The study of indicators on quality of pectins from secondary plant raw materials of Krasnoyarsk region

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Abstract. The work presents the results of the study of organoleptic, physical-chemical safety indicators of pectins obtained from apples pomace, pears, black currants growing in the Krasnoyarsk region and their comparative analysis with the indicators of pectin quality of wood greens of Scots pine. Generally accepted methods of analysis were used for research. It was found that the maximum yield of blackcurrant pomace was 42.6%, and pectin from apples pomace - 8.15% in comparison with other objects of study. Each type of pectin is characterized by individual organoleptic characteristics according to the raw material used. It was found that in all pectin samples, the mass fraction of acetyl groups is from 0.18 to 0.46%, which determines the ability of pectin to exhibit gelling ability. The content of methoxyl groups of pectin from apples pomace, black currants, wood greens was found from 7.42 to 11.24%. The studied pectin samples have an esterification degree of more than 50%. It is determined that pectin of wood green of Scots pine is characterized by the highest value of indicator of complexing ability and number of carboxyl groups, is characterized by low degree of esterification compared to fruit, berry pectins. For pectins from fruits pomace, berries, the indicator of complexing ability varies in the range from 76.42 to 70.9 mg Pb²⁺ / g. The data obtained make it possible to classify pectins according to their technological purpose and use them as gel former - from apples pomace, blackcurrants, pears, and as a functional ingredient - wood greens of Scots pine.

1. Introduction
This study is aimed at solving the problems of improving the efficiency of using secondary raw materials formed during the processing of fruits, berries and the possibility of using domestic pectin for food production. Juices, jams are produced from cultivated fruit and berry raw materials in Krasnoyarsk region. At the same time, local plant resources are not used rationally enough due to the low degree of their processing, today the loss of main and secondary raw materials is from 10 to 45% of the total biomass. This leads to a negative impact on the environment, significant costs of the main production, and the production of a small share of products with high value-added, as confirmed by foreign research in the field of industrial processing of fruit and vegetable raw materials [1]. The main trend in the world practice of processing food raw materials is the use of resource-saving technologies that ensure an
integrated approach, minimal impact on the environment, maximum use of all biomass of plant raw materials and production of products with high value-added.

It is known that in the production of fruit, berry juices, up to 40% of pomace is formed, which may be a source of biologically active substances, dietary fiber, pectin, which contribute to the improvement efficiency of the gastrointestinal tract, cardiovascular disease prevention, weight control, reduction of cholesterol level, glucose in blood, normalize carbohydrate, lipid metabolism, show antioxidant, emulsifying properties and are promising for functional food products [1-9].

Currently, the need of the Russian market for food ingredients, including pectin by 87%, is satisfied by foreign producers. A significant share of 80% of imported pectin from EU countries enters the domestic market, while in recent years there has been a tendency to increase the supply of pectin from China [10].

2. The purpose of the study
The study of organoleptic, physico-chemical indicators, safety indicators of pectins obtained from fruit and berry pomace and establishing the possibility of their use for food production.

Research Objectives: conduct a comparative analysis of the yield, quality and safety indicators of pectin samples obtained from secondary fruit, berry, coniferous raw materials of the Krasnoyarsk region.

3. The object of the study
As objects of research we used: pomace, selected at the industrial production of CJSC "Minusinsk vegetable cannery" from fruits of pears of variety "Veselinka," apples of variety "Minusinskoye krasnoye," berries of blackcurrant of variety "Minusinskaya sladkaya" growing on the territory of the south of Krasnoyarsk region; pectins obtained from pomace of fruit, berry raw materials; pectin of wood greens of Scots pine [11].

4. Materials and methods
During the research, generally accepted analysis methods were used: the quantitative content of pectin in the pomace was determined by the calcium-pectate method.

   Organoleptic, physico-chemical indicators of the obtained types of pectin from fruit pomace and berry raw materials were determined according to GOST 29186-91 "Pectin".

   The content of carboxyl groups, the degree of esterification, and the complex ability of pectin were determined according to the methods [12, 13], the content of the number of acetyl and methoxyl groups [14].

   Microbiological parameters of pectins were determined according to GOST 10444.15, GOST ISO 7218, GOST 31747. Determination of toxic elements: lead - according to GOST 26932, GOST 30178, GOST 30538; arsenic - according to GOST 26930, GOST 30538, GOST 31628; cadmium - according to GOST 26933, GOST 30178, GOST 30538; mercury - according to GOST 26927.

5. Discussion of results
Fruits pomace of pears, apples, currant berries were selected in the production conditions of CJSC «Minusinsky vegetable cannery».

   For research, we selected fruit pomace and berry raw materials, the share of which ranges from 20 to 50% of the total plant biomass, the results are presented in table 1.

   An analysis of the data presented in Table 1 indicates that the processing of blackcurrant varieties "Minusinskaya sladkaya" produces the largest share of pomace from the total biomass of berries. The amount of waste in the processing of apples of the "Minusinskoye krasnoye" variety is 6.2 % less than in the pear fruits "Veselinka". The results obtained confirm the relevance of developing proposals for processing secondary raw materials in order to obtain pectin and study its quality and safety indicators.
Table 1. Quantitative content of pomace in the biomass of fruit and berry raw materials

| Name of fruit -berry raw materials | Quantity content of pomace % |
|-----------------------------------|-----------------------------|
| apples of variety "Minusinskoie krasnoye" | 22.8 |
| pears of variety "Veselinka," | 29.0 |
| blackcurrant of variety "Minusinskaya sladkaya" | 42.6 |

The results of a study of the quantitative content of pectin obtained from secondary fruit, berry, and coniferous raw materials are shown in Figure 1.

Figure 1. Quantitative content of pectin obtained from secondary fruit, berry, and coniferous raw materials, % from absolutely dry mass

In the series of increasing pectin content, all samples are arranged as follows: wood greens of Scots pine < black currant < pears < apples.

It was found that the leader in the ability to accumulate pectin 8.15% is considered pomaceous waste. In the processing pear pomace, pectin is released by 1.71% less than from apple samples. The lowest pectin content of 2.16 % was found in black currant pomace. A comparative analysis of the mass fraction of pectins of secondary plant raw materials showed that its yield from the wood green of Scots pine is twice as large as black currant pomace [11].

The data obtained by us on the content of pectin in apples pomace and wood greens of Scots pine growing on the territory of the Krasnoyarsk region are consistent with the results of research by other authors [15-16].

The pectin content in black currant pomace was 2.16 % from absolutely dry mass. For comparison, the amount of pectin in red currant pomace of the Altai region was 0.5 % [10]. The increased content of pectin in the studied black currant pomace may be due to the specifics of the component composition of this variety and the influence of a regional factor.

The amount of pectin in apple pomace was determined to be 8.15%, which is 2 or more times more than the values presented in the literature [17-18]. According to the results of the authors [17-18], the pectin content in apples is in the range from 1.0 to 4.5 %, the established distinction in data is explained by the influence of climatic factors and the variety of the object of study.

Due to the fact, that the obtained pectins from fruit pomace, berry raw materials and pectin of wood greens of Scots pine are supposed to be used for the production of food products, it is necessary to study the safety indicators, physical - chemical indicators that determine the technological use of pectins (tables 2-4).
Table 2. Organoleptic characteristics of the pectin obtained from secondary plant raw materials

| Name of indicator | Characteristics of pectins by GOST 29186-91 | Pectin of wood greens of Scots pine [11] | Characterization of pectin obtained from pomace apples pears blackcurrant |
|-------------------|---------------------------------------------|------------------------------------------|-----------------------------|
| Exterior appearance | Fine powder without impurities. Fibrous fraction of pectin in the form of flakes are allowed | Fine powder without impurities. Without the fibrous fraction of pectin in the form of small particles. |
| Taste | Slightly acidic | Slightly acidic | Slightly acidic | Slightly acidic | Sweetish |
| Smell | is absent | Faint, typical for apples | Faint, typical for pears | Faint, typical for berries |
| Color | From light grey to cream | Light gray with a cream tint | Light gray with a cream tint | Cream with a brown tint | Dark red |

Analysis of the data in table 2 shows that the results of the evaluation of the organoleptic indicators of the studied pectins from secondary plant raw materials confirm their compliance with the requirements of GOST 29186-91 "Pectin".

It was found that each sample of pectin is characterized by individual organoleptic parameters, in accordance with the raw material used. With an increase in the number of acetyl groups in the pectin molecule, the process of gelling ability deteriorates. The literature indicates that the presence of a large number of acetyl groups reduces the gelling ability of pectin. The permissible limits are set of no more than 1% of the content of acetyl groups for gelatinous pectin.

It is known that the fewer methoxyl groups in the pectin molecule, the weaker its gelling ability. The literature indicates that the normative value for the number of methoxyl groups is not less than 7% for gelatinous pectin. The amount of free carboxyl groups in pectin determines its complexing ability [10] table 3.

Table 3. Physico-chemical indicators of pectin

| Name of indicator | Pectin of wood greens of Scots pine [11] | Experimental samples of pectins, obtained from pomace apples pears blackcurrant |
|-------------------|------------------------------------------|-----------------------------|
| Mass fraction of moisture, % no more | 10.00 | 9.00±0.10 | 9.50±0.04 | 9.08±0.03 |
| Content of pectin in pomace, % from absolutely dry mass | 4.14 | 8.15±0.08 | 6.44±0.07 | 2.16±0.02 |
| Content of carboxyl groups, % | 19.84 | 15.38±0.10 | 16.94±0.12 | 8.94±0.07 |
| Content, % - methoxyl groups | 7.42 | 11.24±0.07 | 5.44±0.05 | 9.50±0.14 |
| -acetyl groups | 0.18 | 0.29±0.01 | 0.35±0.01 | 0.46±0.07 |
The data presented in table 3 indicate the maximum accumulation of acetyl groups by a pectin sample obtained from blackcurrant pomace, which is 0.11% less in the pear object; 0.17% in apple pectin, 0.28% in a sample of green wood compared to blackcurrant pectin. At the same time, it should be noted that all the studied objects can exhibit gelling ability, because they do not exceed the standard value of 1% for the number of acetyl groups.

The number of methoxyl groups of pectin substances in apples pomace, blackcurrant, wood greens was determined, which exceeds the value set for gelatinous pectin by 7%, the largest proportion of methoxyl groups was found in pectin from apples pomace, the smallest value of this indicator was found in the pear pomace sample.

The content of carboxyl groups in pectin characterizes its complexing ability. The number of free carboxyl groups in pectin of Scots pine in the lead, their share more than pectin from the pomace of pear, apple, black currant is 2.9; 4.5; 10.9 %, respectively, which allows us to conclude that its greater complexing ability, significant detoxification properties and application possibilities for the production of functional food products.

A diagram of the dependence degree of esterification and complexing ability on the type of secondary raw materials is presented in Figure 2.

![Diagram](image)

**Figure 2.** Diagram of the dependence degree of esterification, complexing ability of pectins of secondary plant raw materials

It is known from the literature sources that the complexing ability of pectin is inversely proportional to its degree of esterification; the established regularity is confirmed by the results obtained by us.

Analyzing the data presented in Fig. 1, it can be concluded that the pectin of wood greens of Scots pine differs in the highest value of the indicator of complexing ability, and for pectins from fruit pomace, berries, it varies in the range from 76.42 to 70.90 mg Pb²⁺/ g. The high value of the complexing ability of pectin of wood green of the Scots pine causes its use in the production of products of preventive and therapeutic nutrition.

Based on the data obtained, the studied samples of pectin from secondary plant raw materials are arranged in the following order according to the increasing degree of esterification: wood greens of Scots pine < black currant berries < pears < apples. The studied pectins have a degree of esterification of more than 50 %. The listed pectins have the ability to form gels, which allows us to recommend them for use as thickening agent in food technology. A sample of pectin from the wood green of Scots pine has a low degree of esterification, while being a good detoxifier, which indicates that it can be used in the production of functional products. The results of the study of safety indicators are presented in table 4.
### Table 4. Pectin Safety Indicators

| Name of indicator | Requirements of the Technical regulation of the Customs Union 021/2011 | Pectin of wood greens of Scots pine | Apple pectin | Pear pectin | Blackcurrant pectin |
|-------------------|------------------------------------------------------------------------|-----------------------------------|-------------|------------|--------------------|
| Number of mesophilic aerobic and facultative - anaerobic microorganisms, colony forming units/g, no more | 5*10^4 | less 5*10^2 | less 6.2*10^2 | less 8.6*10^2 | less 7.5 *10^2 |
| Yeast, colony forming units/g (KOE/r), no more | 100 | <10 | <20 | <20 | <20 |
| Molds, colony forming units/g, no more | 100 | <10 | <30 | <30 | <40 |
| Bacterium of intestinal bacillus, in 0.1g | are not permitted | is not revealed | is not revealed | is not revealed | is not revealed |
| Pathogenic, including Salmonella in 25 g | are not permitted | is not revealed | is not revealed | is not revealed | is not revealed |
| Arsenic, mg/kg | 3.0 | 0.83 | 0.95 | 0.93 | 0.85 |
| Lead (Pb), mg/kg | 10.0 | 0.2 | 0.5 | 0.4 | 0.5 |
| Mercury(Hg), mg/kg | 1.0 | 0.0022 | 0.001 | 0.003 | 0.002 |
| Cadmium (CD), mg/kg | 1.0 | 0.02 | 0.01 | 0.007 | 0.009 |

Analysis of the obtained data table 4, allows us to conclude that the content of toxic elements, microbiological indicators of the studied objects do not exceed the set normative values of Technical regulation of the Customs Union 021/2011 "About food safety ", that the products of processing secondary plant raw materials are environmentally friendly and can be used in the production of food products.

### 6. Conclusion

The quantitative content of fruits pomace and berry raw materials formed in industrial production conditions was studied. The yield of pectin of the studied objects is identified. It was found that the largest proportion of pectin is contained in apple pomace, the smallest amount is found in black currant berry pomace. Comparative analysis of organoleptic indicators of pectins from secondary fruit, berry and coniferous raw materials has established compliance with the established requirements, while each type has its own distinctive features. The mass fraction of acetyl groups in all objects is approximately the same, but it should be noted that the value of the indicator does not exceed 1 %, as evidenced by the ability of pectins to show gel-forming properties. The content of methoxyl groups in pectin from apple pomace, black currant, and wood greens of Scots pine exceeds the value set for gel-forming pectin by 7 %, in the object from pear pomace this indicator is lower.
The studied samples of pectins from fruit pomace, berries, and wood greens are highly esterified. It was found that the pectin of wood greens of Scots pine accumulates a higher content of carboxyl groups and is the leader in the value of the indicator of complexing ability, has the lowest degree of esterification in comparison with the studied objects.

The obtained data can be used to get a product with a high value-added -pectin in the processing of regional secondary plant raw materials and recommended for the production of food products, taking into account technological features, as a gel former or detoxifier.

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