The quality assessment of raw materials for the production of functional juice drinks

A I Nemchinova, N P Suprun, G S Gusakova and S N Evsta'ev

Irkutsk National Research Technical University, 83, Lermontov St., Irkutsk 664074, Russian Federation
E-mail: gusakova58@mail.ru

Abstract. The present work is aimed at studying the qualitative characteristics of apple fruits growing in the Baikal region and evaluates their technological parameters. The main physicochemical parameters and the total content of phenolic compounds in juice of seven apple breeds are investigated. All fruits were small, their weight varied from 20 g (Pepinchik Krasnoyarskiy) to 80 g (Svetloe), the average weight was 40 g (Krasnaya Grozd). The highest juice yield was shown by the variety with the average size (Krasnoyarsk's Snegirek – 71.8 %), the remaining varieties showed about 60 %. The sugar content of fruits varied from 5 to 12.3 g / 100 cm$^3$ in varieties, and the amount of titrated acid (in terms of malic acid) from 4.8 to 10.8 g / dm$^3$. For the fruits of seven varieties the content of macro- and microelements (Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn, Br, Rh, Sr, Zr, Pb and Ba) was analysed by X-ray fluorescence spectrometry. Total phenolic compounds content as well as content of anthocyanins and leucoanthocyanin were identified in juice. The content of phenolic substances in juice varied (g / dm$^3$) from 3.6 (Krasnaya Grozd) to 0.3 (Krasnoyarskiy Pepinchik). Qualitative and quantitative composition of the main components of the studied juice shows the feasibility of using the fruits of local apple breeds for the production of functional juice-containing drinks.

1. Introduction
A juice is a popular drink in almost all countries of the world. Fruit, berry and vegetable juice are in special demand. Today juice consumption in Russia is about 20 liters per person, which is significantly lower than the norms prevailing those in European countries. It should be noted that the modern juice industry uses up to 80 % of imported raw materials and prepares juice using reconstituted concentrates. It should be noted that the modern juice industry uses up to 80 % of imported raw materials and prepares juice from reconstituted concentrates, the using of which reduces the physiological value of products [1, 2]. In addition, statistics shows that Russian processing enterprises are not located evenly and they are concentrated in the Central and Southern regions. However, the studies of recent years [3-6] show that fruits and berries which grow in the Southern regions of our country are larger and tastier, but they inferior to Siberian products in the content of physiologically active components. Plants growing in this region accumulate significantly more vitamins, antioxidants, mineral and other useful substances during the process of adaptation to harsh climatic conditions. Accordingly, they are more suitable for industrial processing and the creation of new recipes considering the local traditions and nutritional characteristics. Despite the fact that the modern juice market is very diverse and it is crowded in different price segments, in our opinion, it has significant potential for developing, because it does not reach the level of consumption of European countries. The regional manufacturers who use local resources retain the
food traditions and ensure the quality of products using the latest achievements of science and technology deserve special attention. Today the processing of wild plants in Irkutsk region is carried out by such companies as "Travi Baikala" LLC, "Dikaya Sibir" LLC, agro-industrial company "Baikal" LLC, a private entrepreneur "Zolotaya Meditsa" and many others.

The analysis of recent literature data confirms that the market is occupied by large monopolists, and new companies’ entrance to the market is a difficult task. However, import embargo of Australia, Ukraine, the USA, Canada, Norway and the EU [15], which was adopted by the Government of the Russian Federation, can help to realize the Import Substitution Program. In such a situation, large juice producing companies will be interested in establishing relations with local procurement and farming businesses which cultivate, store and process fruits and vegetables. The current situation and population’s orientation toward the consumption of functional products creates great prospects for small enterprises that are ready to produce innovative products. Juice based on local raw materials, enriched with pectin, will be positioned as products for therapeutic purposes and eating.

2. The purpose of the study
The important problem is to obtain reliable information about the possibility of using local apple breeds for the production of functional juice-containing drinks. The aim of the study was to study technological and physico-chemical parameters of apples cultivated in the Baikal region, including a study to assess the organoleptic characteristics of raw materials and a determination of the mineral composition.

3. The object of the study
The objects of the study were fruits of seven varieties of high-yielding and winter-hardy apple trees. There were Krasnoyarskiy seyanets, Krasnaya grozd, Uralskoye nalivnoe, Svetloye, Pepinchik Krasnoyarskiy, Krasnoyarskiy snegirek and Lada. The harvest of 2018 were selected on the Siberian Institute of Plant Physiology and Biochemistry SB RAS collection site.

4. Materials and methods
The soluble solids content was determined by the refractometric method according to GOST R 51433; mass concentration of titratable acids in terms of malic acid (g / dm³) - by potentiometric titration according to GOST R 51434; weight percent of reducing sugars in juice (wt%) – by the the photocolorimetric method according to GOST 8756.13–87; the content of ascorbic acid (wt%) – by visual titration method according to GOST 24556-89; mass concentration of volatile acids (g / dm³) – according to GOST 32001.

The content of chemical elements in apples was determined by X-ray fluorescence spectrometry (XRD). The method is based on the dependence of the intensity of the characteristic fluorescence of an element on its mass fraction in the analyzed sample. The X-ray fluorescence intensity of the determined elements is converted to concentration units according to mathematical models obtained as a result of spectrometer calibration [GOST 33850-2016].

For determination of macro- and microelements (Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn, Br, Rh, Sr, Zr, Pb and Ba ) the analyzed sample was prepared in the tablet's form. For this purpose, the dried plant material was crushed in an agate mortar to a powder of less than 100 μm, then 0.5 g sample was taken, which was then pressed in the form of a radiating tablet on a boric acid substrate. The intensity of the analytical lines was measured on a wave dispersive X-ray spectrometer S4 Pioneer, Bruker (Germany). For calculating the concentrations of macro- and microelements we built linear calibration dependences using the SpectraPlus spectrometer software and standard samples of the composition: potato tubers SBMK-02, wheat grains SBMP-02 [16], birch leaf LB-1 (GSO 8923-2007), meadow grass mixtures Tr-1 (GSO 8922-2007), Chinese tea leaf sample (GBW 07605) [17] and Polish standard samples of soybeans INCT-SBF-4 and cornmeal INCT-CF-3. The validity of the XRD was assessed by comparing the results of determining the elements composition in the Polish standard sample of the grass mixture INCT-MPH-2 with certified values. The comparison of the data showed that the results of the XRD are in good agreement with the certified values.
The determination of the mass concentration of phenolic substances in juice was carried out by the permanganometric method. The method is based on the oxidation of phenolic substances with a standard solution of KMnO4. It is calibrated by gallic acid.

5. Discussion of the results
The fruits of seven high-yielding and winter-hardy apple varieties for the experiment were selected at the stage of harvest maturity, without pests and diseases damages. We received the following results of organoleptic analysis.

The fruits of the apple "Krasnaya Grozd" are small, their average weight varied from 20 g to maximum 38 g, the form are flattened-rounded. The surface is smooth. The skin is yellow color, with dark red stripes that occupy more than half of the surface of the fetus. The pulp is creamy color, sour-sweet and juicy.

The fruits of "Uralskoye nalivnoe" variety are small, rounded in shape. The skin is smooth, shiny, greenish yellow color. The peduncle is long. The fruit pulp is white, tender, juicy, sweet and sour, very pleasant.

"Krasnoyarskiy snegirek" fruits are small, weighing 25.0–35.0 g, rounded, with a closed, small cup. The skin is smooth, oily, with a touch. The skin color is green, with red stripes throughout the fruit. The pulp is unpigmented, juicy. The fruits have a firm flesh and fine-grained texture. It tastes sour-sweet, with a fruity aroma of medium intensity.

The fruits of "Krasnoyarskiy seyanets" are small weighing 20.0-30.0 g, flattened-rounded in shape. The main color is yellow-green, with a faint blush. The pulp is creamy, sweet and sour, with a slight astringency.

"Lada" variety fruits are small and flat-rounded in shape. The color is whitish, along the entire surface of the fruit is a blurry-striped raspberry blush. The skin is smooth. The fruits have a firm flesh. The pulp is white and juicy. The taste is sweet and sour, with an average aroma.

The fruits of Pepinchik Krasnoyarskiy have round-conical form. Their weight is 25–55 g. The main color is yellow, the surface is dark red. The flesh is crispy, very juicy, the taste is pleasant sweet and sour.

The weight of apples "Svetloe" varies from 80 to 90 g. The color is yellow with a greenish tint. The pulp is not pigmented, loose, very juicy. The fruits have sweet and sour taste with a strong, developed aroma [12].

Thus, it is clear that all varieties have astringent, sweet and sour taste with a slight bitterness. The differences are made up of the acid-sugar ratio, which have the greatest importance on the organoleptic evaluation, as well as the presence of an astringent component in the taste, spice and strength of the aroma [7-9].

The organoleptic evaluation was carried out on a 10-point scale in compliance with the principles of tasting. All samples were encoded. As result, the highest tasting score was obtained by Lada and Krasnaya grozd varieties (9.5 point) with sugar-acid indexes of juice of 15.6 and 17.4 and the lowest for Krasnoyarskiy snegirek and Pepinchik Krasnoyarskiy varieties (8.3 point and 7.5 point, respectively) with sugar-acid indexes of 11.0 and 8.8 (see table 1).

It has been known that the environmental conditions of the region and agricultural technology have a great influence the content of minerals. According to the XRD data, in the air-dried apple samples of Krasnoyarskiy Snegirek breed, the following macronutrients were found %: K – 0.762; P – 0.141; Ca – 0.099; Mg – 0.056; Si – 0.012; Mn – 0.01; Na – 0.008 Fe – 0.006; Al – 0.002; S – 0.05. Among the micronutrients is presented in fruits, in ppm: Ti – less than 4; Cr – 7; Ni – 2, Cu – less than 8; Zn – 15, Rb – 8; Sr – 9, Ba – 16 and Pb – less than 3.

As can be seen, among the macronutrients wt%, K (0.762), P (0.141), Ca (0.099) and Mg (0.056) were identified in the largest quantities. It is common knowledge that the potassium favorably affects the human cardiovascular system. According to the literature [19], the daily need for potassium for a child is 16–30 mg per 1 kg of body weight. For an adult, 1.5–2.5 g per 1 kg of body weight, while the required minimum is 1 g per 1 kg of body weight. During exercise and pregnancy, the need for it can
increase to 3.5 g per day. The potassium content in the body of a person is affected by seasonal changes. For example, there is especially little potassium in the spring, and in autumn its amount doubles. The toxic dose (TD) for humans is 6 g, and the lethal dose (LD) is 14 g. Calcium, phosphorus, and magnesium are necessary for the normal functioning of the immune system, muscle contraction, and the construction of human bone tissue. The remaining components are found in smaller quantities, but their importance for the body is no less important. The sodium ions significantly affect the conduction of impulses in the nervous system. The main biological function of manganese and iron is to participate in tissue respiration and blood formation. The silicon - strengthens blood vessels, joints and it is necessary for the absorption of calcium [10-12].

The copper, zinc, lead, at high level are toxic elements. The reason of high level of that elements may be the environment. Therefore it is very important that the environmentally friendly raw materials should be used to produce functional products. From the obtained data it is followed that the content of heavy metals in the fruit does not exceed the maximum permissible concentrations regulated by Sanitary Rules and Regulations (SanPiN 2.3.2.560-96).

To extract the juice, the fruits were crushed (size grinding 2–4 mm), the juice was tap using a hydraulic press. The juice quality recovered from apples largely depends on the biochemical composition and percentage of components. The technological and physico-chemical parameters of juice are shown in table 1.

**Table 1. The technological and physico-chemical parameters of the apple juice**

| The studied varieties of apples | Krasnoyarskiy Seyanets | Krasnaya Grozd | Uralskoe Mal'tvnoe | Svetloe | Pepinchik Krasnoyarskiy | Krasnoyarskiy Snegirek | Lada |
|--------------------------------|------------------------|----------------|--------------------|--------|-----------------------|------------------------|------|
| The soluble solids, %          | 13.6                   | 13.8           | 10.8               | 11.5   | 9.6                   | 12.9                   | 12.0 |
| The sugar content, wt%         | 12.3                   | 12.5           | 7.0                | 6.0    | 5.0                   | 11.7                   | 10.7 |
| The titrated acid (in terms of malic acid) mg / dm³ | 10.8                   | 7.2            | 4.9                | 4.8    | 5.7                   | 10.6                   | 10.8 |
| The sugar-acid index           | 11.4                   | 17.4           | 14.3               | 12.4   | 8.8                   | 11.0                   | 15.6 |
| The content of phenolic substances mg / dm³ | 2.700                  | 3.618          | 1.026              | 2.214  | 0.324                 | 0.810                  | 0.729 |
| The content of ascorbic acid, mg / dm³ | 10.4                   | 13.5           | 10.5               | 12.5   | 9.5                   | 9.7                   | 11.5 |
| Juice yield, %                 | 57.0                   | 59.2           | 58.0               | 56.8   | 60.2                  | 71.8                   | 61.0 |

It is seen from Table 1 that the highest yield of juice is in "Krasnoyarskiy snegirek" variety (71.8 %), and the lowest in "Svetloye" variety (56.8 %). It was established that there is no direct relationship between the size of fruits and the yield of juice, and it agrees well with published data [12].

The solids content of the fruit is largely dependent on the variety. The highest solids content is in "Krasnaya grozd" variety (13.8 %), the lowest – in "Pepinchik Krasnoyarskiy" variety (9.6 %).

It is a matter of general experience that the apple fruits from sugars contain: glucose, sucrose and fructose, which give a sweet taste. In the studied varieties, the amount of sugar varies from 5.0 to 12.5 g / 100 cm³. The highest content is in "Krasnaya grozd" variety (12.5 %) and the lowest – in "Pepinchik Krasnoyarskiy" (5.0 %).

In addition to sugars, the acid content has a great influence on the taste. The titrated acidity varied from 4.8 to 10.8 g / dm³. This indicates that the studied varieties are highly acidic. "Krasnoyarskiy seyanets" varietie is distinguished by the highest content (10.8 g / dm³), "Krasnaya grozd" by the medium
content (7.2 g / dm$^3$) and "Uralskoe nalivnoe" by the lowest (4.9 g / dm$^3$). The high acid content and the average value of the sugar content of the fruit partly reduce the organoleptic characteristics.

The content of phenolic substances in juice ranged from (g / dm$^3$) 3.618 (Krasnaya grozd) to 0.729 (Lada). According to literature data, these compounds are actively involved in redox processes at various stages of technological operations, cause the oxidation of juice and the appearance of brown tones in color. Interacting with proteins, they form sparingly soluble compounds that precipitate.

The highest content of ascorbic acid (vitamin C) was observed in "Krasnaya grozd" variety (13.5 mg / dm$^3$), and the lowest in "Pepinchik Krasnoyarskiy" (9.5 mg / dm$^3$).

The anthocyanins content, the amount of which does not exceed 10.57 mg / l, was determined in colored juice from the varieties Krasnoyarskiy seyanets and Krasnoyarskiy snegirek. They are presented mainly in the skin, and the pulp does not have a pink color. The anthocyanins have a P-vitamin activity, increase the dietary value of products. They are able to form complexes with metals.

In the juice from apples of the "Uralskoye" variety, the content of leucoanthocyanins was amounted to 540 mg / l. These substances belong to the group of phenolic compound C6 – C3 – C6, are easily oxidized, and are responsible for the astringent taste. They are actively involved in redox processes. Their high content can change the colour of juice into brown.

6. Conclusion

As is shown by studies of seven varieties of apples selected in the Baikal region (Krasnoyarskiy seyanets, Krasnaya grozd, Uralskoye nalivnoe, Svetloye, Pepinchik Krasnoyarskiy, Krasnoyarskiy snegirek, Lada), the organoleptic differences mainly consist of the ratio of sugar and acids, depend on the presented astringent component in the taste and aroma's strength of fruits. The highest tasting score was received by the varieties Lada and Krasnaya grozd (9.5).

The study of the mineral composition showed physiologically important macro-, micro elements. Among the macronutrients, wt%, K (0.762), P (0.141), Ca (0.099) and Mg (0.056) were identified in the largest quantities.

The comparative assessment of the technological and physico-chemical parameters of the juice was represented. As result, the highest juice yield was noted for the “Krasnoyarskiy Snegirek” variety (71.8%).

The high content of physiologically active components was confirmed for all apple breeds. The concentration of phenolic substances in juice varied (g / dm$^3$) from 3.618 (Krasnaya grozd) to 0.729 (Lada), and the content of L-ascorbic acid (mg / dm$^3$) from 13.5 (Krasnaya grozd) to 9.5 (Pepinchik Krasnoyarskiy).

In this manner, the obtained results allow us to conclude that the local varieties of the South Baikal region are perspective raw materials for industrial processing and the creation of products with increased physiological value.

Acknowledgments

The authors are grateful to E V Chuparina, Cand. Sci. (Chemistry), Senior Researcher of Vinogradov Institute of Geochemistry SB RAS, for the help in analyzing the content of macro- and microelements by X-ray fluorescence spectrometry.

References

[1] Rachenko M A, Gusakova G S, Nemchinova A I, Rachenko A M and Khudonogova E G 2019 The fruit of Siberian apple varieties as raw material for juice IOP Conf. Ser.: Earth Environ. Sci. 421 032022

[2] Gusakova G S, Suprun N P, Rachenko M A, Chesnokova A N, Chuparina E V, Nemchinova A I, Makarov S S. 2019 Study of the biochemical composition of fruits of the Southern Baikal apple tree and its wine products fermented on wood chips. Izvestiya Vuzov. Prikladnaya Khimiya i Biotehnologiya 9 (4) 722–736
[3] Tipsina N N 2009 Place of pectin in functional nutrition Bulletin of KrasGAU 3 (30) 213–216
[4] Tipsina N N, Prisukhina NV and Kokh D A 2012 Powder from small-fruited apples in the confectionery industry Bulletin of KrasGAU 6 (69) 209–213
[5] Tipsina N N and Prisukhina N V 2009 Dietary fiber in the confectionery industry Bulletin of KrasGAU 9 (36) 166–171
[6] Tipsina N N, Tsuglyonok N V. 2009 Small-fruited apples of Siberia in functional nutrition Bulletin of KrasGAU 1 (28) 152–155
[7] Zacharof M-P 2017 Science and Technology of Fruit Wine Production 599–615
[8] Resurreccion A V A 1998 Consumer sensory testing for product development The University of Georgia – An Aspen Publication. 456–386
[9] Zavrokhina N V and Chugunova O V 2014 Potential of the descriptor-profile method of tasting analysis Vestnik SUSU 2 (8) 58–63
[10] Helgesdotter Rognså G, Rathe M, Agerlin Petersen M, Misje Knut-Espen and Risbo J 2017 International Journal of Gastronomy and Food Science 9 62–74
[11] Zhu Y and Pan Z 2009 Journal of Food Engineering 90 441–452
[12] Yermolina G, Yermolin D, Zavaliy A, Lago L and Raykhman D 2018 Izvestiya sel’skokhozyaystvennoy nauki Tavridy 14 112–118