

# BOVINE BUTTER ENRICHED WITH SESAME OIL: SAFETY INDICES AND TECHNOLOGY

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## Abstract

*The purpose of the study is to determine the fatty acid composition of vegetable oils (sesame, linseed, pumpkin seed) and their safety indices (toxic elements, pesticides, mycotoxins). Such vegetable oils as sesame oil, linseed oil and pumpkin seed oil have been studied in terms of fatty acid composition and safety indices to identify their useful properties. Sweet cream unsalted butter with a mass fat content 72,5%, as well as bovine butter with sesame oil have been examined according to organoleptic, physico-chemical and safety indices. The sesame oil has been added to butter to increase its biological value due to the enrichment of polyunsaturated fatty acids. The production technology of butter “Na Zdorovè” (“To your health”) by enriching butter in polyunsaturated fatty acids containing in sesame oil in sufficient quantities is developed. This technology ensures the improvement of the positive properties of the new product. The studies prove that sweet cream unsalted butter with a mass fat content 72.5% and the produced butter “Na Zdorovè” possess the fatty acid composition and safety indices which do not exceed the acceptable levels of Technical regulations of the customs Union “On safety of food products” (CU TR 021/2011). STO 00430522-001-2016” Bovine butter with flavouring component” has been worked out.*

**Keywords:** butter, fatty acid composition, safety, safety indices, vegetable oils

**JEL Classification:** Q16, Q17

## 1 Introduction

Butter is the product rich in calories which are provided with milk fat. Vitamins A, D, E, provitamin A, water-soluble vitamins B1, B2, C, PP, phosphatides-lecithin provide biological value of the butter [1, 2, 4, 17]. Bovine butter contains such minerals as sodium, potassium, magnesium, calcium. Other components include cholesterol and low molecular weight fatty acids (oleic, caproic), providing a peculiar taste. [3, 17]. Butter has a low content of polyunsaturated fatty acids such as linoleic and linolenic which are also found in vegetable oils in sufficient quantity. Sesame oil is produced by pressing the whole sesame seeds which contain 48-58% of fat and are covered by smooth skin [17]. Seeds might be both of light and dark colour, the seeds of light color possessing the greatest value for getting sesame oil. They are used to obtain the sesame oil of better quality [17]. The important characteristics of sesame oil are pleasant delicate flavour and taste [17]. Refined sesame oil is used both in culinary art and canning, as well as in margarine production [17]. Leenseed oil is produced by pressing leenseeds or by method of extraction [17]. It has peculiar flavour, and its colour might range from light yellow to brown with green tone [17]. Fatty acids, like oleic, linoleic, linolenic can increase nutritious value of milk fat [17]. Alongside with other vegetable oils which are rich in oleic and linoleic acids, sesame oil contains 35-40% of them, pumpkin seed oil has 26-81% of the acids whereas there is 20% of linolenic acid in the linseed oil. [17].

Taking everything mentioned above into consideration, it is essential to develop the technology of butter production by adding vegetable oils rich in polyunsaturated fatty acids. The purpose of this study is to develop production technology and to assess the safety performance of butter “Na Zdorov’e”.

## 2 Data and Methods

The study of sesame oil, linseed oil, pumpkin seed oil, sweet cream unsalted butter and butter “Na Zdorov’e” was conducted by determining the fatty acid composition and potentially hazardous substances such as toxic elements, pesticides, mycotoxins, using standard research methods and modern instruments in triple replications. Detection of fatty acid composition of vegetable oils was performed by gas chromatography (GC). The method is based on the transformation of triglycerides of fatty acids into methyl (ethyl) esters of fatty acids and GC analysis of the latter [14]. The determination of fatty acid composition of butter was also performed by gas chromatography. The method is based on the use of a gas chromatograph using a packed column or a capillary column to determine the qualitative and quantitative composition of a mixture of fatty acids in the form of methyl esters [15]. Stripping voltammetric

method is used to find cadmium and lead in vegetable oils [9]. To determine copper in vegetable oils polarographic method is used. The method is based on dry mineralization (ashing) of a sample using nitric acid as an auxiliary means as well as quantitative detection of copper by means of polarography in the mode of AC current [13]. Stripping voltammetric method is used to find arsenic in vegetable oils [8]. To detect mercury in vegetable oils colorimetric method is used. Stripping voltammetric method is used to specify the amount of arsenic and mercury in bovine butter. Stripping voltammetric method is based on the dependence of the current passing through the cell analyzer with the tested solution on the mass fraction of the element contained in the solution and functionally associated with the shape and parameters applied to the electrodes polarizing voltage [5]. Stripping voltammetric method is also used to detect cadmium, lead and copper in bovine butter. The voltammetric analyzers AKV-07 MK were used for this purpose [6]. To detect iron in both vegetable oils and butter colorimetric method is used. The method is based on measuring the color strength of the solution of complex compounds of bivalent iron with ortofenantroline of red color [12]. Pesticides in vegetable oils were determined by gas-liquid chromatography [16]. The residual amounts of organochlorine pesticides were determined in butter by means of chromatography [10]. The method is based on the isolation of organochlorine pesticides from milk and dairy products, further purification of the extracts and detecting them on glass slides covered with a layer of adsorbent; chromatogram is distilled in the mobile solvent and the chromatogram is developed by silver nitrate. To determine the amount of mycotoxins (aflatoxins B1, M1) in vegetable oils and butter thin-layer chromatography method is used [7]. The method is based on extraction of aflatoxins B1 and M1 from the sample of the product, its further purification and measurement of mass concentrations using thin-layer chromatography while visually determining the amount of the substance in the spot. The study was carried out in the laboratories of the Russian State Agricultural University – Moscow Timiryazev agricultural Academy and in specialized research centers.

### **3 Results and discussion**

When determining the fatty acid composition of vegetable oils such as sesame oil, linseed oil and pumpkin seed oil it was found out that the content of myristic, palmitoleic, heptadecanoic, behenic, lignoceric acids as well as the amount of fatty acids: lauric (sample 1), pentadecanoic (sample 4), CIS-heptadecanoic (samples 2,3,4), eicosandienoic (sample 4), eicosatrienoic (sample 4), arachidonic (sample 4), eicosapentanoic (sample 4), erucic (sample 4) was minimal [table 1].

The maximum content of palmitic acid is detected in the pumpkin seed oil, whereas the lowest is in linseed oil; the maximum amount of fatty acids such as

stearic, oleic, linoleic acids, are found in the sesame oil while linseed oil contains the minimum amount of these. The maximum content of linolenic acid found in sesame oil (sample 1) was equal to that in samples 2,3,4 of vegetable oils. The maximum amount of gamma-linolenic acid is contained in linseed oil and the minimum appear to be in the samples of sesame and pumpkin seed oil.

Fatty acids, in particularly arachidonic one, was found in sesame (Sample 1) and linseed (Sample 4) oils; gondoinic acid was only revealed in the sesame oil samples.

Thus, oleic and linoleic fatty acids existed in all kinds of vegetable oils, having the maximum proportion in the sesame oil samples. So, the decision was taken to use the sesame oil as an additive to the bovine butter.

On determining the safety indices in sesame oil, linseed oil and pumpkin seed oil it was found out that toxic elements (iron, cadmium, copper, arsenic, mercury, lead) existed in all samples,

**Table 1 The study results of changes of vegetable oils fatty acid composition**

Index	Sample 1 Sesame oil	Sample 2 Sesame oil	Sample 3 Sesame oil	Sample 4 Linseed oil	Sample 5 Pumpkin seed oil
<b>C12:0 Lauric, %</b>	< 0,1	-	-	-	-
<b>C14:0 Myristic, %</b>	< 0,1	< 0,1	< 0,1	< 0,1	-
<b>C 15:0 Pentadecanoic, %</b>	-	-	-	< 0,1	-
<b>C16:0 Palmic, %</b>	9,1	9,1	9,2	5,4	11,8
<b>C 16:1 Palmitoleic, %</b>	0,2	0,1	0,1	0,1	-
<b>C17:0 Heptadecanoic, %</b>	< 0,1	< 0,1	< 0,1	0,1	-
<b>C 17:1 CIS-heptadecanoic, %</b>	-	< 0,1	< 0,1	< 0,1	-
<b>C18:0 Stearic, %</b>	5,0	4,7	5,2	4,1	4,5
<b>C18:1 Oleic, %</b>	41,8	38,8	40,8	19,5	22,4
<b>C18:2 Linoleic, %</b>	42,3	45,1	42,4	17,4	32,1
<b>C18:3 Linolenic, %</b>	0,7	0,2	0,2	0,2	-
<b>C18:3n6 Gamma-linolenic, %</b>	-	0,6	0,6	52,5	-
<b>C20:0 Arachidonic, %</b>	0,5	-	-	0,2	-
<b>C20:1 Gondoinic, %</b>	0,2	0,3	0,3	-	-
<b>C 20:2 Eicosandienoic, %</b>	-	-	-	< 0,1	-
<b>C 20:3n6 Eicosatrienoic, %</b>	-	-	-	0,1	-
<b>C 20:4n6 Arachidonic</b>	-	-	-	< 0,1	-
<b>C 20:5n3 Eicosapentanoic, %</b>	-	-	-	< 0,1	-

Index	Sample 1 Sesame oil	Sample 2 Sesame oil	Sample 3 Sesame oil	Sample 4 Linseed oil	Sample 5 Pumpkin seed oil
C22:0 Behenic, %	0,1	0,1	0,1	0,1	-
C22:1 Erucic, %	-	-	-	< 0,1	-
C24:0 Lignoceric, %	< 0,1	0,1	0,1	0,1	-

but their amount does not exceed the acceptable levels [18] [Table2]. Toxic elements (lead, mercury, cadmium, arsenic) can accumulate in water, plants and atmosphere, and consequently, are given to the products processed from the plants, that is vegetable oil. The main sources of copper in vegetable oils are an industrial emissions, chemical crop protection agents. Contamination of vegetable oils with iron is likely to be due to their contact with metal equipment during the manufacturing. The residual quantity of pesticides and mycotoxins were detected in all samples of vegetable oil, but their contents did not exceed permissible levels [18], [table 2]. The penetration of pesticides into vegetable oils appears to be associated with the use of chemicals in agriculture to protect plants. The penetration of mycotoxins in vegetable oils may be caused by delayed harvesting of cultivated plants, the violation of technological modes of processing, storage, transportation, and marketing of oils.

Table 2 The results of vegetable oils safety indices research

Index	Allowable level	Sesame oil Sample 2	Sesame oil Sample 3	Linseed oil Sample 4	Pumpkin seed oil Sample 5
<b>Toxic elements</b>					
Iron, mg/kg	≤ 5,0	1,2	2,0	1,0	1,9
Cadmium, mg/kg	≤ 0,05	< 0,002	< 0,002	< 0,002	< 0,002
Copper, mg/kg	≤ 0,4	< 0,2	< 0,2	< 0,2	< 0,2
Arsenic, mg/kg	≤ 0,1	< 0,04	< 0,04	< 0,04	< 0,04
Mercury, mg/kg	≤ 0,03	< 0,004	< 0,004	< 0,004	< 0,004
Lead, mg/kg	≤ 0,1	< 0,02	< 0,02	< 0,02	< 0,02
<b>Pesticides residues</b>					
HCH (alpha-, beta-, gamma - isomers), mg/kg	≤ 0,2	< 0,001	< 0,001	< 0,001	< 0,001
DDT and its metabolites, mg/kg	≤ 0,2	< 0,001	< 0,001	< 0,001	< 0,001
<b>Mycotoxins</b>					
Aflatoxin B1, mg/kg	≤ 0,005	< 0,003	< 0,003	< 0,003	< 0,003

The technology to produce butter “Na zdorov’e” with sesame oil has been developed. The technological process includes the following operations: reception and preparation of raw materials; making and normalization of high-fat mixture; pasteurizing the mixture; mixture transformation; packaging and labeling.

Butter with sesame oil is produced by the method of converting high-fat cream. Milk, cream and sesame oil are taken according to weight and quality. Milk is separated. The mass fraction of fat in cream is 30-40%. Production of high-fat cream from the cream containing 30-40% fat mass fraction is carried out on the separator in strict accordance with the instructions for the production of sweet butter. The moisture content of high-fat cream is 25.5%, having 72.0% of fat mass fraction. High-fat cream is heated up to  $(65\pm 5)^{\circ}\text{C}$  constantly stirring and sesame oil is added. Normalized high-fat cream has the moisture content of 25.0% and fat mass fraction of 72.5%. Normalized mixture of high-fat cream is stirred for  $15\pm 5$  minutes and, if necessary, is passed through a dispergator a centrifugal pump at the temperature of  $(65\pm 5)^{\circ}\text{C}$ . Normalized mixture of high-fat cream is pasteurized directly in the baths for normalizing at the temperature of  $(85\pm 5)^{\circ}\text{C}$  and is held at this temperature for 3-5 minutes under constant stirring. Normalized pasteurized full-fat mixture is fed to a butter worker at the temperature of  $(65\pm 10)^{\circ}\text{C}$ . The operating modes of a butter churn are set depending on its design. The temperature of butter is set at the level of  $(15\pm 2)^{\circ}\text{C}$  when leaving the butter churn. Butter is packed in a box which has been covered with parchment inside. The butter block should be fully covered with packaging material. Net weight of butter in the shipping container makes 20 kg. The product is stored at the temperature of minus  $(16\pm 2)^{\circ}\text{C}$  and 90% of relative humidity for no longer than 15 months. The shelf life of the product in the consumer packaging at the temperature of  $(3\pm 2)^{\circ}\text{C}$  and relative humidity of not more than 90% is 30 days. Packaging and labeling are carried out in accordance with the requirements of the Customs Union "Food products regarding its marking" (TR TS 022/2011) and the requirements of the Customs Union "On safety of packaging" (TR TS 005/2011).

**Table 3 Study of fatty-acid composition of sweet cream unsalted butter with mass fat content of 72, 5%**

Index	Allowable level	Results
<b>C4:0 Oleic, %</b>	2,4-4,2	3,4
<b>C6:0 Caproic, %</b>	1,5-3,0	2,4
<b>C 8:0Caprylic, %</b>	1,0-2,0	1,5

Index	Allowable level	Results
<b>C10:0 Capric, %</b>	2,0-3,8	3,4
<b>C12:0 Lauric, %</b>	2,0-4,4	3,8
<b>C14:0 Myristic, %</b>	8,0-13,0	11,7
<b>C14:1 Myristoleic, %</b>	0,6-1,5	1,1
<b>C16:0 Palmic, %</b>	21,0,-33,0	29,9
<b>C 16:1 Palmitoleic, %</b>	1,5-2,4	1,6
<b>C18:0 Stearic, %</b>	8,0-13,5	10,5
<b>C18:1 Oleic, %</b>	20,0-32,0	25,2
<b>C18:2 Linoleic, %</b>	2,2-5,5	3,0
<b>C18:3 Linolenic, %</b>	≤ 1,5	0,3
<b>C20:0 Arachic, %</b>	≤ 0,3	0,1
<b>C22:0 Behenic, %</b>	≤ 0,1	< 0,1

The mass fraction of fat in the butter "Na zdorov'e" is no less than 73.0% while mass fraction of sesame oil is more than 1.0%. When analyzing the fatty acid composition of sweet cream unsalted butter with a mass fat content of 72.5%, the results showed that such fatty acids as stearic, myristic and palmitic prevailed in it. The maximum amount of oleic fatty acid was detected there. The existence of such essential fatty acids as linoleic and linolenic was determined. The other kinds of fatty acids were also featured in the bovine butter. However, their content did not exceed the allowable level [Table 3].

When determining the fatty acid composition of butter "Na zdorov'e" such fatty acids as undecanoic, tridecanoic, pentadecanoic, eicosatrienoic, arachidonic, heneicosanic, erucic and tricosanoic were found. The content reduction of such fatty acids as caproic, caprylic, capric, lauric, myristic, myristoleic, palmitic was revealed in the tested sample of butter "Na zdorov'e". [Table 4].

The content of the oleic, palmitoleic and linoleic fatty acids in butter "Na zdorov'e" and sweet cream unsalted butter with a mass fraction of fat 72.5%, was equal [table 4]. However, the content of such fatty acids as stearic, oleic, linoleic and arachidic has increased in butter "Na zdorov'e". Thus, the technology of adding sesame oil provided the butter "Na zdorov'e" with the missing polyunsaturated fatty acids. The heptadecanoic, gondoinic, lignoceric fatty acids passed into butter "Na zdorov'e" [table 4].

Butter "Na zdorov'e" was examined in terms of fatty acid composition and safety indices in comparison to sweet cream unsalted butter with a mass fraction of fat of 72.5%.

Table 4 Study results of fatty-acid composition of butter “Na zdorov’e”

Index	Results
<b>C4:0 Oleic, %</b>	3,4
<b>C6:0 Caproic, %</b>	2,3
<b>C 8:0 Caprylic, %</b>	1,4
<b>C10:0 Capric, %</b>	3,1
<b>C 11:0 Undecanoic, %</b>	< 0,1
<b>C12:0 Lauric, %</b>	3,5
<b>C 13:0 Tridecanoic, %</b>	0,1
<b>C14:0 Myristic, %</b>	10,8
<b>C14:1 Myristoleic, %</b>	1,0
<b>C 15:0 Pentadecanoic, %</b>	1,1
<b>C16:0 Palmic, %</b>	29,2
<b>C 16:1 Palmitoleic, %</b>	1,6
<b>C17:0 Heptadecanoic, %</b>	0,5
<b>C18:0 Stearic, %</b>	10,6
<b>C18:1 Oleic, %</b>	26,8
<b>C18:2 Linoleic, %</b>	3,8
<b>C18:3 Linolenic, %</b>	0,3
<b>C20:0 Arachic, %</b>	0,2
<b>C20:1 Gondoinic, %</b>	< 0,1
<b>C 20:3n6 Eicosatrienoic, %</b>	< 0,1
<b>C 20:4n6 Arachidonic</b>	< 0,1
<b>C 21:0 Heneicosanic, %</b>	< 0,1
<b>C22:0 Behenic, %</b>	< 0,1
<b>C22:1 Erucic, %</b>	0,1
<b>C23:0 Tricosanoic, %</b>	< 0,1
<b>C24:0 Lignoceric, %</b>	< 0,1

On determining the safety performance in bovine butter and butter “Na zdorov’e”, such toxic elements as pesticides (HCH-hexachlorocyclohexane; DDT-dichlorodiphenyl trichloromethylmethane), mycotoxins (aflatoxin M1) were detected, but their content did not exceed the permissible levels [table 5], [18].

Table 5 The results of the examination of safety indices in sweet cream butter “Na zdorov’e”

Index	Allowable level	Sweet cream butter	Butter with sesame oil
<b>Toxic elements</b>			
<b>Lead, mg/kg, max</b>	0,1	0,0372	0,0396
<b>Cadmium, mg/kg, max</b>	0,03	< 0,020	< 0,020
<b>Arsenic, mg/kg, max</b>	0,1	< 0,0020	< 0,0020
<b>Mercury, mg/kg, max</b>	0,03	< 0,0020	< 0,0020
<b>Copper, mg/kg, max</b>	0,4	0,08	0,09
<b>Iron, mg/kg, max</b>	1,5	0,07	0,07
<b>Pesticides residues</b>			
<b>HCH, mg/kg</b>	1,25	< 0,008	< 0,008
<b>DDT, mg/kg</b>	1,0	< 0,005	< 0,005
<b>Mycotoxins</b>			
<b>Aflatoxin M1, mg/kg, max</b>	0,0005	< 0,0005	< 0,0005

Hence, the technology that has been developed to obtain butter “Na zdorov’e” makes it possible to get the product enriched with polyunsaturated fatty acids with safety indices not exceeding the acceptable levels of technical regulations of the Customs Union "On food safety" (TR TS 021/2011). As a result, the standard of the organization “STO 00430522-001-2016. Bovine butter with flavouring components. Full product specifications” was drafted for butter “Na zdorov’e” with sesame oil with a mass fraction of fat of 73.0% [19].

## 4 Conclusions

From the findings of the experimental research:

- it is established that the maximum amount of unsaturated fatty acids (oleic, linoleic, linolenic) was found in sesame oil. As a result, this oil is used as a kind of additive to bovine butter to enrich its qualities;
- it is possible to come to the following conclusion that safety indices of oils (toxic elements, pesticides residues, mycotoxins) do not exceed the allowable level of the technical regulations of the Customs Union "On food safety" (TR TS 021/2011);
- the production technology of butter “Na zdorov’e” has been developed and it has been proved that addition of sesame oil enriches the butter with polyunsaturated fatty acids;

- it has been established that safety indices (toxic elements, pesticides, mycotoxins) in butter “Na zdorov’e” do not exceed the permissible levels of the technical regulations of the Customs Union "On food safety" (TR TS 021/2011).
- the new standard of butter “Na zdorov’e “STO 00430522-001-2016. Bovine butter with flavouring components” has been drafted.

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