Development of low-waste technologies for agro-processing companies

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Abstract. Thos paper is devoted to the development of low-waste technologies for agro-processing companies. The research involved studying the yield percentage of extracted juice and the amount of secondary raw materials depending on the production technology and the types of raw materials used (fresh or frozen) in fruit and berry juices extraction, storage conditions. The results include quantifying the amount of secondary raw materials in the production of fruit and berry juices from: Fresh berries of lingonberry (Vaccínium vítis-idaéa) and cranberry (Oxycóccus), milled into particles sized 2-3 mm; Frozen brushberry and cranberry berries (stored for 36 hours at -5 ° C), milled into particles sized 2-3 mm; Frozen berries of lingonberry and cranberry (stored for 6 months at - 18°C), milled into particles sized 2-3 mm. Wastes of juice production, namely lingonberry and cranberry press residues have high food value. It was found out that the developed technology ensures high retention of vitamins and other valuable chemicals in lingonberry and cranberry press residues, which makes it possible to recommend this method of processing wild-growing and cultivated berries. It is proposed to use lingonberry and cranberry press residues as a biologically active additive in food production for further use in diets of people living in environmentally fragile and hazardous areas.

1. Introduction

Currently, fruits and berries growing in the Krasnoyarsk Territory are advantageous raw materials for the production of juices. They contain vitamins, minerals, dietary fibres [1-5], essential nutrients required by the human body. These substances increase the ability of body defense systems to respond adequately to adverse impacts in environmentally fragile and hazardous areas. Due to the shielding actions they minimize human exposure to radiation [6-10]. The development of low-waste technologies for complex processing of fruit and berry raw materials is crucially important for the production of juices. In particular, yield percentage of extracted juice and the amount of secondary raw materials (waste of juice production) are among the factors to consider for agro-processing companies engaged in the production of juice concentrates.

Yield percentage of extracted juice and the amount of secondary raw materials depend on the type of raw materials. The economic performance of agro-processing companies directly depends on these indicators [11, 12]. Berries of lingonberry and cranberry are of practical interest for the agro-processing companies as raw materials for the production of juices. They have high nutritional value and gain high popularity among the Krasnoyarsk territory residents. Therefore, researches aimed at studying yield percentage of extracted juice and quantifying the amount of secondary raw materials in the production of fruit and berry juices seem to be relevant.

The purpose of this work is to determine the amount of secondary raw materials in the production of fruit and berry juices depending on the production technology and the types of raw materials used (fresh or frozen) in fruit and berry juices manufacturing, storage conditions and study the influence of these factors on the yield percentage of extracted juice, i.e. on the amount of press residues.

The amount of juice and the yield of secondary raw materials (berry press residues) directly depend on pretreatment methods and the technology of juice production applied. Since, in accordance with the theory of biometric yield, developed by B.L. Flaumenbaum, yield percentage of extracted juice from fruits directly depends on elasticity and resistance of cell membranes to mechanical effects, viscosity and content of pectin substances in cells [2].

The objectives of this research include:

1. Determine the amount of secondary raw materials in the production of fruit and berry juices from:

- Fresh berries of lingonberry and cranberry, milled into particles sized 2-3 mm;
- Frozen brushberry and cranberry berries (stored for 36 hours at -5 ° C), milled into particles sized 2-3 mm;
- Frozen berries of lingonberry and cranberry (stored for 6 months at - 18°C), milled into particles sized 2-3 mm.

2. Measure moisture content and the content of vitamin C and P-active substances in press residues from berries stored for 6 months at -18 ° C and relative air humidity 95%.

Research materials and methodology. Objects and methods of research. The study objects of our research include:

- Fresh berries of lingonberry and cranberry, milled into particles sized 2-3 mm;
- Frozen lingonberry and cranberry berries (stored for 36 hours at -5 ° C), milled into particles sized 2-3 mm, followed by grinding;
- Frozen berries of lingonberry and cranberry (stored for 6 months at - 18°C), milled into particles sized 2-3 mm, followed by grinding.

2. Research methods

The standard methods were used for the research. Moisture was determined by GOST 28561-90 [13], potentiometric method was used for determining Vitamin C (GOST 24556-89) [14], total polyphenols (anthocyans and leucoanthocyanins) content was calculated by *Swain* and *Hillis* method with the use of various oxidative reagents, catechin was measured by column chromatography (N.A. Golovkin and N.V. Novotelny).

3. Research results

Fresh berries of lingonberry and cranberry were first processed mechanicaly and hydromechanicaly. Before freezing, berries of lingonberry and cranberry were dried in order to remove excessive moisture from their surface with the subsequent *packing into* the *polyethylene film*. Juice was extracted with the centrifuge and then passed through a 0.4 mm mesh filter for the reduction of pulp content to stabilize the homogeneous structure of juice. The amount of juice and the yield of press residues from berries of lingonberry and cranberry processed by various methods have been studied and shown in figure 1.

The highest press residues yield was found when juice was extracted from previously milled fresh berries of lingonberry and cranberry compared to other samples under study and was 56.5 - 57.5%. On average, the yield of pulp obtained from cranberries is 1% higher than that obtained from lingonberries. This is primarily due to the higher content of pectin substances in cranberries than in lingonberries. It is soluble pectin that mainly affects the ability of fruit tissue to release juice, due to its water-retaining capacity, ability to increase juice viscosity, and thereby prevent juice from flowing out

of the cell membranes. The amount of pectin substances in press residues from fresh berries is slightly lower than in fruits - 23-28% of the total content in berries. And the reason is because the pectin substances in berries of lingonberry and cranberry are mainly soluble pectin, contained in the cell juice.

Figure 1. Dependence of juice and press residues yield on the methods of processing.

On the one side the yield of press residues decreases by 19% on average when juice is extracted from frozen berries of lingonberry and cranberry with subsequent grinding. On the other side the yield of juice increases due to a very low rate of ice crystals formation in berries tissues stored at- 5 ° C. Since ice crystals are formed during storage in the intercellular space, by freezing water from cells and injection into the intercellular space, the previously formed ice crystals enlarge (icing), which causes increase of juice concentration. This process causes an increase in juice extraction due to the

destruction of cell walls by ice crystals. In juices extracted from frozen berries of lingonberry and cranberry at a temperature of - 5 ° C, the content of dry substances increases by 2.7% on average. The content of pectin substances decreases: in lingonberry juice by 10%, in cranberry by 5% compared to juices extracted from fresh berries.

As a result of the research studies carried out, it was found that during the process of storage (at a temperature of - 18 ° C) ice crystals continue to grow on the surface of the packages with lingonberry and cranberry. This process leads to a decrease in the temperature of ice crystals (it decreases to the temperature of the package) compared to the temperature of lingonberries and cranberries. This process contributes to sublimation of ice from lingonberries and cranberries and formation of frost coating on the inner surface of the package. This leads to the internal drying of berries, high content of dry substances and decrease in juice extraction by 1% on average. However, it is 18% higher than in case of fresh milled berries (figure 1). For juices extracted from frozen berries stored at -18 ° C for 6 months there is an increase in dry substances content (in lingonberry juice by 8.1%, in cranberry juice by 8.2%) and further decrease in pectin substances (in lingonberry juice by 26.6%, in cranberry juice by 12.5%). The reduction in the content of pectin substances in berry juices results from the protopectin hydrolysis process.

As our research has shown, the intensity and direction of mass exchanging process within berry packages depend on storage conditions. Since absolute weight loss of berries during the long-term period of storage is determined by the rate and stability of the temperature. Therefore, the temperature of 18 ± 0.5 ° C was found optimal for long-term storage of berries. This allowed reducing the weight loss (due to internal shrinkage) and obtaining a stable amount of juice and press residues during the whole storage period. Since the chemical composition of juices has now been studied quite well, it was interesting to examine the nutritional value of secondary raw materials - berry press residues. This was also useful as we proposed to use berry residues as a biologically active additive in the production of food products for diets of people living in environmentally fragile and hazardous areas.

The research involved studying the moisture content and content of vitamin C, P-active substances in press residues during storage at a temperature of -18 ° C and relative air humidity of 95% for 6 months (September, 1 – March, 1). The data have allowed us to reveal that P-active compounds are exposed to intensive destruction during the first two months of storage, and then accumulation period is observed, and vitamin C is destroyed during the whole storage period. During storage, the moisture content of press residues decreased by 10% on average (figures 2, 3, 4, 5).

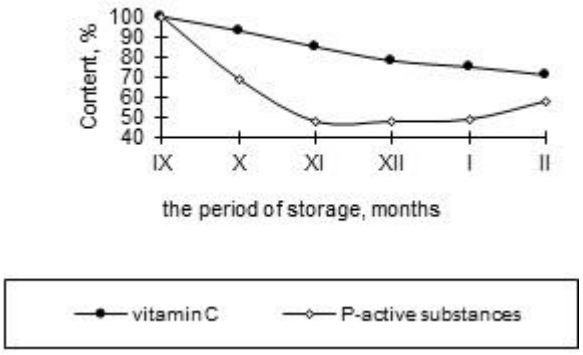

Figure 2. Changes in content of vitamin C and P-active substances in cranberry residues during storage at T = -18 ° C, W = 95%.

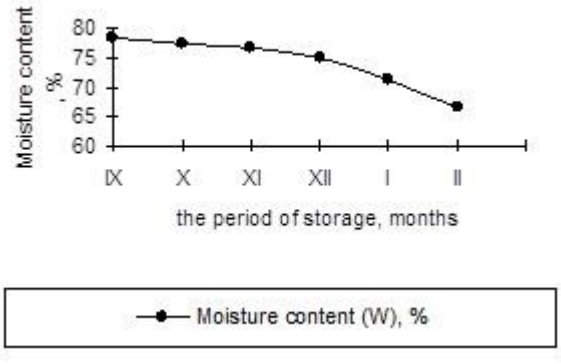

Figure 3. Changes in content of vitamin C and P-active substances in cranberry residues during storage at T = -18 ° C, W = 95%.

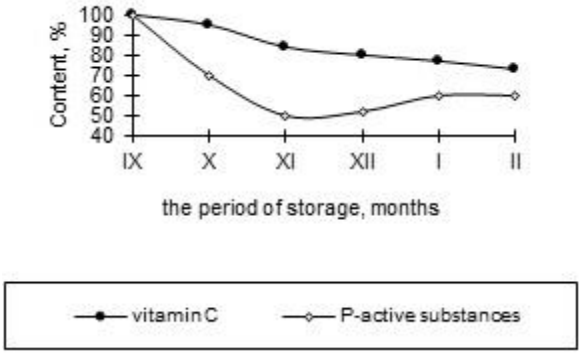

Figure 4. Changes in content of vitamin C and P-active substances in lingonberry residues during storage at T = -18 ° C, W = 95%.

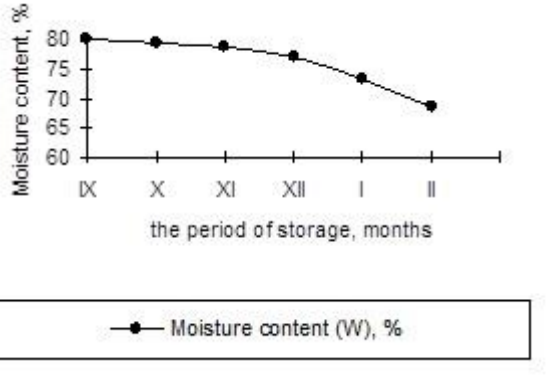

Figure 5. Changes in moisture content in lingonberry residues during storage at T = - 18 ° C, W = 95%.

4. Discussion

The results thus obtained allow us to conclude that it is possible to increase the economic efficiency of the agro-processing companies due to the complex use of berry raw materials. These technological solutions increase the amount of juice extracted and solve the problem of utilizing secondary raw materials. It is proposed to use lingonberry and cranberry press residues as a biologically active additive in the production of food products for diets of people living in environmentally fragile and hazardous areas. A number of authors note high nutrition value of berry raw materials: Prakhina E.I. [1], Flaumenbaum B.L. [2], Hokkanen, J., Mattila, S., Jaakola, L., Pirttila, A.M., Tolonen, A. [3], Meng, F.L., Su, X.T., Li, Y.D. [4], Kartimo, H., Mattila, S., Tolonen, A. [5]. There are some papers describing preventative and anticancer properties of lingonberry and cranberry: Yan X., Murphy B.T., Hammond G.B., Vinson, J.A., Neto C.C. [6], Murphy B.T., Mackinnon, S.L., Yan, X., Hammond, G.B., Vaisberg, A.J., Neto, C.C. [7], Katsube N., Iwashita K., Tsushida T., Yamaki K., Kobori M. [8], 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., Reed J.D. [9], Popov S.V., Markov P.A., Nikitina I.R., Petrishev S.,Smirnov, V., Ovodov, Y.S. [10].

Issues related to increasing the amount of juice extracted from fruit and berry raw materials in the production of juices are considered by many researches. Bobinaite R., Pataro G., Lamanauskas N., Šatkauskas S., Viškelis P., Ferrari G. propose to use pulsed electric fields in the production of juices from blueberry fruits in order to increase extraction of biologically active compounds [11]. Downes, J. reviews available methods of pressing, clarification and concentration and the equipment used for efficient extraction and processing of fruit and berry raw materials [12].

Thus, the complex processing of berry raw materials will ensure increasing the economic efficiency of production for agro-processing companies in general.

5. Conclusion

The research revealed that the intensity and direction of mass exchanging process within berry packages depend on storage conditions. Since absolute weight loss of berries during the long-term period of storage is determined by the rate and stability of the temperature. Therefore, the temperature of 18 ± 0.5 ° C was found optimal for long-term storage of berries. This allowed reducing the weight loss (due to internal shrinkage) and obtaining a stable amount of juice and press residues during the whole storage period.

Lingonberry and cranberry press residues have high nutritional value. The research results found out relatively high retention of vitamins and other valuable chemicals in press residues obtained after juice extraction from berries of lingonberry and cranberry berries (figure 2, 4). Thus it is possible to recommend this method of processing wild-growing and cultivated berries. Press residues obtained in

the process of high-quality natural juices extraction from berries of lingonberry and cranberry, can be recommended for diets and used as biologically active additives in the production of multicomponent products of increased nutritional value.

References

[1] Prakhina E I 1992 *Fruits, berries and food plants of Siberia in children*'s *diet* (Novosibirsk: Science. Sib. Delegation) p 77
[2] Flaumenbaum B L 1993 *The technology of canning fruits, vegetables, meat and fish* (Moscow: Kolos) p 320
[3] 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
[4] 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
[5] Kartimo H, Mattila S and Tolonen A 2006 Characterization of phenolic compounds from lingonberry (Vaccinium vitis-idaea*) J. Agric. Food Chem* **54** 9834-42
[6] 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
[7] 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
[8] 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
[9] 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
[10] 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
[11] Bobinaite R, Pataro G, Lamanauskas N, Šatkauskas S, Viškelis P and Ferrari G 2014 Application of pulsed electric field in the production of juice and extraction of bioactive compounds from blueberry fruits and their by-products *Journal of Food Science and Technology* **10** 13197-1668
[12] Downes J 1995 Equipment for extraction and processing of soft and pome fruit juices *Production and Packaging of Non-Carbonated Fruit Juices and Fruit Beverages Springer* pp 197–220
[13] 2003 *GOST 28561-90 Dated. 01.07.1991 Fruit and vegetable products. Methods for determination of total solids or moisture* (Moscow: Standards)
[14] 2003 *GOST 24556-89 Dated 01.01.1990 Products of fruits and vegetables processing. Methods for determination of vitamin C* (Moscow: Publishing house of standards)