In IOP Conference Series: Earth and Environmental Science (Vol. 1052, Issue 1, p. 012070). IOP Publishing. https://doi.org/10.1088/1755-1315/1052/1/012070
23. Hurtaud, C., Faucon, F., Couvreur, S., & Peyraud, J.-L. (2010). Linear relationship between increasing amounts of extruded linseed in dairy cow diet and milk fatty acid composition and butter properties. In Journal of Dairy Science (Vol. 93, Issue 4, pp. 1429–1443). American Dairy Science Association. https://doi.org/10.3168/jds.2009-2839
24. Surkova, S. A., Slozhenkina, M. I., Gorlov, I. F., Mosolova, N. I., Tkachenkova, N. A., & Grebennikova, J. D. (2022). Vegetable oils in dairy production: perspectives, food safety and guarantee of sustainable development of the food system. In IOP Conference Series: Earth and Environmental Science (Vol. 981, Issue 2, p. 022090). IOP Publishing. https://doi.org/10.1088/1755-1315/981/2/022090
25. Ziarno, M., Kozłowska, M., Ratusz, K., & Hasalliu, R. (2023). Effect of the Addition of Selected Herbal Extracts on the Quality Characteristics of Flavored Cream and Butter. In Foods (Vol. 12, Issue 3, p. 471). MDPI AG. https://doi.org/10.3390/foods12030471
26. Haldar, S., Wong, L. H., Tay, S. L., Jacoby, J. J., He, P., Osman, F., Ponnalagu, S., Jiang, Y. R., Lian, H. P. R., & Henry, C. J. (2020). Two Blends of Refined Rice Bran, Flaxseed, and Sesame Seed Oils Affect the Blood Lipid Profile of Chinese Adults with Borderline Hypercholesterolemia to a Similar Extent as Refined Olive Oil. In The Journal of Nutrition (Vol. 150, Issue 12, pp. 3141–3151). Elsevier BV. https://doi.org/10.1093/jn/nxaa274

27. Denisov, S. V. (2021). Safety and quality indices of vegetable oils, the use of amaranth oil as a functional component for butter. In International Scientific Conference. Agrobiotechnology-2021. Publishing house of RGAU - MSHA. https://doi.org/10.26897/978-5-9675-1855-3-2021-179
28. Kiciński, W., Norek, M., Dziura, A., & Polański, M. (2016). Copolycondensation of heterocyclic aldehydes: A general approach to sulfur and nitrogen dually-doped carbon gels. In Microporous and Mesoporous Materials (Vol. 225, pp. 198–209). Elsevier BV. https://doi.org/10.1016/j.micromeso.2015.11.050
29. Alipour, A., Marhamatizadeh, M. H., & Mohammadi, M. (2023). Studying the shelf life of butter containing fucoidan, by evaluating sensory and chemical properties. In Food Science & Nutrition (Vol. 11, Issue 6, pp. 2956–2963). Wiley. https://doi.org/10.1002/fsn3.3277
30. Sadri-Saeen, Z., Khani, M., & Fadaei, V. (2023). Improving the microbial quality and sensory properties of pasteurized sweet cream butter during refrigerated storage using chia seed ethanolic extract. In Food Science & Nutrition (Vol. 12, Issue 1, pp. 564–573). Wiley. https://doi.org/10.1002/fsn3.3802
31. Kaur, D., Wani, A. A., Singh, D. P., & Sogi, D. S. (2011). Shelf Life Enhancement of Butter, Ice-Cream, and Mayonnaise by Addition of Lycopene. In International Journal of Food Properties (Vol. 14, Issue 6, pp. 1217–1231). Informa UK Limited. https://doi.org/10.1080/10942911003637335
32. Guseva, T., Soldatova, S., & Karanyan, O. (2020). Organoleptic Evaluation of Butter. Features of Conducting and Interpreting Results. In Bulletin of Science and Practice (Vol. 6, Issue 9, pp. 222–228). Publishing Center Science and Practice. https://doi.org/10.33619/2414-2948/58/22
33. Sağdıç, O., Dönmez, M., & Demirci, M. (2004). Comparison of characteristics and fatty acid profiles of traditional Turkish yayik butters produced from goats', ewes' or cows' milk. In Food Control (Vol. 15, Issue 6, pp. 485–490). Elsevier BV. https://doi.org/10.1016/j.foodcont.2003.07.003
34. Méndez-Cid, F. J., Centeno, J. A., Martínez, S., & Carballo, J. (2017). Changes in the chemical and physical characteristics of cow's milk butter during storage: Effects of temperature and addition of salt. In Journal of Food Composition and Analysis (Vol. 63, pp. 121–132). Elsevier BV. https://doi.org/10.1016/j.jfca.2017.07.032
35. Birghila, S., & Dobrinas, S. (2010). The influence of the storage time on the stability of butter. In Environmental Engineering and Management Journal (Vol. 9, Issue 11, pp. 1579–1582). OAIMDD - EcoZone Publishing House. https://doi.org/10.30638/eemj.2010.215

Funds:

This work was not supported by external grants.

Acknowledgments:

-

Competing Interests:

No potential conflict of interest was reported by the author(s).

Ethical Statement:

This article does not contain any studies that would require an ethical statement.

AI Statement:

Artificial intelligence was not used in the article.

Contact Address:

Bagila Jetpisbayeva
Affiliation: Almaty Technological University, Department of Technology of Food products, Tole Bi Str., 100, 050000, Almaty, Republic of Kazakhstan
Tel.: +77072389275
E-mail: dzhetpisbaeva.b@atu.edu.kz
ORCID: https://orcid.org/0000-0002-0792-3903
Author contribution: writing – review & editing

Alma Katasheva
Affiliation: Almaty Technological University, Department of Food Biotechnology, Tole Bi Str., 100, 050000, Almaty, Republic of Kazakhstan,
Tel.: +77075074664
E-mail: alma_81.kz81@mail.ru
ORCID: https://orcid.org/0000-0001-7964-7736
Author contribution: methodology

Sholpan Abzhanova
Affiliation: Almaty Technological University, Department of Technology of Food products, Tole Bi Str., 100, 050000, Almaty, Republic of Kazakhstan,
Tel.: +77753338624
E-mail: sh.abzhanova@atu.kz
ORCID: https://orcid.org/0000-0003-3209-6855
Author contribution: resources

Ulzhan Nuraliyeva
Affiliation: Kazakh Research Institute of Livestock and Foraging, Zhandosov street 51, Almaty, Republic of Kazakhstan
Tel.: +77075074664
E-mail: nua.ulgan@mail.ru
ORCID: https://orcid.org/0000-0003-3499-2629
Author contribution: validation

Akylzhan Kozhabergenov
Affiliation: Kazakh National Agrarian University, Department of Food Technology and Safety, Valikhanov str., 137, 050000, Almaty, Republic of Kazakhstan,
Tel.: +77075074664
E-mail: Kozhabergenov79@yandex.ru
ORCID: https://orcid.org/0000-0002-5963-1435
Author contribution: investigation

Ayazhan Kanatkyzy
Affiliation: Almaty Technological University, Department of Technology of Food products, Tole Bi Str., 100, 050000, Almaty, Republic of Kazakhstan,
Tel.: +77075074664
E-mail: aazankanatkyzy6@gmail.com
ORCID: https://orcid.org/0009-0005-1376-0476
Author contribution: formal analysis

Corresponding author: **Bagila Jetpisbayeva**

Copyright notice: