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## Modeling new vegetable paste and marinade recipes for food processing companies

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# Modeling new vegetable paste and marinade recipes for food processing companies

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**Abstract.** This paper investigates the possibility of using lingonberry (*Vaccinium vitis-idaea*) and cranberry (*Oxycoccus*) press residues in production of homogenized pastes and marinades with the increased microbiological resistance. The research has resulted in development of the method to produce semi-finished products (pastes) from frozen lingonberry and cranberry press residues. Its practical importance is confirmed by the patents of the Russian Federation No. 2560074. New recipes of homogenized vegetable pastes and marinades with semi-finished products produced from frozen berry residues have been developed. Based on preliminary research carried out, the concentration limits of the recipe components are determined. Yield value and acidity were examined for each component ratio. The experimental data obtained were processed using the statistics and analytics software package STATISTICA 6.0. Linear multi-dimensional models of relationships between the components included in the developed compositions with structural-mechanical index (yield value) and acidity have been created. Physical-chemical and microbiological parameters of the developed homogenized vegetable pastes and marinades were studied. The reference documentation for homogenized vegetable pastes and marinades has been developed. The practical importance of the developed pastes and marinades is confirmed by the patents of the Russian Federation: No. 248323 "Homogenized vegetable paste," No. 2480029 "Homogenized beet paste," No. 2476123 "Homogenized vegetable marinade".

## 1. Introduction

Canned fruit and vegetable products, including vegetable pastes and marinades, are among the widely consumed food in the Russian Federation. Currently, the main components of vegetable pastes and marinades are sautéed and boiled vegetables, tomato paste, artificial stabilizers and preservatives. For the human this product serves mainly as a source of carbohydrates and vegetable fats [1]. From the point of view of rational nutrition, vegetable pastes and marinades have a number of disadvantages, first of all, that artificial preservatives are used to produce them. Vegetable cans also contain some amount of vitamins (since the technological process to prepare pastes and marinades includes repeated cooking) [1]. Plant-based raw materials containing organic acids (benzoic, citric, malic, etc.) can be used as natural preservatives [2-11]. In this regard secondary raw materials of plant origin, in particular berry press residues (wastes of juice production) are of special interest [2].

Therefore, studies aimed at developing recipes of homogenized pastes and marinades of increased microbiological resistance are relevant.



This research is aimed at developing new recipes of homogenized pastes and marinades with lingonberry and cranberry press residues of increased microbiological resistance.

The objectives of the study are to develop the recipes of homogenized vegetable pastes and marinades containing lingonberry and cranberry press residues with the specified properties, and determine the optimal concentration of components in these recipes.

## 2. Materials and research methods

The objects of study are berries of lingonberry (*Vaccinium vitis-idaea*) and cranberry (*Oxycoccus*) (growing in Taseevo and Minusinsk districts of the Krasnoyarsk territory, Abaza district of the Republic of Khakassia), press residues obtained after juice extraction; homogenized vegetable pastes and marinades with lingonberry and cranberry press residues. The research was carried out in accordance with the standard procedures.

## 3. Discussion of the results

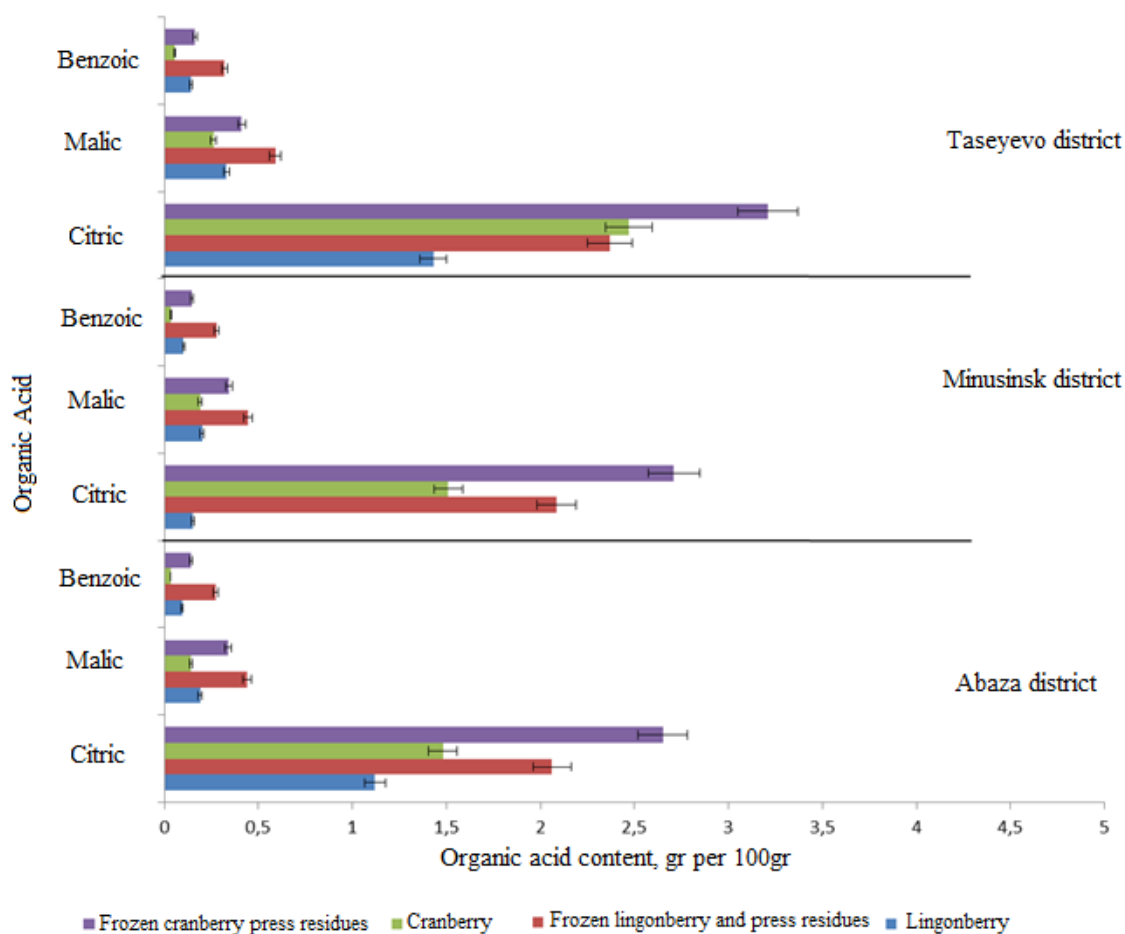
Secondary raw materials of plant origin (frozen lingonberry and cranberry press residues remained after **extraction of juice**) are found to be sources of organic acids (benzoic, citric, malic), fiber, pectin and minerals (sodium, magnesium, potassium, calcium). In terms of citric acid, depending on the growing area, titratable acidity of lingonberry and cranberry berries is (respectively): 2.17 and 2.21% (Taseevo district), 1.94 and 1.99% (Minusinsk district), 1.92 and 1.96% (Abaza district). When moving from north to south, the titratable acidity of the samples increases. The acidity of the test samples is mainly due to the content of free organic acids in their chemical composition. The relationship between the area of growth and the content of organic acids in the research samples has been revealed. The highest content of organic acids was found in berries (and residues remained after juice extraction) growing in the northernmost area (Taseyev), and the lowest content was recorded for berries from Abaza district. On average, in lingonberries gathered in Taseyev district, the content of organic acids compared to lingonberries gathered in Abaza district is higher: by 49.5% in benzoic acid content, by 73.7% in malic acid content, and by 27.6% in citric acid content. Cranberries growing in Taseyev district compared to cranberries that grow in Abaza district contain on average 75% more benzoic acid, 85.7% more malic acid, 66.9% more citric acid.

Composition and content of basic organic acids in berries and frozen lingonberry and cranberry press residues are shown in figure 1.

Titratable acidity of frozen lingonberry press residues is 3.86% and that is of cranberry press residues 5.87%. Lingonberry and cranberry press residues contain benzoic acid, 0.319-0.271 gr/100 gr and 0.163-0.139% gr/100 gr (respectively). Biological and technological properties of lingonberry and cranberry and press residues obtained after juice extraction are determined by the presence of benzoic acid in their chemical composition. Since benzoic acid has antiseptic properties and in combination with other factors provides an ability to preserve berries and products made from them. Based on the obtained data, frozen press residues (lingonberry, cranberry) can be classified as a group of natural preservatives and used in food production. The method of producing semi-finished products (pastes) from frozen press residues of lingonberry and cranberry is developed. The practical importance of the developed method is confirmed by the patents of the Russian Federation: No. 2560074.

New recipes of homogenized vegetable pastes and marinades have been developed with semi-finished products produced from frozen berry residues:

- the homogenized vegetable paste with lingonberry and cranberry press residues;
- the homogenized beet paste with lingonberry and cranberry press residues;
- the homogenized vegetable marinade with lingonberry and cranberry press residues;
- the homogenized beet marinade with lingonberry and cranberry press residues.



**Figure 1.** Composition and content of basic organic acids in berries and frozen lingonberry and cranberry press residues.

For convenience, let's use the following designations:

- composition 1 (tomato-based vegetable mix pastes - paste from frozen lingonberry or cranberry press residues);
- composition 2 (tomato-based vegetable mix marinades - paste from frozen lingonberry or cranberry press residues).

The quality of homogenized vegetable pastes and marinades depends on acidity, structural and mechanical properties. Acidity ( $y_1$ , pH) and yield value ( $y_2$ , Pa) are taken to characterize the quality of homogenized vegetable pastes and marinades. Independent factors are:  $x_1$  - tomato-vegetable mix content,%;  $x_2$  - content of semi-finished product "Paste with frozen lingonberry (or cranberry) press residues "(PFLPR (or PFCPR)),%.

The first stage. The recipes of the developed homogenized pastes and marinades were pre-developed. Organoleptic indices, acidity and yield value were defined for each version of homogenized vegetable pastes and marinades with berry press residues.

The second stage. The experimental data obtained were processed using STATISTICA 6.0 (Regression and Correlation Analysis).

The Fisher (F) criterion is used to estimate the reliability of linear regression equations and the significance of the correlation coefficient.

Table 1 shows the results of linear regression analysis.

**Table 1.** The results of linear regression analysis.

|               | Correlation Coefficient ( <i>R</i> ) | Coefficient of Determination ( <i>R</i> <sup>2</sup> ) | Fisher criterion ( <i>F</i> ) |
|---------------|--------------------------------------|--|-------------------------------|
| Composition 1 |                                      |  |                               |
| Acidity       | 0,98                                 | 0,97   | 196*                          |
| Yield value   | 0,99                                 | 0,98   | 344,77*                       |
| Composition 2 |                                      |  |                               |
| Acidity       | 0,98                                 | 0,97   | 173*                          |
| Yield value   | 0,91                                 | 0,83   | 22,75*                        |

\* – The table Fisher criterion is 4,07.

The results of regression analysis thus obtained confirmed the relation between the components ratio and the indices analyzed (yield value and acidity). This fact is proved by the mathematical models presented below, which allow to describe experimental data, since  $F_{\text{fact}} > F_{\text{table}}$ .

For composition 1:

$$y_1 = -303,475 + 3,06 \cdot x_1 + 3,04 \cdot x_2 \tag{1}$$

$$y_2 = 4200,42 - 40,51 \cdot x_1 - 41,11 \cdot x_2 \tag{2}$$

For composition 2:

$$y_1 = -95,073 + 1,31 \cdot x_1 + 1,28 \cdot x_2 \tag{3}$$

$$y_2 = 1832,66 - 22,62 \cdot x_1 - 22,96 \cdot x_2 \tag{4}$$

Table 2 summarizes the results of the correlation analysis. This type of analysis allows us to evaluate the close relationship between dependent (response functions) and independent factors.

**Table 2.** The results of correlation analysis.

| Response functions | Pair correlation coefficient    |                             |
|--------------------|---------------------------------|-----------------------------|
|                    | Tomato-vegetable mix, $x_1$ , % | PFLPR (or PFCPR), $x_2$ , % |
| Composition 1      |                                 |                             |
| Acidity, pH        | 0,97                            | -0,97                       |
| Yield value        | 0,98                            | -0,98                       |
| Composition 2      |                                 |                             |
| Acidity, pH        | 0,98                            | -0,98                       |

Based on the obtained calculated data, equations and graphs, it can be seen that the desired functions  $y_1$ ,  $y_2$  adequately describe changes in acidity and yield value. The analysis of approximated linear lines revealed the following patterns for homogenized vegetable pastes and marinades:

- the acidity of compositions decreases with the reduction in tomato and vegetable weight ratio ( $r_1 = 0,97$ ,  $r_2 = 0,98$ ) and increase in PFLPR (or PFCPR) weight ratio ( $r_1 = -0,97$ ,  $r_2 = -0,98$ );
- the yield value is significantly affected by the reduction in tomato and vegetable weight ratio ( $r_1 = 0,98$ ,  $r_2 = 0,9$ ) and increase in PFLPR (or PFCPR) weight ratio ( $r_1 = -0,98$ ,  $r_2 = -0,9$ );

The confirmatory data analysis proves the compatibility of the components in the recipes of homogenized pastes and marinades with PFLPR (or PFCPR).

The third stage. The content of the recipe components is directly dependent on the acidity and yield value, and is accordingly linear. The optimal content of ingredients included in the composition is determined with calculations in Mathcad.

The optimum values of functions  $y_1$ ,  $y_2$  were found using the obtained mathematical models.

Based on organoleptic properties of homogenized pastes and marinades minimum and maximum content of components included in compositions  $x_1, x_2$  are as follows:

$$75 \leq x_1 \leq 81 \tag{5}$$

$$20 \leq x_2 \leq 30 \tag{6}$$

The limits of functions  $y_1, y_2$  were defined based on organoleptic properties and requirements for acidity and yield value of homogenized vegetable pastes and marinades. For the developed compositions, inequations are written in the form as follows:

$$2,29 \leq y_1 \leq 2,4 \tag{7}$$

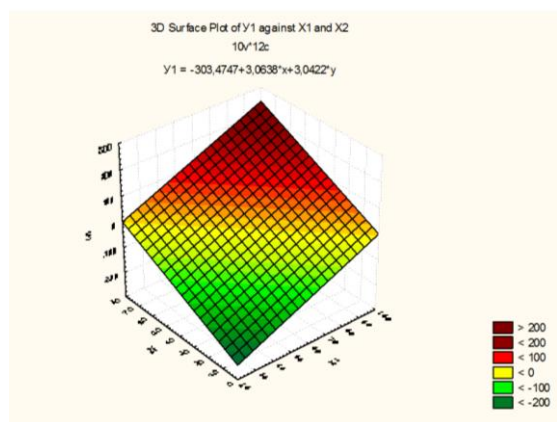
$$129,2 \leq y_2 \leq 134 \tag{8}$$

The optimal ratio is determined for each component in the composition. The optimal ratio of the components included in the developed compositions is shown in table 3.

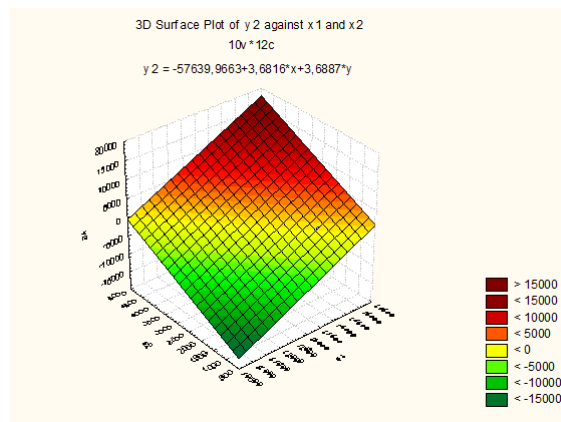
**Table 3.** Optimal component ratio in the compositions developed.

| Composition No | Minimum search for the function $y_n$ | Optimal component ratio, %       |  | Value of function $y(x_1, x_2, x_3)$ |
|----------------|---------------------------------------|----------------------------------|--|--------------------------------------|
|                |                                       | Tomato-vegetable mix,, $x_1$ , % | Paste with frozen lingonberry (or cranberry) press residues, $x_2$ , % |                                      |
| 3              | $y_1$                                 | 81                               | 19   | 2,4                                  |
|                | $y_2$                                 | 79                               | 21   | 134,09                               |
|                | Mean value $x$                        | 80                               | 20   | -                                    |
| 4              | $y_1$                                 | 43                               | 31   | 2,29                                 |
|                | $y_2$                                 | 47                               | 29   | 129,2                                |
|                | Mean value $x$                        | 45                               | 30   | -                                    |

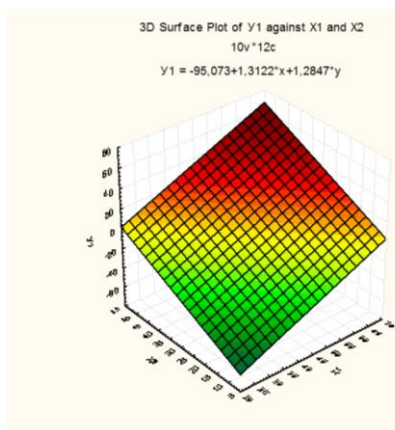
Optimal ratio of components: for composition 1 -  $x_1 = 80, x_2 = 20\%$  at the value of functions  $y_1 = 2,4$  pH,  $y_2 = 134,09$  Pa; For composition 2 -  $x_1 = 45, x_2 = 30\%$  at the value of functions  $y_1 = 2,29$  pH,  $y_2 = 129,2$  Pa. The optimal ratio of components in the compositions by acidity and yield value is graphically shown in figures 2-5.



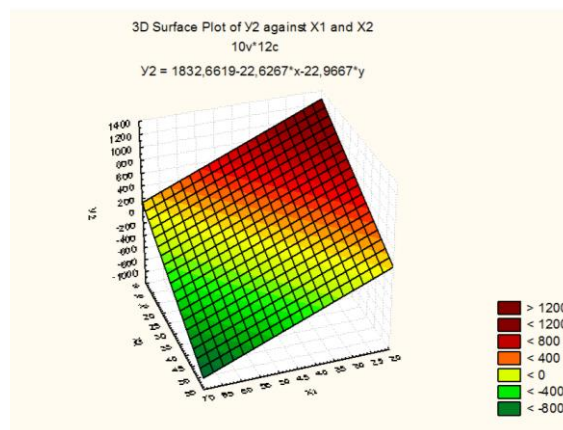
**Figure 2.** Optimal ratio of components in homogenized vegetable paste with lingonberry (or cranberry) press residues by acidity.



**Figure 3.** Optimal ratio of components in homogenized vegetable paste with lingonberry (or cranberry) press residues by yield value.



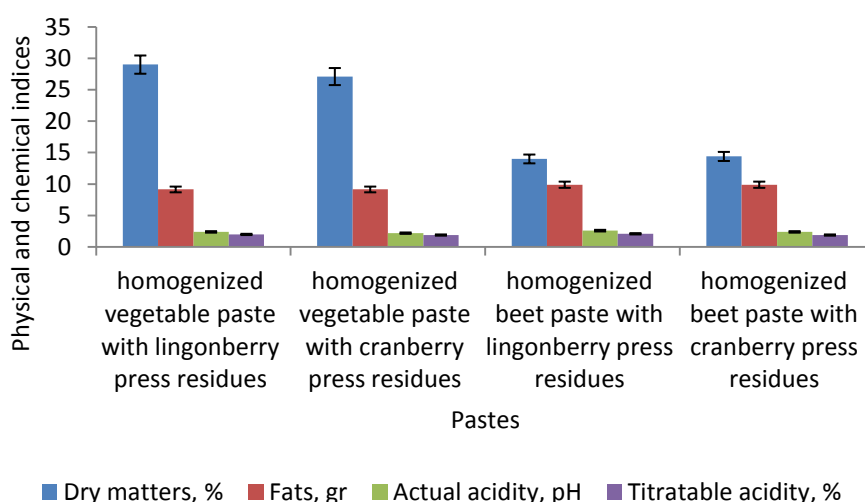
**Figure 4.** Optimal ratio of components in homogenized vegetable marinade with lingonberry (or cranberry) press residues by acidity.



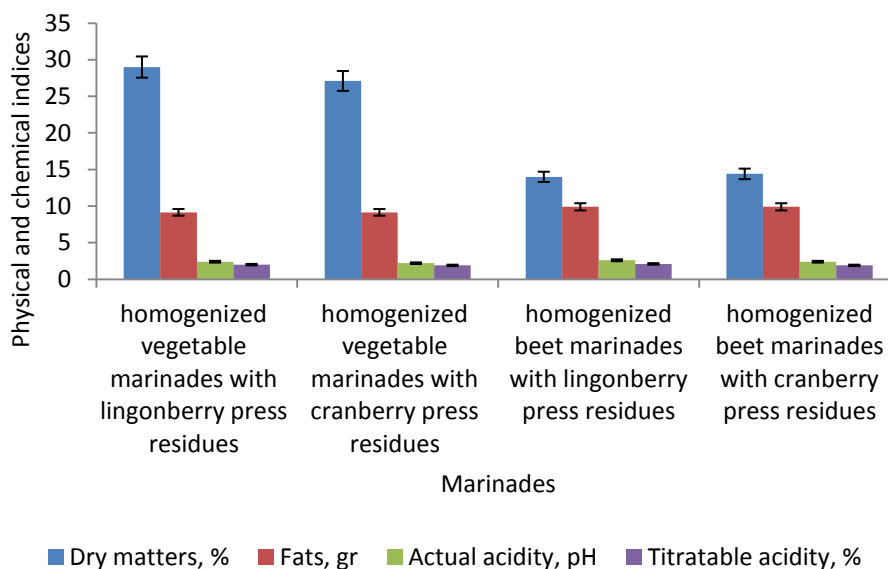
**Figure 5.** Optimal ratio of components in homogenized vegetable marinade with lingonberry (or cranberry) press residues by yield value.

Physical and chemical indices of the developed homogenized vegetable pastes and marinades were studied. The results are presented in figure 6, 7.

Microbiological parameters of the developed homogenized vegetable pastes and marinades were studied in the State Regional Center for Standardization, Metrology and Testing of the Krasnoyarsk territory. Microbiological indices of homogenized vegetable pastes and marinades comply with the requirements established by Technical Regulation of the Customs Union 021/2011 "On food safety" [12]. The reference documentation for homogenized vegetable pastes and marinades has been developed. The practical importance of the developed pastes and marinades is confirmed by the patents of the Russian Federation: No. 248323 "Homogenized vegetable paste," No. 2480029 "Homogenized beet paste," No. 2476123 "Homogenized vegetable marinade." [14].



**Figure 6.** Physical and chemical indices of homogenized vegetable pastes with lingonberry (or cranberry) press residues.



**Figure 7.** Physical and chemical indices of homogenized vegetable marinades with lingonberry (or cranberry) press residues.

#### 4. Discussion

The obtained results prove the possibility of making homogenized vegetable pastes balanced in basic food substances with addition of lingonberry (or cranberry) press residues. Due to the content of organic acids lingonberry or cranberry press residues allow avoiding artificial preservatives and obtaining safe food products. These properties of berry raw materials are described in papers of the following researchers: O.Ya. Kolman [2], Häkkinen S.H., Törrönen A.R. [3], Łata B., Trąpczyńska A., Mika A. [4], Kähkönen MP, Hopia AI, Heinonen M. [5], Mane C, Loonis M, Juhel C, Dufour C, Malien-Aubert C. [6], Popov, S.V., Markov, P.A., Nikitina, I.R.; Petrishev, S., Smirnov, V., Ovodov, Y.S. [7], Cesoniene, L.; Daubaras, R.; Jasutiene, I.; Vencloviene, J.; Miliauskiene, I. [8], Lehtonen, H.-M., Lehtinen, O., Suomela, J.-P., Viitanen, M., Kallio, H. [9], Ek, S.; Kartimo, H.; Mattila, S.; Tolonen, A. [10], Ho, K.Y.; Tsai, C.C.; Huang, J.S.; Chen, C.P.; Lin, T.C; Lin, C.C. [11].

As a result, complex processing of berry raw materials makes it possible to increase the nutritional value of homogenized pastes and marinades produced in Siberia.

#### 5. Conclusion

Based on the research carried out, it can be concluded that lingonberry and cranberry press residues are a natural source of organic acids, so berry residues may be used as preservatives in production of homogenized pastes and marinades with the increased microbiological resistance. The optimal ratio of components to obtain pastes and marinades with specified properties is determined. The developed technological schemes are considered as a solution for food processing companies of Siberia.

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