

PAPER • OPEN ACCESS

Modern aspects of using secondary plant-based raw materials in food production

To cite this article: O Ya Kolman *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **315** 022032

View the [article online](#) for updates and enhancements.



IOP | ebooks™

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the [collection](#) - download the first chapter of every title for free.

Modern aspects of using secondary plant-based raw materials in food production

O Ya Kolman, G V Ivanova, T N Yamskikh and A N Ivanova

Siberian Federal University, Svobodny prospect, 79, Krasnoyarsk, 660041, Russia

E-mail: kolmanolya@mail.ru

Abstract. The paper substantiates the efficiency of using non-traditional plant materials in *food and culinary recipes with high nutritional value*. The purpose is to find new technological solutions for using secondary raw materials in the technology of functional food production. The chemical composition of lingonberry (*Vaccinium vitis-idaea*) and cranberry (*Oxycoccus*) press *residues* obtained after juice extraction was investigated. The sanitary-hygienic indicators of lingonberry and cranberry press *residues* were determined. Based on this research, we developed the method for the production of powders and pastes from secondary berry resources - lingonberry and cranberry press *residues*. The research involved quantitative assessments in order to define if the manufacturing process for the production of powders and pastes satisfies *non-wastefulness*. The optimal storage parameters for lingonberry and cranberry powders and pastes, ensuring maximum safety of biologically active substances - antioxidants: ascorbic acid, P-active substances were determined. Tests revealed that lingonberry and cranberry powders can be referred to the group of baking improvers, while lingonberry and cranberry paste can be used as thickening and gelling agents.

1. Introduction.

The problem of enriching food with essential nutrients that can improve many physiological processes of human metabolism, increase the ability of body defense systems to respond adequately to adverse environmental conditions, reducing the risk of foodborne diseases has recently become one of the most important [1-5]. Therefore, one of the priorities that can solve the problem of healthy nutrition for people living in the Krasnoyarsk territory is searching for new types of non-traditional plant-based raw materials, which will enrich food with vital nutrients to a level satisfying physiological needs of the human [1-5].

Secondary raw materials from other industries, in particular, juice production, which makes about 23.5–43.5% of the total volume of processed berries (in the Russian Federation) are of practical interest among the promising types of additional raw materials for food industry. Waste products from juice production, namely lingonberries and cranberries press residues, were chosen as secondary plant-based raw materials [1-5]. At present, berry press residues are not used in food industry. There are some data that suggest that this type of raw material is an important source of dietary fiber, vitamins, mineral and other substances [6-8] and there is no information concerning the methods for canning, processing, using them as enriching additives in food production. Therefore, comprehensive study aimed at solving persistent national economic problem - the rational use of secondary plant-based raw materials with a high content of biologically active



substances and the development of manufacturing process for the production of preventive confectionery products is the most crucial task on the long list of things to do. What's more, national confectioners offer products with a high energy value but with fiber, mineral and vitamin deficiency.

The purpose of this research is to find new technological solutions for using secondary raw materials in the technology of functional food production.

The research study is guided by the following specific objectives:

- to investigate the chemical composition, food safety indicators for berries and press residues of wild berries (lingonberries, cranberries) in order to broaden the base of raw materials for the food processing industry;
- to develop the stages of processing lingonberry and cranberry press residues and determine optimal storage mode for the obtained semi-finished products - powders and pastes, ensuring maximum safety of biologically active substances;
- to ground the expediency of using powders and pastes in production of confectionery products;
- to develop regulatory requirements and technical documentation.

2. Materials and research methods

The objects of study are secondary products of lingonberry and cranberry processing (frozen press residues); powders from dried lingonberries and cranberries press residues; pastes from frozen lingonberry and cranberry press residues.

The research was based on physical and chemical, functional and technological, microbiological, atomic absorption, and other research methods. Sanitary-chemical safety indicators (mercury, arsenic, cadmium, lead), and radiological indicators (cesium-137, strontium-90) were investigated by standard methods: GOST 26927–86, GOST 26930–86, GOST 30178–96, measurement procedure by D.I. Mendeleyev Institute for Metrology from December 01, 2005 “Methodology for measuring the specific activity of radionuclides including radium-226, thorium-232, potassium-40, cesium-137, strontium-90 in samples of industrial and agricultural products and environmental objects” in accordance with technical regulations of the Customs Union (TR CU 021/2011) “On Food Safety”. Microbiological studies of experimental samples were carried out to determine the presence of mesophilic aerobic and optional aerobic microorganisms; coliform bacteria (coliforms); *S.aureus*; salmonella; yeast and mold by standard methods: GOST 10444.15–94, GOST R 5281620–07 (GOST R 50474–93), GOST 10444.2–94, GOST R 50480–93, GOST 10444.12–88 in accordance with TR CU 021/2011 “On Food Safety”.

Quantitative assessments of manufacturing process for the production of powders and pastes from lingonberry and cranberry press residues were carried out using the method developed by V. I. Komarov and T. A. Manuilova.

3. Research results

The research revealed that Lingonberries press residues obtained after juice extraction contain pectin - 0.41%, acids - 2.77%, water - 77.91%, cellulose - 12.67%, vitamin C - 5.51 mg%, acids - 2.95%, Na - 3.1 mg%, K - 174.80%, Ca - 32.14 mg%, Mg -19.31 mg%. Cranberry press residues contain pectin - 0.97%, acids - 2.77%, water - 76.63%, fiber - 13.16%, vitamin C - 7.42 mg%, acids - 3.37%, Na - 11.78 mg%, K -221.71 mg%, Ca 48.14 mg%, Mg -34.26 mg%.

The safety indicators of lingonberry and cranberry press residues were studied: sanitary-chemical (mercury, cadmium, arsenic, lead), radiological (cesium-137, strontium-90) and microbiological indicators.

Tests revealed that the concentration of mercury and lead in the cranberries press residues is 20% higher as compared to the lingonberries press residues, but does not exceed the value of permissible

level. The content of cadmium and arsenic in lingonberries press residues is respectively 50% and 12.5% higher than in cranberries press residues, but does not exceed the value of permissible level.

The content of strontium-90 in the frozen lingonberries and cranberries press residues is respectively 15.4% and 16.3% lower as compared to dried lingonberries and cranberries press residues. The content of strontium-90 in the frozen and dried lingonberries press residues is 6.8% and 5.7% higher as compared to frozen and dried cranberries press residues, but does not exceed the value of permissible level. The concentration of cesium-137 in the frozen lingonberries and cranberries press residues is 5.3% and 9.7% lower than in the dried lingonberries and cranberries press residues. The content of cesium-137 in the frozen and dried cranberries press residues is 12.4% and 16.4% higher as compared to the frozen and dried cranberries press residues, but does not exceed the value of permissible level.

The content of mercury, cadmium, arsenic, lead, cesium-137, strontium-90 in lingonberries and cranberries press residues does not exceed the permissible levels in accordance with TR CU 021/2011 “On Food Safety”.

It was investigated that lingonberries and cranberries press residues are a good source of dietary fiber, P-active substances, vitamin C, organic acids, mineral substances, therefore they can be used as a dietary supplement in prophylactic food production. Currently, there is no adequate information concerning the methods for canning, processing and using press residues as enriching additives in food production.

Based on information gained during this study, we proposed an industrial-oriented, efficient way of processing non-traditional plant materials and developed optimal storage requirements for semi-finished products obtained from lingonberries and cranberries press residues, ensuring maximum safety of biologically active substances.

We developed the method for the production of pastes from frozen lingonberries and cranberries press residues and powders from dried lingonberries and cranberries press residues.

To obtain pastes, the berries are laid out in a uniform layer (layer thickness is 5 mm) on baking sheets, pre-frozen in a shock freezing chamber (LAINOX DX 106) to -18°C for 240 minutes (in order to obtain a homogeneous mass due to the disruption of cell membranes by ice crystals), then the frozen press residues are crushed (using a mixer-blender) until smooth and packaged.

To obtain powders, berries are laid out in a uniform layer (layer thickness is 10 mm) on wire-meshed trays and dried using radiation-convection method in the Universal-SD-4 drying cabinet at a temperature of 70 °C for 4 hours to a residual moisture content of 20-17%. The principle of Universal-SD-4 infrared electrical cabinet operation is based on the combined radiation-convective method for drying food products. With this method, the evaporation of moisture in the food product occurs mainly through thermo-radiation heating by infrared radiation of certain wavelengths, and dehumidification due to forced convection of the air-vapor mixture. Electric tubular heaters with ceramic coating are arranged in pairs in a row of four sections inside the electrical cabinet. Wire-meshed trays for drying food products are placed above each level of the heaters. The control system of the cabinet ensures automatic temperature maintenance not to exceed the set value at all levels inside the cabinet and forced air circulation through the food product due to the built-in ventilation system and a special system of shields and air ducts. The room for the cabinet must be equipped with inflow exhaust ventilation with a capacity of at least 500 m³ / h per a cabinet, or the exhaust system can be located outside with a duct which length is not more than 4 m. All side walls of the cabinet, as well as its doors, are insulated, which allows reducing energy consumption in the process of drying. Dried berries are crushed in a mill to a powdery substance (particle size of 0.4–0.5 mm); the powder is then put through a sieve (with a cell size of 0.5 mm) and packaged.

The research involved quantitative assessments in order to define if the manufacturing process for the production of powders and pastes satisfies non-wastefulness which was calculated in terms of non-wastefulness coefficient. The non-wastefulness coefficient is an integral indicator that takes into account the scale of natural resources consumption, the volume of manufactured products, the quantities of environmental wastes and the degree of danger inherent in them. This coefficient is a

multiplicative factor consisting of separate contributors - the fullness coefficient showing the degree of using raw materials, which describes the closeness of the process at the "input" and "output" in relation to the environment, and the environmental factor, characterizing the intensity of the process impact on the environment. The environmental factor is essentially stability of food qualities and quantities in the production process, i.e., it is the difference between the unit and the coefficient of production waste.

The results of quantitative assessments carried out in order to define if the manufacturing process for the production of powders and pastes satisfies non-wastefulness is presented in table 1.

Table 1. Quantitative assessments to define if the manufacturing process for the production of powders and pastes satisfies non-wastefulness.

Criteria for assessing non-wastefulness	Paste from berries press residues		Powder from berries press residues	
	Lingonberries (Vaccinium vitis-idaea)	Cranberries (Oxycoccus)	Lingonberries (Vaccinium vitis-idaea)	Cranberries (Oxycoccus)
Actual amount of press residues obtained after juice extraction from 1 ton of berries, kg	400	320	400	320
Wastes, kg	4	3,2	303	245
The volume of processed raw materials, kg:	396	316,8	97	75
The fullness coefficient	1	1	0,99	0,98
The coefficient of production waste	0	0	0	0
The environmental factor	1	1	1	1
The non-wastefulness coefficient	1	1	0,99	0,98

The non-wastefulness coefficients of the manufacturing process for obtaining powders from lingonberries and cranberries press residues are 0.99 and 0.98 respectively. The manufacturing processes with K_w in the range from 0.9 to 1.0 are categorized as relatively wasteless, therefore the manufacturing process for the production of powders is relatively wasteless, the manufacturing process for pastes production is absolutely wasteless, since its K_w is equal to 1 (the method was developed by V. I. Komarov and T. A. Manuilova).

As part of this research we have developed storage requirements for pastes and powders obtained from lingonberries and cranberries press residues to preserve the content of vitamin C and P-active substances throughout the entire storage period. It is recommended to store pastes from lingonberries and cranberries press residues at a temperature of - 18 ° C and relative air humidity maintained on the level of 95% for 9 months, and powders from lingonberries and cranberries press residues - at a temperature of + 18 ° C and relative air humidity 65% for 9 months.

The technological properties of the obtained semi-finished products from lingonberries and cranberries press residues are investigated. The expediency of using powders and pastes in the production of confectionery products has been substantiated when studying the effect of powders from lingonberries and cranberries press residues on the baking properties of high-grade wheat flour and the jelly-forming ability of pastes from lingonberries and cranberries press residues.

The flour baking potential was defined with the following indicators: gassing ability, gas-retaining ability, water absorbing ability, and flour color. Wheat flour of the highest grade with a low content of

crude gluten up to 28%, i.e. having low gassing ability, was used to study the effect of dried powdered lingonberries and cranberries press residues on the baking properties of flour. Powder from dried lingonberries or cranberries press residues was added to the dough, varying its content in the range from 5 to 25% with respect to the weight of flour. The powder free dough was taken as a control sample. It was investigated that in case of replacing 5–25% of the highest-grade flour with powder from lingonberries and cranberries press residues the content of carbon dioxide released during the 5 hours of fermentation has increased on an average by 53.6–74.7 %. The gassing ability of flour increases mainly due to the vital for yeast cells elements - mineral substances, vitamins, organic acids, sugars, involved in the biosynthesis of the main components of the yeast cellular substance and being activators of enzymatic activity. Acceleration of fermentation process in the test samples with an increase of the dried lingonberries or cranberries powder content is attributed to the corresponding increase in the dough acidity. Since the powder from lingonberries or cranberries press residues is a natural source of organic acids (benzoic, citric, etc.), P-active substances, polysaccharides, therefore, powder from lingonberries or cranberries press residues used as a yeast dough ingredient causes a decrease in the mass fraction of crude gluten and gluten deformation.

The water absorbing ability of flour in samples containing 25% of the berry powder with respect to the weight of flour increases, as compared to a control sample, on an average by 33–37%.

On the basis of the research findings some recommendations are made that will add value to the improvement of flour properties and obtaining higher quality products using dried powder produced from lingonberries and cranberries press residues in flour confectionery recipes. Therefore, the powder obtained from lingonberries and cranberries press residues can be referred to the group of baking improvers.

The properties of paste from the frozen lingonberries and cranberries press residues for food production is mainly determined by its jelly-forming ability, which was evaluated by the texture and firmness of the paste-based marmalade jelly. The texture and firmness of jellies were determined using a texture analyzer by the Valent method (The methods to determine fruit and berry puree gelling ability according to GOST 8756.12).

The texture and firmness of marmalade jelly is 180–200 g, when prepared using the paste from the frozen cranberries press residues, and 450–500 g. when using the paste from the lingonberries press residues.

Due to a sufficiently high gelling ability, it is considered expedient to use a paste prepared from berries (lingonberries and cranberries) as a gelling substance for the production of confectionery.

The concentration of hydrogen ions is an important factor in the process of marmalade gelatinization. The pH effect of the paste on pectin gelation is shown in table 2.

When mixing a paste from berries press residues (lingonberries, cranberries) with sugar ratio of 1: 0.7, it is possible to reach optimal content of pectin, sugar and acids for the most efficient gelatinization without acids addition. Pastes obtained from lingonberries and cranberries press residues can be used as gelling substances for the production of sugary confectionery.

Table 2. The pH effect of the paste on pectin gelation.

Paste	Citric acid content in 100 g of marmalade mixture	Moisture, %	pH	Reducing sugars content of, %	Texture and firmness of jelly	Time of jelly formation, h
from frozen cranberries press residues	1,6	29,54	3,2	57,4	1700	0,5-0,6
from frozen lingonberries press residues	2,09	29,54	3,0	58,2	2200	0,5-0,6

The following regulatory requirements and technical documentation have been developed for semi-finished products obtained from lingonberries and cranberries press residues: TR 9169-102-02067876-12. Powder from dried berries press residues (lingonberries, cranberries), TR 9169-101-02067876-12. Paste from berries press residues (lingonberries, cranberries).

The practical importance of the developed method for secondary raw materials processing is confirmed by the patents of the Russian Federation: No. 2560074 "Method for producing pastes from frozen lingonberries and cranberries press residues" (authors: Kolman O.Ya., Ivanova G.V.), No. 2555592 "Method for producing powders from dried lingonberries and cranberries press residues" (authors: Kolman O.Ya., Ivanova G.V.).

4. Discussion

The results of the research make it possible to create low waste or relatively waste-free technological solutions for the processing of plant-based raw materials. These technological solutions are a good way to obtain semi-finished products with enhanced nutritional value and high technological properties from secondary raw materials (berries press residues). These semi-finished products can be used to produce prophylactic food products. The issues related to investigating the preventive properties of lingonberries and cranberries were discussed in the research works of the following authors: Yan X., Murphy B.T., Hammond G. B., Vinson, J.A., Neto C.C. [1], Murphy, B.T., Mackinnon, S.L., Yan, X., Hammond, G. B., Vaisberg, A.J., Neto, C.C. [2], Katsube N., Iwashita K., Tsushida T., Yamaki K., Kobori M. [3], Neto CC, Krueger CG, Lamoureux TL, Kondo M., Vaisberg AJ, Hurta RAR, Curtis S., Matchett MD, Yeung H., Sweeney MI, Reed JD [4], Popov S.V., Markov P.A., Nikitina I.R., Petrishev S., Smirnov, V., Ovodov, Y.S. [5]. The preventive properties of lingonberries and cranberries were considered and proved, in particular antitumor activity. The preventive property of these berries is attributed to the presence of nutrients capable to reduce the negative environmental impact, as evidenced by the following authors' results: Hokkanen J., Mattila S., Jaakola L., Pirttila AM, Tolonen A. [6], Meng, FL ; Su, X.T. ; Li, Y.D. [7], Kartimo, H. ; Mattila, S.; Tolonen, A. [8].

Thus, using powders and pastes produced from the lingonberries and cranberries press residues in recipes of food products, in particular flour and sugar confectionery, will reduce the energy value, increase the nutritional value and foster their preventive properties.

5. Conclusions

1. The research revealed that lingonberries and cranberries press residues are a good source of dietary fiber, P-active substances, mineral substances, that makes it possible and expedient to use them as an enriching additive in the production of prophylactic confectionery products.

2. The method for the production of powders and pastes from secondary berry resources - lingonberry and cranberry press residues was proposed. The optimal storage parameters for the obtained semi-finished products were determined ($T = 18.0 \pm 2.0$ ° C, relative air humidity $65.0 \pm 2.0\%$ for powders and $T = -18.0 \pm 2.0$ ° C, relative air humidity $95, 0 \pm 2,0\%$ for pastes from lingonberries and cranberries press residues), to ensure maximum safety of biologically active substances.

3. The efficiency of using powders and pastes in confectionery production is substantiated. The regulatory requirements and technical documentation for semi-finished products obtained from lingonberry and cranberry press residues were developed: TR 9169-102-02067876-12. Powder from dried berries press residues (lingonberries, cranberries), TR 9169-101-02067876-12. Paste from berries press residues (lingonberries, cranberries).

References

- [1] Yan X, Murphy B T, Hammond G B, Vinson J A and Neto C C 2002 Antioxidant activities and antitumor screening of extracts from cranberry fruit (*Vaccinium macrocarpon*) *J. Agric. Food Chem.* **50** (21) 5844-9
- [2] Murphy B T, Mackinnon S L, Yan X, Hammond G B, Vaisberg A J and Neto C C 2003 Identification of hydroxycinnamates with in vitro antitumor activity from whole cranberry fruit (*Vaccinium macrocarpon*) *J. Agric. Food Chem.* **51** 3541-5
- [3] Katsube N, Iwashita K, Tsushida T, Yamaki K and Kobori M 2003 Induction of apoptosis in cancer cells by bilberry (*Vaccinium myrtillus*) and the anthocyanins *J. Agric. Food Chem.* **51** 68-75
- [4] Neto C C, Krueger C G, Lamoureaux T L, Kondo M, Vaisberg A J, Hurta, R A R, Curtis S, Matchett M D, Yeung H, Sweeney M I and Reed J D 2005 MALDI-TOF MS characterization of proanthocyanidins from cranberry fruit (*Vaccinium macrocarpon*) that inhibit tumor cell growth and metalloproteinase expression in vitro *J. Sci. Food Agric.* **86** 18-25
- [5] Popov S V, Markov P A, Nikitina I R, Petrishev S, Smirnov V and Ovodov Y S 2006 Preventive effect of a pectic polysaccharide of the common cranberry *Vaccinium oxycoccos* L. on acetic acid- induced colitis in mice *World J. Gastroentero* **12** 6646-51
- [6] Hokkanen J, Mattila S, Jaakola L, Pirttila A M and Tolonen A 2009 Identification of phenolic compounds from lingonberry (*Vaccinium vitis-idaea* L.), bilberry (*Vaccinium myrtillus* L.) and hybrid bilberry (*Vaccinium intermedium* Ruthe L.) leaves *J. Agric. Food Chem.* **57** 9437-47
- [7] Meng F L, Su X T and Li Y D 2004 Extraction, separation and structure identification of cyanidin-3-galactoside in fruit of *Vaccinium vitis-idaea* *J. Jilin. Agric. Univ.* **26** 529-31
- [8] Kartimo H, Mattila S and Tolonen A 2006 Characterization of phenolic compounds from lingonberry (*Vaccinium vitis-idaea*) *J. Agric. Food Chem.* **54** 9834-42