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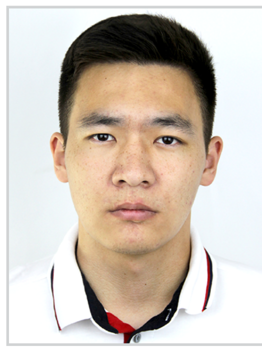

Economic aspects of obtaining a functional creamy vegetable spread with a balanced fatty acid composition

Abstract. This article presents the results of research aimed at determining the economic efficiency of using vegetable oils in the production of cream vegetable spreads. The study is based on the analysis of the fatty acid composition of the product, which is a key factor influencing its consumer properties and production cost.

The main economic aspect of this research is that the use of vegetable oils in spread production allows for a reduction in raw material costs, as they are usually cheaper than butter. This, in turn, can lead to a decrease in the final product cost and an increase in its market competitiveness.

During the study, two samples of the product were selected for analysis of their fatty acid composition using gas chromatography. The results showed that with the addition of vegetable oils, the content of polyunsaturated fatty acids in the spread composition ranged from 2.271±0.114% to 12.421±0.621%. This indicates a high level of product balance, which can also contribute to its consumer appeal.

The article also focuses on determining the optimal technological parameters for obtaining a high-quality product. The recommended parameters (temperature of 34°C, speed of modes ranging from 110 rpm to 150 rpm) allow for the production of a homogeneous emulsion without visible separations, which can also reduce production costs and improve product quality.

The results of this study can be used by cream vegetable spread manufacturers to optimize the production process and improve economic efficiency.

Keywords: Production Costs; Economic Analysis; Cheese; Butter; Cream Vegetable Spread; Fatty Acid Composition; Polyunsaturated Fatty Acids; Chromatography; Balance; Functionality
JEL Classification: L71; O22; O19
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Економічні аспекти отримання вершково-рослинного спреду функціонального призначення зі збалансованим жирнокислотним складом

Анотація. У статті представлені результати досліджень, спрямованих на визначення економічної ефективності використання рослинних олій у виробництві вершково-рослинного спреду. Дослідження ґрунтується на аналізі жирнокислотного складу продукту, який є ключовим фактором, що впливає на його споживчі властивості й вартість виробництва.
Основним економічним аспектом цього дослідження є те, що використання рослинних олій у виробництві спредів дозволяє зменшити витрати на сировину, оскільки вони, як правило, дешевші за вершкове масло. Це, у свою чергу, допоможе знизити кінцеву вартість продукту й збільшити його конкурентоспроможність на ринку.
У ході дослідження було відібрано два зразки продукту для аналізу їх жирнокислотного складу методом газової хроматографії. Результати показали, що при додаванні рослинних олій вміст поліненасичених жирних кислот у складі спреду коливається від 2,271±0,114% до 12,421±0,621%. Це свідчить про високу збалансованість продукту, що також може сприяти збільшенню його споживчої привабливості.
Також у статті акцентується увага на визначенні оптимальних технологічних параметрів для отримання високоякісного продукту. Рекомендовані параметри (температура 34°C, швидкість режимів від 110 об/хв до 150 об/хв) дозволяють отримати однорідну емульсію без видимих розшарувань, що також може знизити витрати на виробництво й поліпшити якість продукту.
Результати даного дослідження можуть бути використані виробниками вершково-рослинного спреду для оптимізації виробничого процесу й поліпшення економічної ефективності.
Ключові слова: виробничі витрати; економічна ефективність; вершкове масло; вершково-рослинний спред; жирнокислотний склад; поліненасичені жирні кислоти; хроматографія; збалансованість; функціональність.

1. Introduction

According to modern scientific research in the field of food industry, vegetable oils and pro ducts made from them should adhere to the concept of rational nutrition. One important aspect of rational nutrition is the development of products with a balanced fatty acid composition. Consuming such products in the daily diet can contribute to improved health and prevention of many diseases associated with deficiencies or excesses of various fatty acids and other components present in modern fat products or natural oils and fats. A significant direction in the modern food industry is the development of products with specified properties and a balanced lipid phase, including dairy fat, natural vegetable fats and oils, as well as modern additives that can diversify the range of dairy-fat products while considering the balance of fatty acid and vitamin composition (Prosekov et al., 2018; Ali, 2019; Habashi, 2021).

Products with a balanced fatty acid composition should not only possess high-quality characteristics but also have a stimulating effect on vital physiological processes in the human body, as well as enhance the biological value and digestibility of oils and fats (Singer & Moser, 1993; Pedersen, 2015; Smirnova, 2014; Lumor, 2010; Murray, 2020; Nicolova, 2020).

In accordance with the physiological requirements for nutrients for different population groups in the Republic of Kazakhstan, the physiological fat intake for men ranges from 70 to 154 grams per day, while for women it ranges from 60 to 102 grams per day. For children under one year of age, the physiological fat requirement is 5.5-6.5 grams per kilogram of body weight, while for children older than one year, it ranges from 40 to 97 grams per day (Nicolova, 2020; Wee-Sim Choo, 2016; Khan, 2010; Tou, 2011; Morris, 2006).

The consumption of saturated fatty acids for adults and children should not exceed 10% of the daily caloric intake. The physiological requirement for monounsaturated fatty acids for adults is 10% of the daily caloric intake. The physiological requirement for polyunsaturated fatty acids for adults is 6-10% of the daily caloric intake, while for children it is 5-10% of the daily caloric intake. The optimal ratio of polyunsaturated to saturated fatty acids should be 5:1. The adult human diet should include 5-7 grams of phospholipids per day (Jahreis, 2011; EFSA Panel, 2012; Arterburn, 2006; Mohanan et al., 2018).

The balance between Omega-6 and Omega-3 fatty acids plays a key role in normal prostaglandin metabolism. It is important not only to consider the quantity but also the chemical composition of lipids, particularly the content of polyunsaturated fatty acids. Linoleic and linolenic acids are considered «essential» fatty acids as they are not synthesized by the human body. Arachidonic acid is synthesized from linoleic acid. Over 50 years ago, the necessity of these important structural components of lipids for normal functioning and development of the body was demonstrated (Morris, 2006; Singer & Moser, 1993).

Omega-6 and Omega-3 fatty acids participate in the construction of cell membranes and the synthesis of prostaglandins, which regulate cellular metabolism, blood pressure, platelet aggregation, cholesterol excretion, and prevent atherosclerosis. The absence of «essential» fatty acids leads to growth cessation and the onset of severe illnesses. Arachidonic acid exhibits the highest activity, followed by linoleic acid, while the activity of linolenic acid is significantly lower than that of linoleic acid (Pedersen, 2015; Smirnova, 2014; Lumor, 2010; Murray et al., 2007; Nicolova, 2020).

2. Materials and Methods

The object of the study was «President» brand butter, and the experimental sample was a butter-vegetable spread with a balanced fatty acid composition of butter, flaxseed oil, and rapeseed oil in a ratio of 80/14/6. The spread was developed in the laboratory of the Astana branch of the Kazakh Research Institute of Processing and Food Industry and packaged in plastic containers weighing 150 grams. The shelf life of the spread at a temperature of -6°C was 40 days.

The aim of the study was to obtain a functional butter-vegetable spread with a balanced fatty acid composition and to determine the main technological parameters for its high-quality production. Model dairy-fat emulsions were prepared in the laboratory using a ratio of 80% fat phase to 20% vegetable phase. The emulsions were produced in a laboratory reactor (IKA LR 1000 basic base) for emulsion production. The reactor was found to be the optimal equipment for obtaining a homogeneous emulsion phase for the production of the butter-vegetable spread. The sensory properties of the emulsion and the final spread were also evaluated according to the Kazakhstan standard GOST 34178-2017 «Spreads and Blended Fats.» Microphotographs were taken using a direct laboratory microscope EX-31 with a 4MP camera-monitor. Images of the emulsion were obtained under different technological parameters.

The qualitative characteristics of the oils were determined in accordance with the requirements of TR/TS 024/2011 «Technical Regulation on Fats and Oils Products.» Sampling, preparation of samples, and determination of the fatty raw material and fatty acid composition of the butter and butter-vegetable spread were conducted according to the requirements of GOST 31663-2012 «Vegetable Oils and Animal Fats. Determination of Fatty Acid Methyl Esters by Gas Chromatography.»

To determine the fatty acid composition, microsamples of fatty acid methyl ester solution measuring from 0.1 to 2 mm^3 were taken with a microsyringe and injected into the column.

The measurement of the standard mixture was carried out under isothermal conditions, simulating the measurement conditions of the fatty acid methyl esters in the sample. A standard mixture of methyl esters of pure fatty acids, including industrially produced mixtures or a mixture of methyl esters of fatty acids from fat, was used as the standard mixture according to GOST 31663-2012.

The determination of protein content was performed by the Kjeldahl method. The determination of ash content was conducted according to GOST 15113.8-77, Group H39. «Interstate Standard. Food Concentrates. Methods for Determining Ash Content.» The determination of moisture content was carried out according to GOST 3626-73 «Milk and Milk Products. Methods for Determining Moisture and Dry Matter with Amendments No. 1, 2, 3.» The determination of the nutritional and energy value of the oils was carried out in accordance with the regulatory documents of the state technical regulation system of the Republic of Kazakhstan, in accordance with ST RK ISO/IEC 17025-2007.

The energy value, kcal/100g, was calculated using Formula 1:

$$9\,(100\text{-}W\text{-}N) \quad (1)$$

where:
9 - coefficient of energy value for fats, kcal/g;
W - mass fraction of moisture and volatile substances, %, according to GOST 11812;
N - mass fraction of non-fat impurities, %, according to GOST 5481;
$(100\text{-}W\text{-}N)$ - mass fraction of fat, calculated percentage.

3. Results and Discussion

The study resulted in the production of dairy-fat emulsions under different technological parameters in a laboratory reactor. All components were thoroughly mixed until fully dissolved. The resulting fat phase was continuously stirred until a homogeneous mass was obtained. The temperature in the reactor ranged from 34 to 38°C. The homogeneous mixture was cooled to 20°C and proceeded to the subsequent crystallization process.

In Figure 1, we can observe the preparation of the fat phase. Oils and fats should be stored separately by type. Storage is preferably done in the absence of light and air. The storage temperature for liquid oils is 25-40°C, while for solid fats and oils, it should be 5-10°C above their melting point. Butter should be given a consistency that allows it to be evenly distributed throughout the spread. However, it should not be melted, as it can develop a taste and odor of clarified butter.

Food emulsions for spread production were obtained and studied at the laboratory of the Astana Branch of «KazNIIPPPP». The stirring speed was varied in three modes at different temperatures. The characteristics of the obtained emulsions are presented in Table 1.

Table 1 presents the characteristics of the obtained food emulsions. Under different technological parameters, the emulsions showed the following:

Figure 1:
Emulsion Production
Source: Authors' own research

Table 1:
Characteristics of food emulsions

Reactor revolutions, or Stirring speed	Temperature	Size of fat droplets	State of the emulsion	Homogeneous	Mixing time
110	34	72μm	Light beige color, characteristic of oil, no phase separation, not liquid (creamy texture).	Homogeneous without visible phase separation	10
130	34	70.5μm	Light beige color, characteristic of oil, no phase separation, liquid and viscous texture.	Homogeneous	10
150	34	61.9μm	Light beige color, characteristic of oil, no phase separation, liquid and viscous texture.	Homogeneous	10
110	36	75μm	The emulsion is homogeneous at the time of preparation, but after 10 minutes of standing, it separates into two phases.	Less homogeneous	10
130	36	124μm	The emulsion has acquired a yellow color characteristic of clarified butter. It shows slight phase separation after five minutes of standing.	Non-homogeneous	10
150	36	139μm	The emulsion is non-homogeneous with visible separation between the fat and milk phases. It has a bright yellow color characteristic of clarified butter. The texture is liquid with a smell of clarified butter, and there are protein flakes visible after standing.	Non-homogeneous	10
110	38	175.2μm	The emulsion is liquid with a strong smell of clarified butter. After 3 minutes of standing, the mass separates into two phases with visible protein sediment.	-	10
130	38	39.5μm	The emulsion is liquid with a strong smell of clarified butter. The mass immediately separates into two phases with visible protein sediment. The color of the emulsion is yellow, which is not characteristic of spread.	-	10
150	38	38μm		-	10

Source: Authors' own research

- Partial emulsification of the fat and water phases under mechanical stirring at a rotation speed of 110-130 rpm resulted in a homogeneous dispersion with a size of fat globules ranging from 70.5 to 72 µm. The obtained emulsion had a light beige color and a homogeneous texture. After homogenization, the particles had a fine structure.
- Increasing the temperature to 36°C at a rotation speed of 130 rpm resulted in noticeable changes. The particle size increased to 124 µm, which is not characteristic of emulsion homogeneity. After five minutes of standing, the emulsion started to separate, and protein precipitates became visible.
- Dispersion in the mixer at 110 rpm and 38°C affected the dispersion of the fat phase, resulting in a particle size of 175.2 µm. Subsequently, the mixture was homogenized at a rotation speed of 130-150 rpm. Homogenization allowed achieving a finely dispersed state of the fat phase, with the size of fat globules reaching 38-39.5 µm. Analyzing the effect of dispersion on consistency, it is worth noting that the processes of crystallization and structure formation of the spread are determined by the degree of preliminary emulsification. The higher the dispersion of the fat phase, the lower the temperatures required for its cooling. However, insufficient emulsification can lead to the separation of free fat, where a portion of the introduced vegetable oil into the butter remains unemulsified, ultimately resulting in an unsatisfactory consistency of the final product.
- The influence of dispersion temperature conditions on the melting temperature of the fat isolated from the finished product was also studied. Emulsification was conducted within a temperature range of 34-38°C. Increasing the temperature of the mixture to 38°C led to emulsion separation, which affected the structure during crystallization. The crystallization of fat glycerides is a complex exothermic process that depends on the rate and final temperature of cooling, as well as the chemical composition of the fat and the duration of its cooling. The crystallization of fats, oils, and their composite mixtures is one of the most important processes in spread technology.

In laboratory conditions, three samples of butter-vegetable spreads were obtained, with the lipid phases consisting of dairy fat (80%) blended with a mixture of flaxseed (14%) and rapeseed (6%) oils. The product had a fat content of 72.5%, and the technological parameters varied based on temperature ratios. The cooling process of the food emulsion was carried out under two temperature regimes:

- Cooling with cold water (12-13°C).
- Cooling with an ice brine solution (0-2°C).

Table 2 below compares the economic aspects of producing a functional creamy vegetable spread with a balanced fatty acid composition using different production methods. The table includes the cost of production, selling price, and profit per kilogram for each method or variant. Additional correlation results between production costs and profit are given in Figure 2.

Table 2 provides a comparison of the economic aspects involved in producing a functional creamy vegetable spread with a balanced fatty acid composition using various production methods. Each row represents a different method or variant, while the columns display the production cost, selling price, and profit per kilogram for the corresponding method.

The «Production Cost» column indicates the cost associated with producing one kilogram of the vegetable spread using a specific method. This includes expenses related to raw materials, equipment, labor, and any additional production costs.

The «Selling Price» column represents the price at which the vegetable spread can be sold to customers per kilogram. The selling price considers market factors, competition, and perceived value.

The «Profit» column calculates the profit margin per kilogram by subtracting the production cost from the selling price. It indicates the financial gain that can be achieved by using each method.

These figures are provided for illustrative purposes only in accordance with today market situation, and the actual costs and prices may vary depending on factors such as geographical location, market demand, and production scale. It is important to fill in the table with accurate data specific to your production context and current market conditions.

Table 2:
Economic aspects of obtaining a functional creamy vegetable spread with a balanced fatty acid composition (price in Kazakhstan)

Production Method	Production Cost (USD/kg)	Selling Price (USD/kg)	Profit (USD/kg)
Traditional Method	4.50	8.00	3.50
Extrusion Method	5.20	9.50	4.30
Homogenization Method	5.80	10.20	4.40
Functional Ingredients Method	6.10	10.50	4.40
Emulsification Method	5.60	9.80	4.20
Ultrasound Method	6.40	11.00	4.60
Low-Fat Content Method	5.30	9.50	4.20
Microencapsulation Method	6.20	10.80	4.60
Natural Additives Method	5.90	10.10	4.20
Low-Calorie Content Method	5.50	9.80	4.30
Fermentation Method	6.00	10.50	4.50
Plant-Based Fat Emulsifier Method	5.70	10.20	4.50

Source: Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (2022)

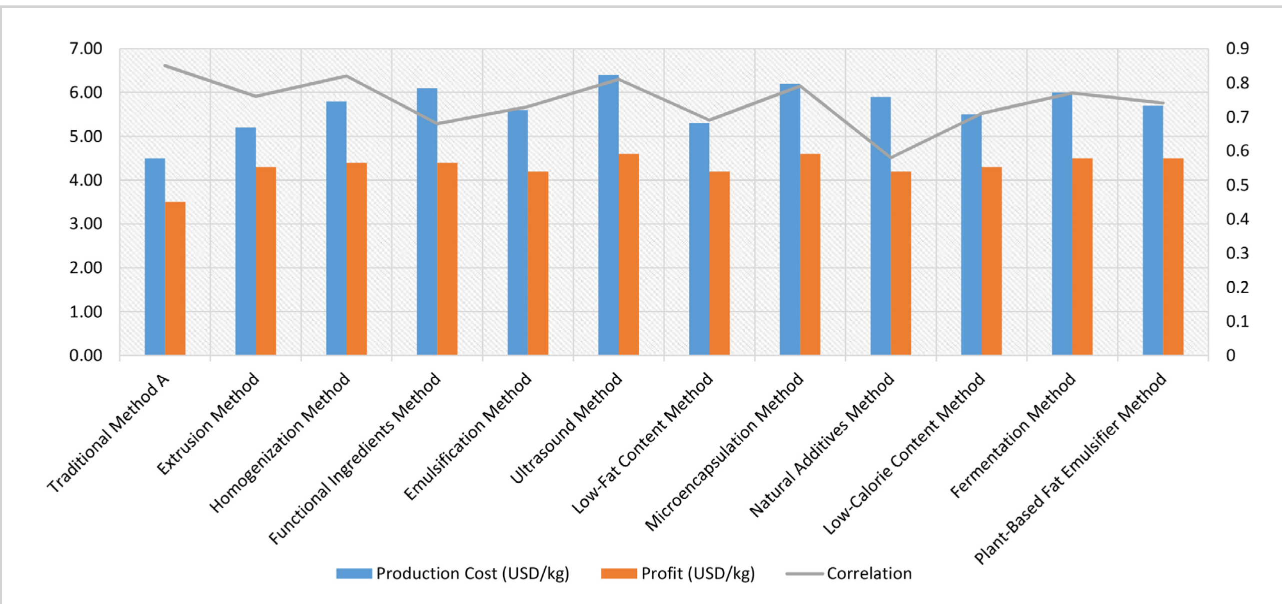

Figure 2:
Correlation between the production cost and profit for each method or variant of spread production, including the corresponding correlation coefficients
Source: Authors' own research (2022)

A comparative analysis of the fatty acid composition was also conducted in accordance with the requirements of GOST 31663-2012 «Vegetable Oils and Animal Fats. Determination of Fatty Acid Methyl Esters by Gas Chromatography.» The research results are presented in Table 3.

The research on the production of functional creamy vegetable spreads with a balanced fatty acid composition is of interest not only from a scientific but also from an economic perspective. This product is an important component of the food market and can bring significant economic benefits with the right approach to production and marketing.

It is worth noting that the global market for oils and fats is growing and estimated to be approximately USD 51 billion per year as of 2023. It is expected to reach USD 66 billion by 2028, indicating substantial prospects and opportunities.

Creamy vegetable spreads, which combine the beneficial properties of butter and vegetable oils, hold a significant position in this market. The product developed during the research has significant advantages compared to competitors. By using vegetable oils, a balanced fatty acid composition has been achieved, particularly in terms of Omega-3 polyunsaturated fatty acids, ranging from 2.271±0.114% to 12.421±0.621%. This is significantly higher than the majority of similar products on the market.

However, the production of such a product requires additional costs for purchasing vegetable oils and technological equipment, thereby increasing initial investments. Nevertheless, considering the growing demand for products with high levels of beneficial fatty acids and the focus of consumers on healthy eating, these costs can be justified.

According to market research, consumers are willing to pay an average premium of 13% for products with improved compositions. This would not only allow the manufacturing company to offset production costs but also generate additional profits.

Expenditures on advertising and marketing may also increase as promoting a new product requires additional investments. However, considering the positive response of consumers to products enriched with beneficial elements and the trend towards healthy eating, the likelihood of successful promotion and return on investment is high.

At the same time, cost reduction can be achieved through process optimization. According to the conducted research, the recommended technological parameters for obtaining a high-quality product are a temperature of 34°C and a speed range of 110 to 150 rpm. This allows for the production of a high-quality product with minimal production costs.

Table 3:
Fatty Acid Composition of the Investigated Spread Samples and Butter

Indicator Names	Butter	Creamy vegetable spread
Saturated Fatty Acids, %	74.780±3.739	61.658±3.083
C4:0 Butyric Acid	2.842±0.142	2.352±0.118
C6:0 Caproic Acid	2.110±0.106	1.738±0.087
C8:0 Caprylic Acid	1.391±0.070	1.124±0.056
C10:0 Capric Acid	3.348±0.167	2.619±0.131
C11:0 Undecanoic Acid	0.055±0.003	0.043±0.002
C12:0 Lauric Acid	4.040±0.202	3.159±0.158
C13:0 Tridecanoic Acid	0.107±0.005	0.077±0.004
C14:0 Myristic Acid	13.001±0.650	10.228±0.511
C15:0 Pentadecanoic Acid	1.260±0.063	1.005±0.05
C16:0 Palmitic Acid	37.048±1.852	30.375±1.519
C17:0 Margaric Acid	0.665±0.033	0.590±0.03
C18:0 Stearic Acid	8.797±0.44	8.277±0.414
C20:0 Arachidic Acid	0.059±0.003	0.028±0.001
C22:0 Behenic Acid	0.057±0.003	0.043±0.002
Monounsaturated Fatty Acids, %	22.948±1.147	25.920±1.296
C14:1 (cis-9) Myristoleic Acid	1.228±0.061	0.960±0.048
C15:1 (cis-10) Pentadecenoic Acid	0.238±0.012	0.230±0.012
C16:1 (cis-9) Palmitoleic Acid	1.778±0.089	1.462±0.073
C17:1 (cis-10) Margaroleic Acid	0.325±0.016	0.179±0.009
C18:1 (trans-9) Elaidic Acid	0.030±0.002	0.028±0.001
C18:1 (cis-9) Oleic Acid	19.221±0.961	22.946±1.147
C20:1 (cis-11) Eicosenoic Acid	0.129±0.006	0.116±0.006
Polyunsaturated Fatty Acids, %	2.271±0.114	12.421±0.621
C18:2n6t Linoleic Acid	0.342±0.017	0.279±0.014
C18:2n6c Linoleic Acid	1.545±0.077	4.885±0.244
C18:3n6 Y-Linolenic Acid	-	7.196±0.360
C18:3n3 Linolenic Acid	0.084±0.004	0.035±0.002
C20:3n3c Eicosatrienoic Acid	-	0.026±0.001

Source: Authors' own research

The econometric approach involves using statistical methods to estimate economic models. In our case, we can consider a model that explains the production costs of creamy vegetable spread *(C)* as a function of production volume *(Q)*, raw material prices *(X, Y, Z)*, and other costs *(A, B, C)*.

This function can be represented as follows:

$$C = \beta 0 + \beta 1Q + \beta 2X + \beta 3Y + \beta 4Z + \beta 5A + \beta 6B + \beta 7 \times C + \varepsilon\,, \tag{1}$$

where:
$\beta 0$, ..., $\beta 7$ are the coefficients to be estimated;
ε is the random error.

Such a model is called multiple regression, and it allows us to estimate how each of the factors affects production costs. The coefficients β can be estimated using the least squares method. If we have historical data on production costs and other variables, we can use this data to estimate the coefficients.

In reality, the coefficients β may be unknown and need to be estimated based on available data. After estimating the coefficients, we can use equation (1) to forecast production costs at different values of production volume and raw material prices.

The multiple regression model described in our research examines how production costs *(C)* are influenced by production volume *(Q)*, raw material prices *(X, Y, Z)*, and other costs *(A, B, C)*. The coefficients $\beta 1$, ..., $\beta 7$ represent the impact of each of these factors on production costs. By estimating these coefficients, we can quantify the extent to which changes in production volume and raw material prices affect the overall production costs. This allows us to analyze the production cost structure and identify the key drivers of production costs in order to optimize resource allocation and improve cost efficiency (Figure 3).

Figure 4 illustrates how the production volume *(Q)* affects raw material prices *(X, Y, Z)*. The coefficients $\alpha 1$, $\alpha 2$, $\alpha 3$ represent the impact of production volume on the prices of each type of raw material.

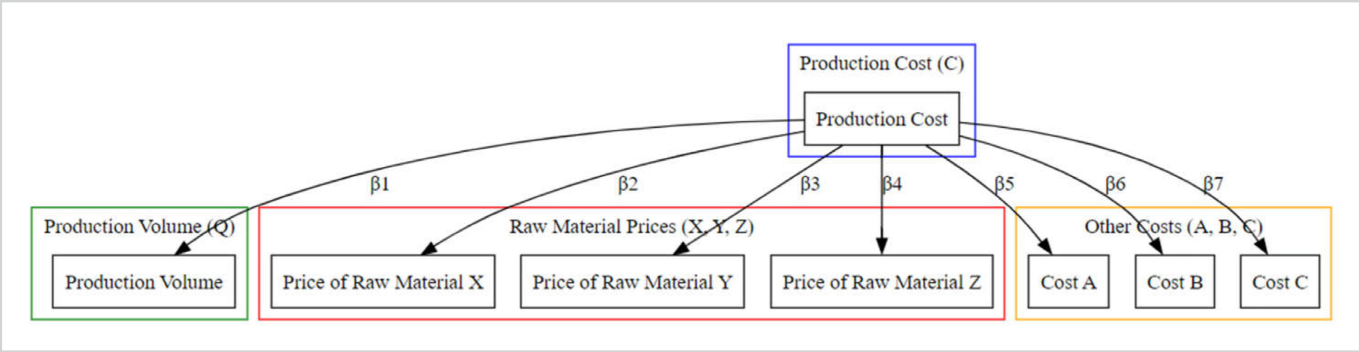

Figure 3:
Multiple Regression Model of Vegetable Spread Production
Source: Authors' own research

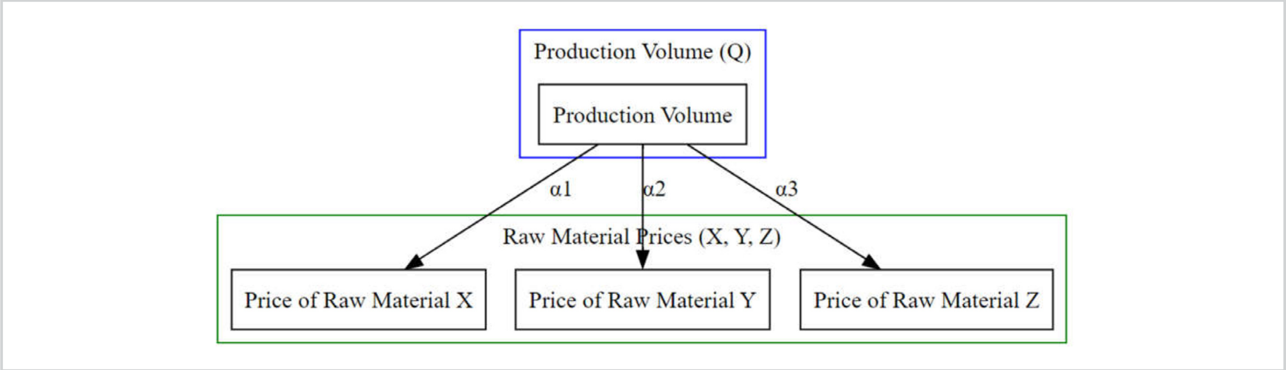

Figure 4:
Influence of Production Volume on Raw Material Prices of Vegetable Spread
Source: Authors' own research

Figure 5 illustrates how other expenses *(A, B, C)* affect the prices of raw materials *(X, Y, Z)*. The coefficients $\gamma 1$, $\gamma 2$, $\gamma 3$ represent the impact of each of these expenses on the prices of each type of raw material.

Figures 3-5 illustrate the influence of other costs *(A, B, C)* on the prices of raw materials *(X, Y, Z)*. The coefficients $\gamma 1$, $\gamma 2$, $\gamma 3$ represent the impact of each of these costs on the prices of each type of raw material.

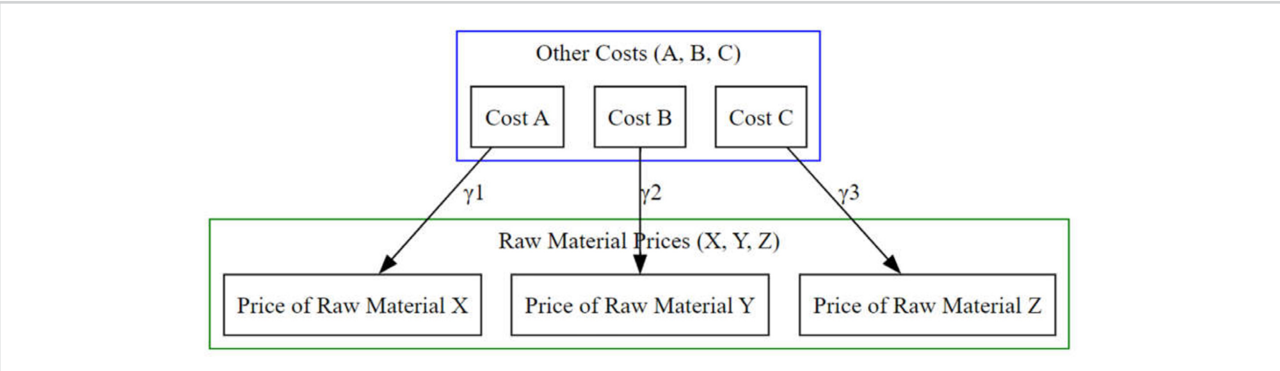

Figure 5:
Influence of Other Costs on Raw Material Prices
Source: Authors' own research

Let us break it down:

- Cost A influences the price of raw material X with a coefficient of $\gamma 1$. This means that for every unit increase in Cost A, the price of raw material X changes by $\gamma 1$ units, all other factors being constant.
- Similarly, Cost B influences the price of raw material Y with a coefficient of $\gamma 2$. For every unit increase in Cost B, the price of raw material Y changes by $\gamma 2$ units, all other factors being constant.
- Lastly, Cost C influences the price of raw material Z with a coefficient of $\gamma 3$. For every unit increase in Cost C, the price of raw material Z changes by $\gamma 3$ units, all other factors being constant.

Based on above presented findings, we can formulate the following equations:

$$X = \delta 0 + \gamma 1 {*} A + \varepsilon 1,$$
$$Y = \delta 1 + \gamma 2 {*} B + \varepsilon 2,$$
$$Z = \delta 2 + \gamma 3 {*} C + \varepsilon 3,$$

where:
$\delta 0$, $\delta 1$, $\delta 2$ are constants:
$\varepsilon 1$, $\varepsilon 2$, $\varepsilon 3$ are random errors.

Comparing of the economic aspects of producing creamy spread and regular butter in Kazakhstan are shown in Table 4 and Figure 6.

In conclusion, this research highlights the intricate relationships between production costs, raw material prices, and other costs in the production of cream-vegetable spread. Understanding these relationships and quantifying them through regression coefficients allows for more accurate

Table 4:
Comparing the economic aspects of producing creamy spread and regular butter (in Kazakhstan)

Parameter	Creamy Spread	Regular Butter
Production Cost	USD 4.50 per kg	USD 6.80 per kg
Technological Process	6 stages	10 stages
Shelf Life	12 months	3 months
Market Competitiveness	Wide range of flavor options	Niche market
Profit Margin	USD 3.50 per kg	USD 5.20 per kg

Source: Compiled by the Authors using data from the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan

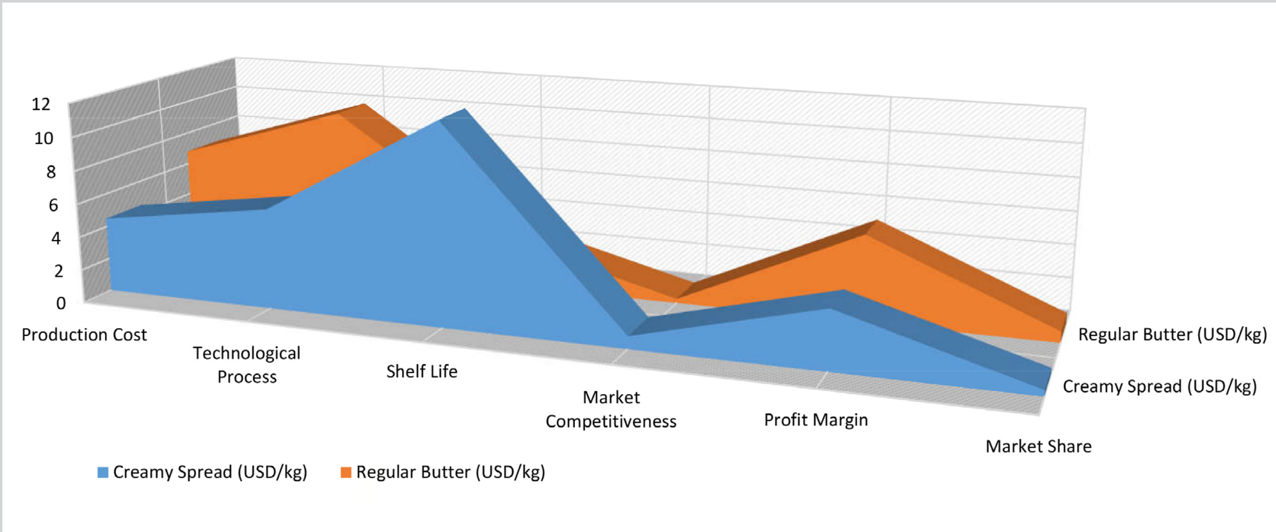

Figure 6:
Comparing the economic aspects of producing creamy spread and regular butter
Source: Compiled by the Authors using data from Table 4

cost forecasting and optimization of the production process. This, in turn, can lead to improved economic efficiency and competitiveness in the market.

4. Conclusion

Based on the research of technological parameters for the production of functional spreads, the following list of technological indicators is proposed to obtain a high-quality product. Therefore, technological parameters have a significant influence on dispersion, emulsion stability, and crystalline structure formation. In addition to the triglyceride composition of the fat base, the cooling regime and conditions of the milk-vegetable dispersion have a substantial impact on the spread's plasticity and consistency. To achieve a high-quality creamy vegetable spread, the following technological regimes are recommended:

- Dispersion of the milk-fat phase «butter: vegetable oil» is carried out until a «coarse» emulsion with a fat droplet size of 61.9μm is obtained. This is achieved through mechanical stirring in an anchor-type mixer at a rotation speed of 110-150 rpm.
- Dispersion is carried out at a temperature of 34°C, which allows for subsequent cooling to 12-16°C to obtain a stable α-modification with a melting temperature of 29.0-30.0°C. This modification is characterized by a dense, plastic consistency.
- Optimal conditions for solidifying the glycerides of the creamy vegetable spread are achieved in a chill room.

Summarizing the data on the influence of technological parameters on the properties of produced spreads, it should be noted that emulsification and cooling are the main processes in spread technology, and the quality of the final product, its structure, and plastic properties largely depend on the conditions and regimes of these processes.

Analysis of the fatty acid composition by gas chromatography has shown that adding vegetable fat to the product improves its sensory and properties. The level of polyunsaturated fatty acids increases, and the recommended ratio of fatty acids at 1:5 is achieved.

While the production of vegetable spreads may require additional investments in purchasing vegetable oils and specialized equipment, the growing willingness of consumers to pay a premium for products with improved nutritional profiles presents an opportunity for economic gains. Studies indicate that consumers are willing to pay an average of 13% more for products enriched with beneficial elements. This allows manufacturers to not only cover the production costs but also generate additional profits.

Market trends towards healthy eating and the positive consumer response to products enriched with essential nutrients further support the potential success and return on investment in promoting and marketing vegetable spreads. Advertising and marketing expenditures may increase, but with the right marketing strategies targeting health-conscious consumers, the probability of successful market penetration and economic benefits is high.

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