Functional beverages containing pectin from different raw material

N Limareva¹, L Donchenko², V Malaknov¹, E Semenova¹
¹North-Caucasus Federal University 355009, Stavropol, Russia
²Kuban State Agrarian University, 350044, Krasnodar, Russia

* Corresponding author: nlimareva@pfncfu.ru

Abstract. The article presents the results of experimental studies on the development of new types of pectin-containing beverages. Vegetable and berry juice, liquid pectin and natural flavor are selected as a recipe basis of drink. The results of study of chemical composition of the developed beverages showed that the recipe ratio of the selected raw materials provides an optimal ratio of physiologically active components, giving them functional properties. Such data provides a basis for their inclusion in the human diet to reduce the number of alimentary diseases.

1. Introduction
During almost the entire period of human civilization, food was mainly considered as a means of satisfying hunger, appetite and taste needs. However, in recent decades, it has been established that unbalanced nutrition is the cause of the increase in the number of chronic diseases. Thus, the incidence of cardiovascular disease has increased 8–12 times, endocrine disorders 5 times. Diabetes mellitus ranks third in the world among all diseases [1].

According to domestic and foreign studies of scientists and specialists of the world health organization (WHO), the health of the population is more than 50% dependent on the way and conditions of life; in 10 – 20% it is due to the influence of heredity (genetic factors); approximately the same effect is exerted by the external, human environment, and only about 8 – 10% is accounted for the work of practical health care[2].

In view of the above, the organization of rational nutrition is relevant in modern society. It is possible on the basis of expansion of the range and increase in volumes of production of functional food.

The concept of functional nutrition as an independent scientific and applied direction in the field of healthy nutrition in modern terminology was developed in the early 90s. From the modern point of view, the term "functional food products" means such food products that are intended for systematic use in the composition of food rations by all age groups of the healthy population in order to reduce the risk of diseases associated with nutrition, preserve and improve health through the presence in their composition of physiologically functional food ingredients [3].

No less important in modern environmental conditions is the presence of components with detoxification properties in food. According to the Corte-Dubinin scale to assess the toxicity of pollutants recommended by the world health organization (WHO), toxic metals are ranked first in terms of the degree of negative impact on human health (135 points) [4].

Such natural polysaccharides as pectin substances have the highest detoxification properties in relation to toxic metals [5]. In addition, pectin is a physiological component. Thus, in accordance with...
EU432/2012, pectins are recommended for lowering cholesterol and glucose levels in the blood by 6 and 10 g/day respectively [6].

The most physiologically effective food is a drink. It should be noted that the market of soft drinks is one of the most dynamically developing amid other food products. Manufacturers do not get tired to offer new drinks, preparing new items for the beginning of the summer season.

According to various sources, the world market of non-carbonated beverages amounted to about 80 million liters in 2018. This segment has been developing steadily over the past 4 years, showing an average global growth of 4.7% per year. At the end of 2018, taking into account the planned growth of the category of 5.4%, the world market of non-carbonated beverages should exceed 85 million liters. Analysts agree that the growth rate of the global market of non-carbonated beverages will not only continue over the next few years, but even slightly accelerate to 5.7% by 2019-2020.

One of the main trends in the European beverage market is health care. Consumers are beginning to pay more attention to certain useful properties of certain drinks. At the same time, manufacturers, respectively, by all means and possible methods try to emphasize the usefulness of the product for health. No less popular trend is the functionality. Consumers want to have the magic drink. Categories of functional drinks, sports drinks, brain improvement and other activities continue their world ascent to Olympus.

With this in mind, the aim of our study was to develop recipes of juice-based drinks with the addition of pectin substances as prolongators of biologically active compounds, as well as detoxicants of toxic metals.

To achieve this goal, the following research objectives are set:

- to study the chemical composition of the main industrial raw materials to determine their physiologically active ingredients;
- perform simulations of beverages recipes with balanced composition based on their functional orientation;
- experimentally confirm the recipes of new types of functional drinks.

2. Theoretical and experimental research methods

As an experimental site we have chosen 2 regions in the South of Russia, in particular Krasnodar and Stavropol territories.

Krasnodar region is located in the South of Russia, in the South-Western part of the North Caucasus. The region takes the 3rd place among regions of the Russian Federation, in number of inhabitants — after Moscow and the Moscow region.

Stavropol region is located in the Central part of Ciscaucasia and on the Northern slope of the greater Caucasus. The area of the region is larger than, for example, the Netherlands. In the West and South-West of the Stavropol territory is bordered by Krasnodar territory.

This geographical location determines the features in the chemical composition of plant materials. In addition, the agro-industrial sector and the resort and sanatorium complex are traditionally developed in these regions. This, in turn, leads to the development of the beverage market, both for indigenous people and vacationers.

Varieties of pumpkins cultivated on an industrial scale, pumpkin juice and puree, pectin concentrated extracts of apple, grape pomace, forage watermelon and beet pulp, juice of BlackBerry fruits, rose hips were selected as the objects of our research.

Pumpkin varieties. There are three types of pumpkin:

- Large-fruited pumpkin (Cucurbita maxima),
- Butternut Pumpkin (Cucurbita moschata),
- Hard or ordinary Pumpkin (Cucurbita pepo), and its varieties are zucchini and Patisson.

We have selected the following varieties of pumpkin for the study:

Volga grey 92. Middle-maturing type, resistant to disease, belongs to large-fruited pumpkin. Powerful plant forms rounded-flat large (weighing 10-12 kg) fruit of greenish-gray color. Rind is hard and thin. The flesh is dense, bright orange, taste is very good.
Mozoleevskaya 47 belongs to a hard-core or ordinary pumpkin. Middle-maturing type. The elongated fruits with striped rind. Flesh is dense, orange. Fruit weight up to 5 kg. Long shelf life.

Marble. It belongs to the Muscat varieties of pumpkin. The variety is late-maturing (about 135 days); fruits are average, weighing 5-6 kg, flattened, the surface is wrinkled-segmented, lumpy, gray and dark gray bark, with specks of marble type. The flesh is intense orange, thick, firm, crispy, very sweet and tasty. Shelf life of 8-9 months.

Ker-2. New product of Kuban breeders. The fruit is orange in color, weight of of 1.17 to 2.45 kg. Rind of Mature fruit is a thin (1 mm), plastic. The subcortical layer 1.5-2.0 mm is light orange with yellow tint. Ripe pumpkins have a dense sweet flesh with no grassy taste and look attractive.

The chemical composition of pumpkin fruits and juices used to improve organoleptic characteristics and increase nutritional value was determined by methods generally accepted in the biochemistry of plant products: soluble dry substances – by refractometric method; fractional composition of sugars and acids, mineral content – by capillary electrophoresis; vitamin content – by HPLC and fluorometry.

The method of quantitative determination of pectin substances in plant raw materials is based on the extraction of pectin from plant raw materials and its transfer to the dissolved state [3]. The basis of the study of the extracts of hydropectin and protopectin is the calcium-pectat method and precipitation with ethanol. In addition, the content of free and esterified carboxyl groups in pectin preparations and the degree of esterification by conductometric method were studied. Complexing ability was determined by trilonometric titration according to the degree of binding of lead ions.

For the correct assessment of the chemical composition of the studied varieties of pumpkin fruit were selected in harvest maturity.

3. Results and discussion
Pumpkin, like other vegetables, consists of water, insoluble and soluble substances. Pumpkin fruit contain about 70-90% water, 1.3-3.3% insoluble substances (cellulose, lignin, kutin, protopectin, insoluble proteins, etc.), 7.5 – 23% and higher soluble substances (sugars, organic acids, nitrogenous soluble substances, hydratopectin, water-soluble vitamins, coloring, vitamins, minerals, etc.).

In our objects of research humidity ranged from 81.3±0.5% (grade Ker-2) to 84.9±1.2% (grade Marble).

The most important part of pumpkin fruit are sugars and organic acids.

The results showed that the total amount of sugar in the varieties of pumpkins ranged from 5.7 (sort Mozoleevskaya) to 8.1% (Marble).

Pumpkin fruit contained three types of sugar: fructose, glucose and sucrose. At the same time, sucrose prevailed in all varieties. The glucose content is 8.6 times less in the Marble variety (0.12%) than in the Ker – 2 variety (1.03%). At the same time, the content of fructose in the Marble variety is 31.5% less than in the Volga gray variety 92.

According to the content of organic acids, the studied samples do not differ significantly (figure 1.)
However, by fractional composition in the type of the Volga gray 92 there is 2.5 – 3 times more tartaric acid. It is known that natural tartaric acid has antioxidant properties and has a beneficial effect on metabolic and digestive processes in the body. Citric acid and lactic acid in the studied varieties are absent, and by the content of malic acid, they do not differ (0.01%) and its content is very low.

Relatively high content of succinic acid was found in all varieties (0.26 – 0.28%). The results of previous studies have shown that succinic acid is an adaptogen (increases the body's resistance to adverse environmental factors), which is a positive factor in the development of functional products.

Vitamins play an important role in the prevention of various diseases. It is known that pumpkin fruits are rich, first of all, in carotene. Therefore, we have evaluated the pumpkin fruit according to the content of this vitamin. It was found that the studied samples are indeed characterized by a high content of carotene. Its contents amounted to 440 mg/100 g in sample of the pumpkin varieties of the Volga grey 92, and 390 mg/100g – of Marble. In other varieties the content of carotene was in the range of 370 mg/100 g (cultivar Mozoleevskaya 47) and 300 mg/100 g (in the type of Ker-2). The mass fraction of water-soluble vitamins-C and Niacin – is relatively high and practically does not differ among varieties, and is 14 and 0.1 mg/100 g of fruit pulp, respectively. Vitamin B6 content-low (0.02 mg / 100 g of fruit pulp). There are no significant differences between the varieties.

It should be noted that the daily requirement of the human body in vitamin C is 50 mg with this in mind, it is clear that the fruit of pumpkin can be reasonably considered as a functional source of this vitamin to meet the physiological needs (the degree of providing daily needs is 28%).

Taking into account the recommended norms of consumption of the considered vitamins, the degree of safety in the consumption of 100 g of pumpkin fruit will be: in niacin – 50%, in vitamin B6– 1.0%.

Thus, pumpkin fruit in accordance with the requirements for food products are a functional source of vitamin C, niacin and carotene.

The nutritional value of food is determined by the mineral composition. Minerals are essential components of food.

In this regard, we have analyzed the studied pumpkin fruit for the content of such basic macronutrients as potassium, calcium, magnesium, sodium, phosphorus and trace elements as iron, zinc, copper.

Data on the mineral composition of the studied varieties of pumpkin fruit is presented in table 1.
Table 1. The content of minerals in the studied samples of pumpkin fruit

| Substance | Volga grey 9292 | Mozoleevskaya 47 | Marble | Ker-2 |
|-----------|-----------------|------------------|--------|-------|
| K         | 84,1            | 90,0             | 80,4   | 89,1  |
| Ca        | 26,5            | 25,0             | 27,2   | 24,0  |
| Mg        | 10,0            | 12,0             | 14,0   | 13,5  |
| Na        | 3,5             | 4,0              | 4,1    | 3,9   |
| P         | 14,7            | 15,0             | 15,5   | 16,0  |
| Microelement, mg /100 g | | | | |
| Fe        | 0,40            | 0,40             | 0,5    | 3,7   |
| Zn        | 0,20            | 0,24             | 0,24   | 0,23  |
| Cu        | 0,20            | 0,18             | 0,19   | 0,18  |

From the tabular data it follows that by the degree of daily provision of macronutrients calcium is higher. Safety range is 3,3-4,7%. The degree of daily provision of the human body with potassium while eating pumpkin fruit is insignificant-about 2%. A low degree of daily provision is observed in phosphorus-only 1.2%.

The degree of daily supply of iron, copper and zinc is low in the range of 4.5 – 12%.

Taking into account the requirements for functional food test samples can not be considered as a source of minerals.

A very important component of pumpkin fruit are pectin substances.

The results of the study of the total content and fractional composition of pectin substances of the selected objects are shown in figure 2.

Figure 2. Fractional composition and total content of pectin in the selected objects of research, % to absolutely dry substance

From the presented data it can be seen that by the total content of pectin substances Muscat Marble variety (21.8%) is higher.
In all studied samples fractional composition of pectin substances is represented by protopectin and soluble pectin (hydropectin). In this case, the content of protopectin prevails over the soluble fraction, which is natural for vegetable raw materials.

The results of studies of the analytical characteristics of the pectin taken from the studied pumpkin fruit showed that the content of free carboxyl groups of pectin samples is practically the same. At the same time, the lowest degree of esterification was observed in pectin of the pumpkin of the Volga gray variety 92 (37.94%), the largest – in pectin of the pumpkin of the marble variety (43.27%).

Thus, the taken pectins should be attributed to low esterified.

It is known that the complexing properties of pectin substances depend on the content of free carboxyl groups, i.e. the degree of etherification of carboxyl groups with methanol. The degree of esterification determines the linear charge density of the macromolecule, and, consequently, the strength and method of communication of cations.

With a decrease in the degree of esterification, that is, with an increase in the charge of the macromolecule, the connection of pectin substances with cations increases. Therefore, we can predict a greater complexing ability of the variety Volga grey 92.

Thus, the results of the study give grounds for the conclusion that the fruit of pumpkin should be considered a recipe component as a source of low-esterified pectins and carotene. This is consistent with the results of our earlier study [8]. This is preferable when processing large-fruited pumpkin with extracting juice from it, in particular variety of the Volga grey 92.

We further consider BlackBerry juice and rosehip fruit as possible recipe components in order to expand the functional orientation. This choice is due to their unique chemical composition and availability.

Thus, to improve the organoleptic properties and enrichment of functional drinks by P-active substances, vitamins and organic acids BlackBerry juice is of greatest interest as a recipe component.

It was found that the juice of BlackBerry berries contains glucose (2.8-3.6%), fructose (3.1-3.2%), sucrose (0.35-0.58%), organic acids (up to 2.2%), in particular malic and citric acid.

BlackBerry is also rich in P-active substances-up to 1500 mg %. It should be noted that the study of substances with p-vitamin activity has recently become increasingly important. Substances of vegetable origin, often with different chemical properties, but with commonality of biological action contain vitamin P.

The main representatives of P-active substances are flavonoids (catechins, leucoanthocyanins, flavonols, anthocyanins and copolymerized forms of these compounds). The BlackBerry juice from the above group mainly contains leucoanthocyanins, flavonols, and anthocyanins, which have not only capillary-strengthening action, but also antitoxic. The latter property is manifested in the binding by complexation of heavy metal ions, which is relevant in modern conditions. To prevent diseases and maintain physical and mental activity R-active connections required for 100 – 200 mg per day, to provide therapeutic action daily intake increases by 5 – 10 times, i.e. up to 1 – 2 g.

In the study of BlackBerry juice from different manufacturers, the amount of P-active substances amounted to 598 and 708 mg/100g. The content of flavonols was in the range of 111.6 – 129,1; anthocyanins – 309,6 – 465,0; leucoanthocyanins – 116,0 – to 105.3 mg/100 g.

Thus, judging by the experimental data, BlackBerry juice can be reasonably considered as a functional source of P-active compounds.

To enhance the antioxidant properties it is necessary to use ascorbic acid. Ascorbic acid regulates energy metabolism, reduces oxidative stress, stimulates the formation of collagen and procollagen, participates in the metabolism of folic acid and minerals, activates the synthesis of some steroid hormones, catecholamines. Wild rose berries can be considered such a natural source of raw materials.

It is known that rosehip berries contain a whole complex of essential minerals and vitamins, including the highest concentration of vitamin C (higher than in lemons, oranges, black currants), which makes them valuable for medicine and healthy eating. Rosehip fruit contain up to 17% vitamin C, 12% carotene, vitamins B2, E, K, P, flavonoids, 18% sugar, 3.7% pectin, 4.5% tannins, organic acids, trace elements — iron, manganese, phosphorus, potassium, magnesium, molybdenum, cobalt, chromium,
copper, a significant amount of potassium salts. The use of rosehip helps to strengthen the immune system, increase the body's resistance to bacteria, helps to improve the digestive system, helps to slow down the aging process.

Liquid pectin in the form of pectin concentrate from Apple pomace with a mass content of pectin substances 4% is produced in industrial volumes by "SunLand" (Hungary), from beet pulp, feed watermelon and grape pomace – by experimental production of the Kuban state agrarian University.

In the preparation of recipes we used the method of profiling with the construction of profilograms. Based on the analysis of sensor profiles, the optimal ratio of components was chosen.

When optimizing the beverage recipes with the help of mathematical modeling, in order to obtain a product that combines a balanced micronutrient composition, functional activity and favorable taste, first were determined the optimal ratio of fruit and vegetable fillers and pectin substances that provide favorable taste qualities of beverages.

For this purpose, three-factor simplex-centroid plans were used. The model samples prepared according to the planning matrix were tasted, assessing them by five indicators (signs): color, sweetness, consistency, aroma, fullness of taste. These signs for the created a beverage are chosen as preferred that best reflect the type of the future drink.

The results were processed using the methods of statistical and graphical analysis by building ternary graphs in the program "STATISTIKA 7.0", which allowed to determine the most appropriate in terms of organoleptic characteristics of the final product. On the basis of the tasting assessment on a 10-point scale implemented in the non – alcoholic food industry, the following ratios of the mass content of recipe components in the drink were established: berry juice – 15%, pumpkin pectin – containing juice – 30%, liquid pectin from various raw materials with a pectin content of 4% - 40%, infusion of rose hips-15%.

The pectin part of the drink was made up of liquid Apple, beet and grape pectin, liquid pectin from feed watermelon. This choice is due to the difference in the properties of pectins. Thus, Apple liquid pectin and liquid pectin from the feed watermelon play the role of thickeners, which gives the full taste of drinks. Beet and grape liquid pectin are good complexing agents in relation to toxic metals. Complexing ability is from 40 (for the wine), 75 mg of Pb2+/g of dry pectin (of beet).

The results of experimental studies have also shown that the use of Apple and grape liquid pectin may increase the optimal content of the beverage pectin to 50 – 60 %, which increases its detoxification properties.

Physical and chemical parameters of the studied beverages, including pumpkin and BlackBerry juice, rosehip infusion and liquid pectin of different types are presented in table 1.

| Pectin extract | Dry substance, % | Total pectin, % | Acidity, % |
|----------------|-----------------|----------------|------------|
| apple          | 17,2            | 2,06           | 3.8        |
| beet           | 14,6            | 1,98           | 2.0        |
| forage watermelon | 13,6     | 1,67           | 2.6        |
| grape          | 15,5            | 1,25           | 3.2        |

The content of pectin substances in the developed beverages based on pectin concentrates from various types of plant raw materials is from 1.27 to 2.06 %.

In order to determine the functional properties, we conducted research to determine the complexing ability of the developed beverages. The data obtained is presented in figure 3.
Figure 3. Complexing ability of drinks

It follows from figure 3 that as a result of the use of liquid pectins in the recipe, the complexing ability of the developed beverages increases. The juices with beet pectin have the greatest complexing ability – 5 times more in comparison with the control sample. Comparative analysis of beverages using pectin products obtained from different raw materials showed that drinks with pectin from the fruit of forage watermelon by complexing ability are not inferior to drinks with Apple pectin and surpass drinks with grape pectin.

4. Summary

Based on the above, it can be concluded that the recipe ratio of the selected raw materials provides good organoleptic characteristics and optimal ratio of physiologically active components, giving them functional properties.

At the same time, drinks have high detoxification and antioxidant properties and are a functional daily source of vitamins (C, niacin, carotene), P-active compounds, pectin and minerals for modern human. This provides a basis for their inclusion in the human diet to provide a rational and balanced diet.

In addition, these drinks can be classified as specialized food products and recommended for hard labour workers (mining, chemical, nuclear, metallurgical and other industries) and the population living in ecologically polluted areas.

5. Conclusion

Thus, the results of experimental studies give grounds for the conclusion that it is advisable to consider the selected raw sources – pumpkin and BlackBerry juice, infusion of rose hips, liquid pectin – as a basis for the development of functional food drinks.

6. Conflict of interest

Authors declare no conflict of interest.

References

[1] World health organisation 2016 Global report on diabetes
[2] Donchenko L V, Nady’kta V D 2018 Food safety
[3] Donchenko L V et al 2018 Functional food technology (Moscow: Urait)
[4] Dubinin N P 1997 Some problems of modern genetics
[5] Il’ina I A, Donchenko L V, Zemskova Z G 2003 Technology features of pectins with high-prolonging properties Vestnik Rossijskoj akademii sel’skohozyaistvennyh nauk 3 pp 8–10
[6] EU 432/2012. Commission Regulation official Journal of European Union 2012
[7] Zhirenchina Z U, Kizatova M Z, Donchenko L V, Donchenko E V, Kurasova L A 2016
Comparative characteristics of the chemical structure of apples for the elaboration of functional food products Res. J. of Pharm., Biolog. and Chem. Sci. 7(3) pp 2360-70

[8] Limareva N S, Donchenko L V 2014 Innovative drinks based on functional vegetable juices. Polythematic network electronic scientific journal of Kuban state agrarian University 95 pp 511–40

[9] Bush P L 2014 Pectin chemical properties, uses and health benefits ed Bush P L (New York: Nova Science Publishers)