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# PERSPECTIVES OF THE USE OF SEA BUCKTHORN IN THE TECHNOLOGY OF EMULSION-TYPE SAUCES

*The possibility of using dried sea buckthorn fruits in the technology of sauce preparation to increase their nutritional and biological value is considered. Rheological studies of the viscosity of the resulting mixtures were performed to determine the optimal amount of sea buckthorn powder required for the formation of oil extracts with their subsequent use in sauce preparation technologies (mayonnaise sauce). It was found that the studied additives have rheological properties similar to analog samples, which are made synthetically and added to sauces as structurants. It was found that increasing the content of sea buckthorn oil extract with a concentration of 10% in an amount of from 5 to 15% by weight of sour cream helps to stabilize the emulsion system. It was found that the use of dried sea buckthorn fruit powder as an oil extract improves the ability of macroscopic systems to self-restore the structure after its destruction. The technology of using sea buckthorn oil for making sour cream sauce was developed.*

*Based on the IR spectroscopy of sauces with sea buckthorn oil extract, the content of proteins, carbohydrates, a large amount of fat and vitamins A and E was shown. The available set of absorption bands, which is inherent in the corresponding types of oscillations: 3400 cm$^{-1}$ (phenolic oxy groups with intermolecular hydrogen bonds), 1651 cm$^{-1}$ (carbonyl group of γ-pyrone); 1457 cm$^{-1}$ (skeletal vibrations of aromatic rings) and 2925 cm$^{-1}$ (methoxyl groups); 1645 cm$^{-1}$, 1549 cm$^{-1}$ and 3400 cm$^{-1}$ (proteins of amide I, amide II and amide A), 2800-3000 cm$^{-1}$, bands 1750 cm$^{-1}$ and 1165 cm$^{-1}$ with two weaker bands 1240 and 1198 cm$^{-1}$ (valence vibrations of C = O groups of ester bonds of fats).*

***Key words:*** *berry raw materials, sea buckthorn, IR spectroscopy, sauces, rheology*

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## *ПЕРСПЕКТИВИ ВИКОРИСТАННЯ ОБЛІПИХИ В ТЕХНОЛОГІЇ ПРИГОТУВАННЯ СОУСІВ ЕМУЛЬСІЙНОГО ТИПУ*

*Розглянуто можливість використання сушених плодів обліпихи в технології приготування соусів для підвищення їх харчової та біологічної цінності. Для визначення оптимальної кількості порошку обліпихи, необхідного для утворення екстрактів з подальшим застосуванням їх у технологіях приготування соусів (майонезний соус), здійснено реологічні дослідження в'язкості одержаних сумішей. Установлено, що досліджувані добавки мають реологічні властивості, подібні до аналогових зразків, які виготовляють синтетичним шляхом і додають у соуси як структуроутворювачі. Встановлено, що збільшення концентрації олійного екстракту обліпихи при 10 % до сметани вершкової у кількості від 5 до 15 % сприяє стабілізації емульсійної системи. Виявлено, що використання як олійного екстракту порошку сушених плодів обліпихи поліпшує здатність макроскопічних систем до самостійного відновлення структури після її руйнування. Розроблено технологію використання обліпихової олії для виготовлення сметанного соусу.*
*На підставі ІЧ-спектрів соусів з олійним екстрактом обліпихи було показано вміст білків, вуглеводів, велику кількість жирів і вітаміни А та Е. Відмічено наявний набір смуг поглинання, притаманних відповідним типам коливань: 3400 см-1 (фенольні оксигрупи з міжмолекулярними водневими зв'язками), 1651 см-1 (карбонільна група γ-пірону); 1457 см-1 (скелетні коливання ароматичних кілець) і 2925 см-1 (метоксильні групи); 1645 см-1, 1549 см–1 та 3400 см- 1 ( (амід І, амід ІІ та амід А білків); 2800-3000 см-1, смуги за 1750 см-1 та 1165 см-1 із двома слабкішими смугами за 1240 і 1198 см-1 (валентні коливання С=О груп естерних зав'язків жирів).*
***Ключові слова:*** *дикоросла сировина, обліпиха, ІЧ-спектроскопія, соуси, реологія.*

**Problem formulation.** In the last decade, the issue of resource conservation has become relevant around the world. It involves the complex processing of raw materials of plant or animal origin. As this type of processing of raw materials is not only economically advantageous, but also guarantees receipt of biologically valuable useful substances which are made in the form of powders as natural biological additives. Today, the use of biological additives in the human diet is an integral part of traditional food. In the conditions of deterioration of an ecological situation and quality of food raw materials, in the world the tendency of artificial saturation of products with necessary microcells for maintenance of a healthy food is observed [1; 2].

Despite the need to establish a comprehensive processing of raw materials in the food industry, this problem is solved rather slowly, because it is quite expensive. Complex processing of raw materials is directly related to the processing of secondary products, and therefore the question arises of a more careful study of the functional and technological properties and chemical composition of the raw materials for the development of new foods [3].

Analysis of recent research and publications. Most of the scientific developments that have been introduced into food production depend on modern equipment and its mechanization..

Sublimation drying of wild raw materials has become widespread, which greatly simplifies the primary processing of berries [4]. According to the literature, freeze-drying is used for vegetable raw materials, from which press cake (food additives) and oil, concentrates for juices or extracts from it are obtained [5]. First of all, we can emphasize the works, which show developments involving the use of sea buckthorn in dairy products, fruit drinks, whey, cottage cheese, yogurt [6-8].

The most popular plant-based food supplements to enrich a person's daily diet are quinoa and chia seeds, vegetable oil extracts of various oilseeds (flax, hemp, avocado, etc.), seaweed in natural form or in powder form.

One of the current areas of modern research is to study the peculiarities of the use of medicinal raw materials, namely sea buckthorn in the production of traditional foods. Increased attention is due to market demand. In general, the global market for sea buckthorn and products based on it in 2017 amounted to $ 18 billion, which is much more than in 2012. At the same time, the market for sea buckthorn products is $ 17 billion [9].

Note that the results of scientific research indicate that the edible parts of sea buckthorn is a source of valuable nutrients and therefore should pay more attention to the study of the impact of sea buckthorn on quality indicators in food technology.

The aim of the research. Study the emulsion properties of the oil extract obtained by infusion of dried sea buckthorn fruit powder in sunflower oil to obtain emulsion-type sauces of high nutritional and biological value.

Methods and conditions of the research. The materials for the study were dried sea buckthorn fruits, which were pre-ground to a powdery state and mixed with sunflower oil and infused for one hour. For research, experimental samples of emulsion-type sauces were made with the addition of 10% sea buckthorn oil extract in an amount of from 5% to 15% to replace the appropriate amount of basic raw materials.

To obtain the extract used refined sunflower oil made in accordance with DSTU 4492:2005.

The effective (dynamic) viscosity of the emulsions was determined using a rotary viscometer Brookfield DV-II + PRO in the autonomous mode in the range of spindle speed (shear rate) 0.3…100 rpm-1 [10].

The effect of sea buckthorn extract concentration on the effective (dynamic) viscosity of mayonnaise was described by a statistical model of simple regression [10].

The calculation of the coefficient of consistency and the rate of destruction of the structure of the emulsion was performed in the Mathcad system by the method of least squares, as well as the coefficient of thixotropy, which characterizes the ability of the macroscopic system to self-restore structure after its destruction [11].

Determination of the chemical composition of crushed dried sea buckthorn fruits was carried out by IR spectrometer on a Fourier spectrometer Perkin-Elmer Spectrum One FTIR

Spectrometer using potassium bromide in the range from 500 cm$^{-1}$ to 4000 cm$^{-1}$. The spectra of the test samples were recorded in a thin layer between the plates with zinc selenide [12].

Sensory indicators (appearance, color, taste, smell) were evaluated in view of their compliance with current standards for sauces [13].

**Research results.** To expand the range, the effect of sea buckthorn extract on the viscosity of sour cream was studied. The obtained data are given below (Table 1). The curves of the dependence of the effective viscosity of the studied samples on the shear rate are shown in Fig. 1.

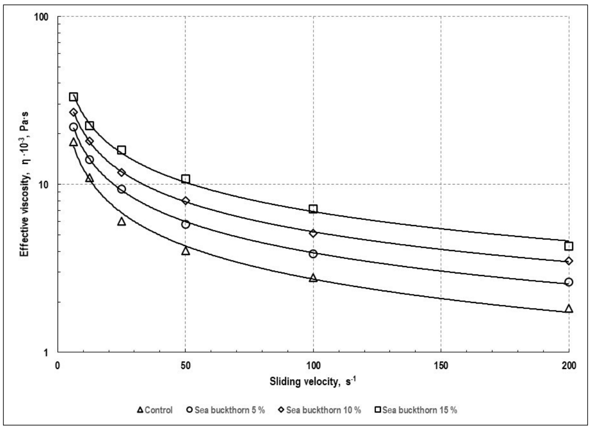


*Fig.1* ***Dependence of the effective viscosity of the studied samples on the shear rate***

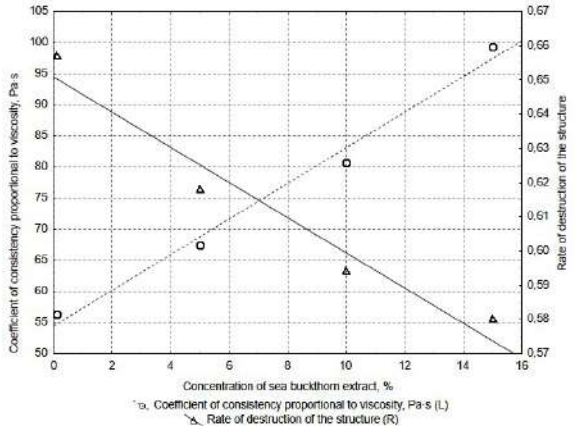


*Fig.2* ***Dependence of the effective viscosity of the test samples on the concentration of sea buckthorn extract***

*Table 1*

***Equation coefficients***

| ***Name of the sample*** | ***B, Pa•s*** | ***m*** | ***R²*** |
|---|---|---|---|
| ***Control*** | 56,4·10$^{-3}$ | 0,657 | 0,99 |
| ***Sea buckthorn 5 %*** | 67,5·10$^{-3}$ | 0,618 | 0,99 |
| ***Sea buckthorn 10 %*** | 80,7·10$^{-3}$ | 0,594 | 0,99 |
| ***Sea buckthorn 15 %*** | 99,4·10$^{-3}$ | 0,580 | 0,99 |

*Table 2*

***Equation coefficients***

| ***Name of the sample*** | ***$b_0$*** | ***$b_1$*** | ***R²*** |
|---|---|---|---|
| ***Coefficient of consistency proportional to viscosity*** | 54,5·10$^{-3}$ | 2,7·10$^{-3}$ | 0,98 |
| ***Rate of destruction of the structure*** | 0,651 | -0,051 | 0,95 |

***Visualization of these results is presented in Fig. 2.***

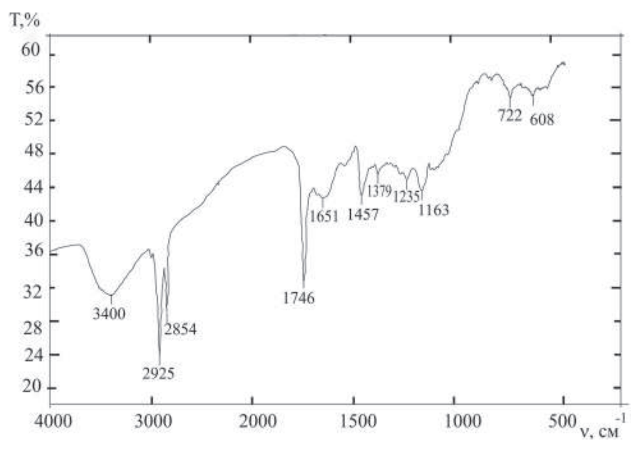


*Fig.3* ***IR spectra of a sample of sea buckthorn powder***

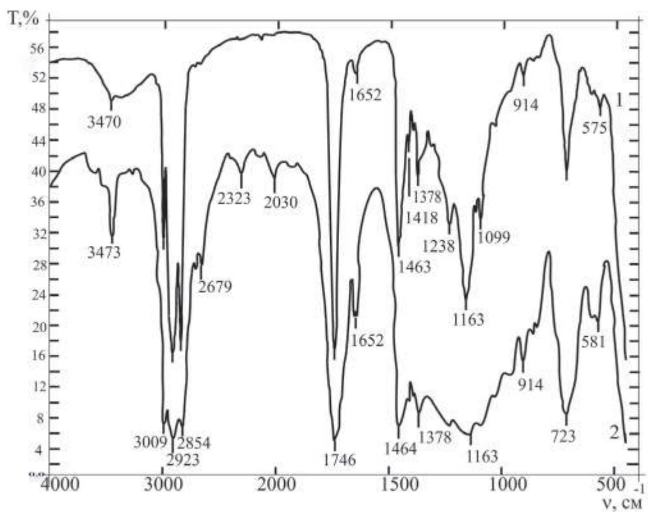


*Fig.4* ***IR spectra of samples: 1 – oil extract of sea buckthorn;***
***2 – refined deodorized sunflower oil***

The calculated values of the coefficients of determination ($R^2$) indicate the high reliability of the analytical equations that describe the behavior of each of the studied samples. The results of mathematical processing of experimental data are given below (Table 1).

To establish the quantitative effect of the concentration of sea buckthorn extract on the characteristics of the effective (dynamic) viscosity of the studied samples, the obtained data were subjected to linear regression analysis by the method of least squares. The results of statistical processing are presented below (table. 2).

It is established that the increase in the concentration of sea buckthorn extract in sour cream by 1%, at least in the studied area of the factor space, causes an increase in the analytical index "Coefficient of consistency proportional to viscosity" by 2.7•10-3 Pa•s (by 4.8%). At the same time, the value of the analytical indicator "Rate of destruction of the structure" becomes lower by 5.1•10-2 units (7.8%). The calculated values of the coefficients of determination ($R^2$) indicate the high reliability of the analytical equations that describe the behavior of each of the studied samples.

Based on the obtained data, it was determined that the addition of oil extract from dried sea buckthorn fruit to the weight of sour cream in the entire study range has a positive effect on the rheological properties of the finished sauces.

The IR spectra of sea buckthorn powder are characterized by the presence of specific absorption bands at 3400, 2925, 2854, 1746, 1651, 1457, 1379, 1235, 1163, 1056, 722, 608 $cm^{-1}$ (Fig. 3).

Peculiarities of the chemical composition of samples with the addition of sea buckthorn oil extract determine not only its effect on the nutritional and biological value of sauces with their use, but also determine the behavior of these additives during technological processes. In view of this, the purpose of the research presented in this section was to study the qualitative chemical composition of sauces using sea buckthorn oil extract.

The presence of carbohydrates in the sample of sea buckthorn powder is confirmed by the manifestation of absorption bands due to asymmetric and symmetric valence oscillations of $-CH_2-$ groups at frequencies 2854 and 2925 $cm^{-1}$; oscillations associated with groups C-O-H and R-O-H frequency 1457, 1235, 722 $cm^{-1}$ and OH groups frequencyv(OH) 3300 – 2500 $cm^{-1}$. The appearance of valence oscillations of C = O groups 1746 $cm^{-1}$ and C – O oscillations of 1379 and 1235 $cm^{-1}$ bonds confirms the content of carboxylic acids and their esters.

In the IR spectra of a sample of sea buckthorn powder, the absorption bands characteristic of the aromatic part of flavonoids were isolated: 3400 $cm^{-1}$ (phenolic oxy groups with intermolecular hydrogen bonds), 1651 $cm^{-1}$ (carbonyl group of γ-pyrone), 1457 $cm^{-1}$ (aromatic rings) and 2925 $cm^{-1}$ (methoxyl groups). IR spectroscopy revealed that the chemical composition of sea buckthorn powder is represented by: carotenoids, tocopherols, phospholipids, essential fatty acids, organic acids, sugars, flavonoids, amino acids, tannins and other nutraceutical.

The IR spectra for sea buckthorn oil extract (curve 1 Fig. 4) and refined deodorized sunflower oil (curve 2) have bands characteristic of both samples and some differences. Thus, in the sample of oils there is a strong band of 1746 $cm^{-1}$, due to the valence vibrations of the carbonyl group (bonds C=O) of the ester bonds; in the region of 1200 - 1170 $cm^{-1}$ characteristic valence oscillations of the bond –C–O– of esters of higher carboxylic acids; three peaks with maxima of 1238, 1163 and 1099 $cm^{-1}$ due to C–O valence oscillations for triglycerides; maximum absorption at 1378 cm-1, associated with fluctuations of the methyl group. The oscillation bands 2923, 2854 and 1464 $cm^{-1}$ should be attributed to asymmetric, symmetrical and foot valence oscillations of groups $–CH_2–$.

*Table 3*

***Assignment of absorption bands, sea buckthorn powder, oils and ready-made sauces***

| ν (cm-1) | Functional group | The type of oscillations and the corresponding structural fragment | Major contributions |
|---|---|---|---|
| 3400 | ν(OH) | Phenolic oxy groups with intermolecular hydrogen bonds, hydroxyl groups | Flavonoids<br>Carbohydrates |
| 2925 | $\nu_{as}(-CH_2-)$<br>$\nu_{as}(-CH_3)$ | Asymmetric valence oscillations of C-H bonds on saturated hydrocarbon rings, asymmetric valence oscillations of C-H bonds in $-CH_2-$ and $-CH_3$ groups | Carbohydrates<br>Lipids<br>Flavonoids |
| 2854 | $\nu_s(-CH_2-)$ | Symmetric valence oscillations of groups $-CH_2-$ | Lipids<br>Carbohydrates |
| 1746 | ν(C=O) | Vibrations of the carbonyl group C = O of ester bonds | Acids<br>Esther |
| 1651 | ν(-C=C-)<br>σ(HOH)<br>ν(C-O) | Deformation oscillations of HOH of free and bound water, oscillations of C=C bond in six-membered related bonds of hydrocarbon rings; valence vibrations of the C=C bond of the aromatic nucleus, the carbonyl group of the γ pyrone | Water<br>Tocopherols<br>Flavonoids |
| 1457 | νs(C-O)<br>δ(OH)<br>$\delta_{as}CH_2$ | Deformation oscillations of OH and C-H bonds in $CH_2OH$ end groups; asymmetric deformation oscillations of groups $-CH_2-$; skeletal oscillations of aromatic rings | Flavonoids<br>Carbohydrates Lipids |
| 1379 | δ(OH)<br>$\delta_s(CH_2)$<br>ν(C-O) | Deformation oscillations of C-H bonds in saturated six-membered rings; oscillations of C-O connection | Carbohydrates Tocopherols<br>Acid Carotenoids<br>Esther |
| 1235 | $\delta(CH_2)$<br>δ(C–O-H)<br>ν(C–O) | Deformation oscillations of C-O-H bonds in saturated six-membered rings and in $CH_2OH$ groups | Carbohydrates<br>Tocopherols<br>Acids<br>Esther |
| 1163 | ν(C–O)<br>$\omega(CH_2)$ | Valence oscillations of -C-O- bonds of esters of higher carboxylic acids in acylglycerides; valence oscillations of C-O bonds in saturated six-membered rings and hydroxyl groups; pendulum oscillations of several connected groups $-CH_2-$ ; deformation oscillations of annular $-CH_2$ groups | Lipids<br>Carbohydrates<br>Carotenoids |
| 1056 | ν(C-O) | Valence oscillations of C-O bonds in $CH_2OH$ end groups | Carbohydrates Tocopherols |
| 722 | $\rho(CH_3)$ | C-H deformation pendulum oscillations in saturated six-membered rings; pendulum oscillations of several connected groups $-CH_2-$ | Acids<br>Lipids<br>Carotenoids<br>Carbohydrates |

Since fragments of higher aliphatic acids are present in the studied samples, oscillations in the region of 723 $cm^{-1}$ appear in the spectra, which correspond to the pendulum oscillations of several connected $–CH_2–$ groups, and the band at 1163 cm-1 also belongs to the same oscillations [15].

Unsaturated hydrocarbon chains of triglycerides with cis-configuration are manifested in the IR spectrum of oil samples in the form of maxima at 3009 $cm^{-1}$ (valence oscillations of the group –CH=CH– for cis-isomers) and 1418 cm-1 (deformation oscillations of the group –CH=CH– for cis-isomers). As is known, the bands of deformation oscillations of the CHR=CHR' type bonds are located for the trans-isomers in the region of 1310 – 1290 $cm^{-1}$, and for the cis-isomers in the region of 1420 – 1400 $cm^{-1}$.

For carboxylic acids are characterized by fluctuations: carbonyl group in the range of 1725 – 1700 $cm^{-1}$ (acid dimers) or 1760 cm-1 (acid monomers); oscillations of the free or bound hydroxyl group in the range 3550 – 3500 $cm^{-1}$ (free group); 3300 - 2500 $cm^{-1}$ (wide weak band of bound hydroxyl group); 955 – 890 $cm^{-1}$ (any hydroxyl group). Since the characteristic bands of the hydroxyl group are absent in both oil samples, it is possible to deny the presence of free fatty acids in them. The absence of a wide absorption band in the range of 3400 – 3200 $cm^{-1}$, characteristic of polyassociated hydroxyl groups, eliminates the presence in the samples of oils of free glycerol.

Sour cream with sea buckthorn extract contains proteins, carbohydrates, a large amount of fat and vitamins A and E.

Comparing the IR spectra of sour cream with different content of sea buckthorn oil extract (Fig. 5 sample 2 - 5%; sample 3 - 10% and sample 4 - 15%), we can see that in all samples approximately the same set of absorption bands

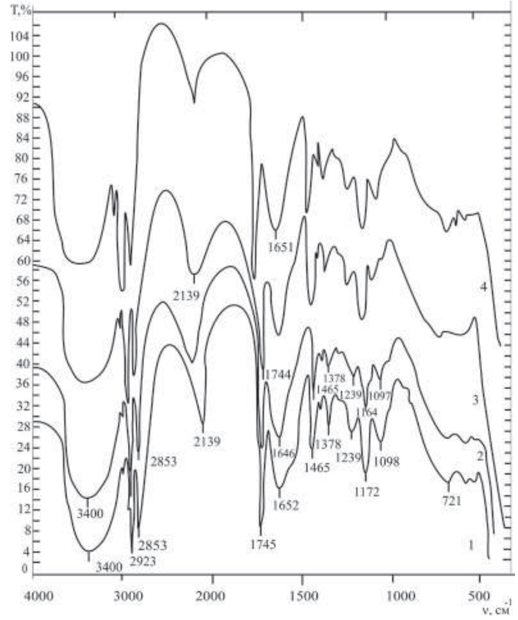


*Fig.5* ***IR spectra of sour cream samples with sea buckthorn oil extract:***

*1 – control (sour cream); 2 – sour cream with 5% sea buckthorn extract; 3 – sour cream with 10% sea buckthorn extract; 4 – sour cream with 15% sea buckthorn extract*

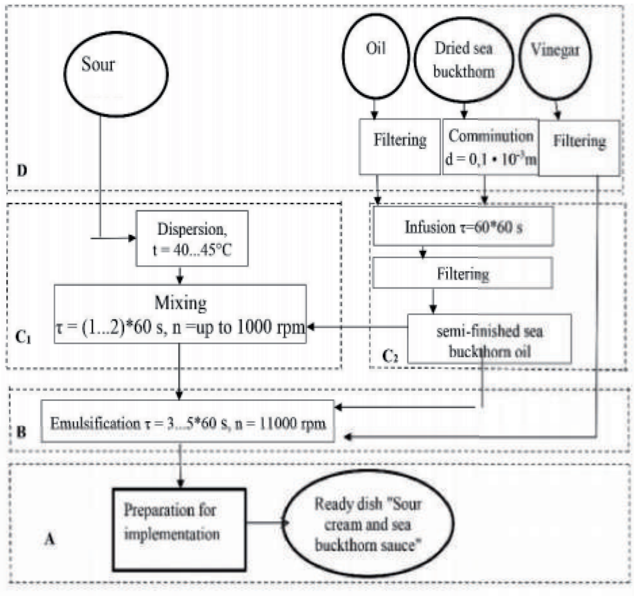


*Fig.6* ***Technological scheme for the production of emulsion-type sauce using sea buckthorn***

*Table 4*

***Equation coefficients***

| ***Sub-system*** | ***Name of the subsystem*** | ***The purpose of the subsystem*** |
|---|---|---|
| A | Getting the finished sauce | Obtaining a sauce of semi-thick consistency with certain properties and quality indicators from the prescribed recipe components using sea buckthorn processing products (sea buckthorn powder) |
| B | Preparation of the composite mixture, emulsification | The combination of the obtained semi-finished products. Emulsification of the resulting mixture to obtain a homogeneous consistency |
| C1 | Preparation of semi-finished products | Dispersion and mixing of sour cream and oil extract. Preparation of semi-finished product - sea buckthorn oil, which involves the infusion of oil on sea buckthorn powder, followed by filtration |
| C2 | | |
| D | Preparation of raw materials | Preparation of raw materials, which involves sifting bulk and filtering liquid products to remove impurities, grinding sea buckthorn to form a powder for further preparation of the fat extract |

Table 4

**Equation coefficients**

| | **5% extract** | **10% extract** | **15% extract** |
|---|---|---|---|
| **Sour cream** | 95 | 90 | 85 |
| **Sea buckthorn oil extract** | 5 | 10 | 15 |

3400, 2923, 2853, 2139, 1744, 1646, 1465, 1378, 1239, 1173 (1163), 1097, 721 $cm^{-1}$. However, with increasing content of sea buckthorn extract, the bands increase 3009, 2923, 2853, 1744 and 721 $cm^{-1}$ increase and there is a shift of the absorption maximum by 1173 $cm^{-1}$ into the low frequency range.

Samples of sour cream-sea buckthorn sauce show two main absorption bands - amide I (1645 $cm^{-1}$) and amide II (1549 $cm^{-1}$), due to the valence oscillations of the C = O - bond (amide I) and the deformation oscillations of NH (amide II) indicating the presence of proteins in products with sour cream (casein) and mayonnaise (egg white). Evidence of the presence of proteins is the absorption band in the IR spectrum at 3400 $cm^{-1}$ (amide A) [14].

Carbohydrates in samples of sour cream and sea buckthorn sauce are confirmed by the presence of a wide and intense band of valence vibrations of the associated OH-groups: in the region of 3400 $cm^{-1}$, in the region of 2800-3000 cm-1 there are bands of valence vibrations of CH-groups, bands for 1744 and 1652 $cm^{-1}$ due to valence oscillations of C=O-groups of non-ionized and ionized acids, in the region of 1465 $cm^{-1}$ are bands of flat deformation oscillations of CH-groups, in the region of 1098 $cm^{-1}$ – bands of oscillations of the skeleton of the carbohydrate molecule [14].

The lipids in sauces are evidenced by intense bands of valence oscillations of CH groups at 2800-3000 $cm^{-1}$, bands at 1750 cm-1 (valence oscillations of C=O groups of ester bonds), valence oscillations of C=O groups of esters in the form of an intense band for 1165 cm-1 with two weaker bands for 1240 and 1198 cm-1 .

The lipids in sauces are evidenced by intense bands of valence oscillations of CH-groups at 2800-3000 $cm^{-1}$, bands at 1750 $cm^{-1}$ (valence oscillations of C=O groups of ester bonds), valence oscillations of C=O groups of esters in the form of an intense band for 1165 $cm^{-1}$ with two weaker bands for 1240 and 1198 $cm^{-1}$ [15].

The conducted researches allowed to develop the recipe and technology of preparation of emulsion-type sauce with the use of sea buckthorn oil extract.

According to the technological scheme the structure of preparation of semi-finished products and reception of ready sauce is resulted (Tab. 4).

Thus, to expand the range and increase the biological value of ready meals, it is proposed to add 10% oil extract to sour cream in an amount of 5 to 15%. The component composition of sour cream-sea buckthorn sauces is given below (Table 5).

To make "Sour cream and sea buckthorn sauce", the prepared portion of sour cream is combined with sea buckthorn oil extract prepared according to the method described in the technology of making sea buckthorn mayonnaise. The resulting mixture is stirred for 1 ... 2 min to form a mass of homogeneous consistency. The resulting sour cream sauce can be used as a stand-alone dish, as a dressing for salads, served with hot dishes or used for stewing.

Conclusions. As a result of the conducted researches the possibility of application of oil extracts from dried sea buckthorn fruits in the technology of preparation of sour cream-sea buckthorn sauces is experimentally substantiate. Using the method of IR spectroscopy, it is proved that with an increase in the content of sea buckthorn extract in the sauce from 5.0 to 15.0% increases the content of nutrients such as tocopherols, phospholipids, essential fatty acids, organic acids, vitamins C, group B, PP. Based on the analysis of experimental data and their mathematical processing, it was found that the use of sea buckthorn extract in the technology of preparation of sour cream and sea buckthorn sauce increases its viscosity compared to the control sample, and improves the ability of macroscopic systems to restore structure after destruction.

Thus, the possibility of production of emulsion-type sauces with the use of oil extracts of dried sea buckthorn fruits without adding to the formulation of structurants of synthetic origin is proved.

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