Food pectin-containing phytocompositions as the basis of functional herbal teas

L V Donchenko¹, N S Limareva*, A V Temnikov¹, N V Sokol¹ and S M Gorlov³

¹Kuban State Agrarian University, Faculty of Processing Technologies, 13, Kalinina str., 350044, Krasnodar, Russia
²North-Caucasus Federal University, Institute of Service, Tourism and Design, 56, 40 let Oktyabrya str., Pyatigorsk, 357500, Russia
³Krasnodar Research Institute for Storage and Processing of Agricultural Products-branch of the North Caucasus Federal Research Center for Horticulture, Viticulture, and Winemaking. 39, 40 let Pobody str., Krasnodar, 350044, Russia

*E-mail: nlimareva@pfncfu.ru

Abstract: Tea drinks are the most common type of food products for therapeutic and preventive nutrition. This article is about the results of research on pectin-containing phytocompositions as the basis of functional herbal teas. Selected samples of medicinal raw materials: Acorus calamus, Elecampane, Eleutherococcus, Polygonum aviculare, oregano, St. John's wort, motherwort, arrow, dill, Bidens tripartita L., purple Echinacea, dioecious nettle, peppermint, plantain large, aronia, hawthorn, Rosehip, marigold medicinal, chamomile and Siberian fir needles have shown that in addition to the known pharmacological properties, it can be considered in herbal teas as a raw material containing pectin substances. It should also be noted that the pectin substances of medicinal plants belong to the group of low-esterified pectins (E<40%), which indicates the possibility of their use as complexing agents. The results of experimental studies have confirmed the feasibility of using black and green tea as a base component with high antioxidant properties.

1. Introduction
Hippocrates wrote about the need to organize medical and preventive nutrition in his essay "On diet". He emphasized that the amount of food should depend on the type of body, age, time of year, weather, region, and other factors. In another work, "on diet in acute diseases". Hippocrates wrote that the treatment of various diseases should be reduced mainly to the regulation of diet, since food substances should be a remedy, and medicinal products should be food substances. In the mid-twentieth century, with the development of chemistry, biology, biochemistry and the discovery of amino acids, polyunsaturated fatty acids, vitamins, vitamin-like substances and other biologically active compounds, a scientific and experimental basis for therapeutic and preventive nutrition emerged.

In recent years, there has been a significant progress in the development of therapeutic and preventive nutrition, due to the emergence of pharmaconutritionology, a new field of knowledge that borders on the science of nutrition and pharmacology [1-6]. Its occurrence is associated with significant changes in the nature of nutrition and lifestyle.
Tea drinks are the most common type of food products for therapeutic and preventive nutrition. Among juices, nectars and non-carbonated beverages, tea drinks are the second largest both in terms of volume and in terms of production growth, causing increased interest of consumers all over the world.

In our opinion, by forming the composition of tea drinks, it is possible to expand their range, taking into account their functional orientation.

The most physiologically active additive is pectin substances [7]. It has been established that pectins entering the human body as part of food products perform a regulatory function [8]. They bind biologically active molecules contained in gastric juice, such as superoxide radical, estrogens, endotoxin, leptin, tumor necrosis factor, pancreatic amylase, xanthine oxidase, and food protein antigens. It is assumed that by binding low-molecular bioregulators in the lumen of the upper gastrointestinal tract, pectins inhibit their resorption and affect the processes of digestion, carcinogenesis, immune response, free radical damage and inflammation [9]. On the example of immunomodulatory activity was revealed polypotency a unique property of pectins, meaning the potential for pectins to have a multidirectional physiological effect [10, 11].

The expediency of including pectin substances in the diet is due to technogenic factors that will lead to disruption of normal life processes. Schematically, the causal chain of this disorder is as follows: external negative factors (environmental pollutants + radiation + poor nutrition + systematic stress + other factors) → metabolic disorders → formation of autotoxins → development of autointoxication → allergic manifestations of endoecological disease. At the same time, the problem of detoxification of the human body is complicated by the need to remove not only one or two toxic substances, but dozens formed in the body.

Against the background of the impact of technogenic factors, the body's sensitivity to ionizing radiation significantly increases, which, in turn, leads to not only functional, but also structural changes.

No less physiologically important role in the diet is played by foods containing antioxidants. The main natural source of antioxidants is black and green baichu teas. Thus, phenolic compounds make up the most valuable part of the tea leaf and are mainly represented by catechins and their gallic esters. They include more than 30 compounds that are similar in nature and make up up to 25% of the dry weight of the tea leaf. It is known that catechins account for 60-70% of the total amount of phenolic compounds [12]. The physiological role of catechins is expressed in the ability to reduce capillary permeability to normal, restore elasticity and permeability to their walls. This, in turn, allows to regulate blood pressure and contribute to the prevention of hypertension.

The composition of phenolic compounds of tea leaves, along with catechins, includes flavonoids [12]. This group of substances in tea is represented by a set of mono-, di- and triglycosides of three aglycones: kaempferol, quercetin and myricetin. These compounds are contained in small amounts, but, being plant antioxidants, they are quite resistant to oxidative transformations, so that when processed, they retain up to 80% of the amount of flavonoids contained in fresh tea leaves.

Therefore, one of the possible ways to solve this problem is to expand the range of functional food products, in particular herbal teas containing pectin substances and antioxidants. To this end, we conducted research to determine the content and analytical characteristics of pectin in medicinal plants. To develop prescription food phytocompositions, we also studied the fractional composition of pectin substances.

The total content of pectin substances (PS), the ratio of protopectin (PP) and soluble pectin (SP) are biochemical characteristics of plant raw materials. In different types of raw materials, the content of PS, PP and SP varies. Knowledge of the fractional composition allows to assess the technological significance of raw materials as a source of pectin substances.

2. Materials and methods
As objects of research, we selected medicinal raw materials that are often used in medicine: common calamus, high elderberry, Eleutherococcus, mountain bird, oregano, St. John’s wort, common motherwort, common yarrow, garden dill, three-part series, purple Echinacea, dioecious nettle, peppermint, large plantain, black Aronia, hawthorn, rosehip may, marigold medicinal, chamomile
pharmacy and needles of Siberian fir. Isolation and physico-chemical characterization of pectin from the studied raw materials was carried out using generally accepted methods (Donchenko et al., 2007). 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 conversion to a dissolved state. The study of hydratopectin and protopectin extracts is based on the calcium-pectate method and precipitation with ethyl alcohol [13]. Analytical characteristics of the obtained pectin samples were determined by conductometric titration [13]. Chemical composition studies were carried out using standard methods used in complex chemical analysis: the total content of nitrogenous substances — by the Kjeldahl method using the FOSS autoazotoanalyzer; carbohydrate composition and mineral content-by capillary electrophoresis; vitamin content by HPLC and fluorometry. Determination of the total content of phenolic substances was carried out according to the method [14] with modification for their tea extracts. The test extract in an amount of 0.25 cm$^3$ is mixed with 4 cm$^3$ of distilled water and 0.25 cm$^3$ of an aqueous solution of Folin-Chokalteu reagent is added (in a ratio of 1:1), followed by 0.25 cm$^3$ of a solution of saturated sodium carbonate. The resulting mixture is left alone for 30 minutes, and then the optical density of the samples is measured on a spectrophotometer at a light wavelength of 725 nm. The results are calculated from the calibration curve in mg of gallic acid/100 g of feedstock. Flavonoids were determined photometrically by measuring the optical density of the study solution on a spectrophotometer at a light wavelength of 510 nm [15]. the Results are expressed in mg of catechin/100 g of feedstock, determined by the calibration curve. To determine tannins, a spectrophotometric method was used, measuring the optical density at a light wavelength of 500 nm [16]. The measurement results are expressed in mg of catechin/100 g of feedstock, determined according to the calibration schedule.

3. Discussion and results
One of the main valuable components of plant raw materials, including medicinal ones, is pectin substances. We conducted studies to determine the fractional composition and total content of pectin substances (table 1).

Table 1. Content of pectin substances in medicinal raw materials.

| Name of raw materials | The content of pectin substances, % |
|-----------------------|-----------------------------------|
|                       | soluble pectin | protopectin | pectin substances |
| Acorus calamus         | 0.08           | 2.41        | 2.49              |
| Elecampane (rhizomes with roots) | 0.06           | 4.41        | 4.47              |
| Eleutherococcus (Siberian ginseng) (root) | 0.18           | 1.13        | 1.31              |
| Polygonum aviculare (grass) | 0.17           | 6.84        | 7.01              |
| Oregano (herb)         | 0.12           | 5.82        | 5.94              |
| St. John’s wort (grass) | 1.33           | 7.10        | 8.43              |
| Motherwort (grass)     | 0.09           | 3.53        | 3.62              |
| Yarrow (grass)         | 2.40           | 4.60        | 7.0               |
| Dill garden (grass)    | 0.10           | 0.41        | 0.51              |
| Bidens tripartita L. (grass) | 0.14           | 4.12        | 4.26              |
| Echinacea purpurea (grass) | 1.70           | 5.08        | 6.78              |
| Stinging nettle (leaves) | 1.81           | 5.42        | 7.23              |
| Peppermint (leaves)    | 0.58           | 6.63        | 7.21              |
| Plantain large (leaves) | 0.95           | 4.63        | 5.58              |
| Aronia chokeberry (fruit) | 0.25           | 2.38        | 2.63              |
| Hawthorn (fruit)       | 0.93           | 3.20        | 4.13              |
| Rosehip may (fruit)    | 3.30           | 9.60        | 12.90             |
| Medicinal marigolds (calendula) | 0.02           | 3.82        | 3.84              |
| Chamomile (flowers)    | 0.45           | 4.13        | 4.58              |
| Siberian Fir (needles) | 0.04           | 1.71        | 1.75              |
Analysis of experimental data showed that the content of soluble pectin is distinguished by rosehip fruits (3.3%), yarrow grass (2.4%), nettle leaves (1.8%), Echinacea purpurea grass (1.7%) and St. John's wort grass (1.3%). The content of protopectin ranges from 0.4% in dill herb to 9.6% in rosehip fruit. In almost all samples, the protopectin fraction prevails over the soluble one, which is typical for plant raw materials in general.

The content of total pectin in the studied medicinal raw materials ranges from 1.31% in the root of Eleutherococcus to 12.90% in rosehip fruits.

Taking into account the obtained data, the studied medicinal raw materials are conditionally divided into 3 main groups. The first group includes raw materials with a total pectin content of more than 6.0%, the second group – with a total pectin content of 4.0...6.0%, and the third-less than 4.0%.

In order to optimize the recipe composition of herbal teas according to their functional orientation, we have developed a classification of the studied medicinal raw materials by the total content of pectin substances, which is shown in figure 1.

**Figure 1.** Classification of dry medicinal raw materials according to the total content of pectin substances.

Analysis of the results of the research allows to conclude that the content of pectin substances in plant medicinal raw materials is quite high, which, in turn, makes it possible to use it in the production of herbal teas for functional purposes.

The next stage of research was to study the analytical characteristics of pectin substances isolated from medicinal plants. At the same time, the root of Eleutherococcus and dill herb as objects of research are excluded due to the low content of pectin (<1.5%).

According to the degree of esterification, all the obtained samples of pectin substances of medicinal plants belong to the group of low-esterified pectins (E< 40%), which indicates the possibility of their use as complexing agents (figure 2).

At the same time, the highest value of the degree of esterification is peppermint pectin – 35.3%, the lowest - chamomile pectin – 5%. It should be noted that the degree of esterification and the content of free carboxyl groups are inextricably linked with the complexing ability. With an increase in the degree of esterification, the ability to complex in pectins decreases. Analyzing the experimental data, it can be assumed that the greatest complexing ability will be possessed by pectins of chamomile and nettle.
dioecious, since they have the lowest values of the degree of esterification (5 and 15.0%, respectively). To confirm this assumption, we conducted additional studies to determine the complexing ability of pectin substances isolated from medicinal raw materials. The complexing ability of pectins was determined by wet burning of the Pb-pectate precipitate and subsequent trilonometric analysis for the amount of absorbed lead [13]. The research results are shown in figure 3.

**Figure 2.** Influence of the type of medicinal raw materials on the degree of esterification of pectin substances.
It was found that pectin obtained from chamomile (383.7 mg Pb2+/g) has the highest complexing capacity, and pectin from peppermint (120.4 mg Pb2+/g) has the lowest. The results of research showed almost high values of complexing ability in all pectins (120.4...361.9 mg Pb2+/g).

It is known that beet pectin has the highest complexing capacity – about 300 mg Pb2+/g [17].

To compare the complexing ability of pectins of medicinal raw materials with the complexing ability of beet pectin, we introduced a new indicator—the reduced complexing coefficient, which is the ratio of the values of complexing pectin of medicinal plants to the complexing of beet pectin.

Based on the data obtained, we have developed a conditional classification of the studied raw materials, taking into account the values of the reduced coefficient of complexation (figure 4).

From the data shown, it can be seen that the studied medicinal raw materials can be divided into two main groups. The first group includes raw materials whose pectin substances have a complexing ability (K) higher than that of beet pectin (K>1). To the second-raw materials, pectin substances which have a complexing ability less than beet pectin (K < 1). It should be noted that the first group is not so numerous.

The developed classification allows to theoretically and experimentally substantiate the directions of application of medicinal plants in the food combinorics of functional food products. Thus, the medicinal raw materials of the group should be used for the production of medical nutrition products; the group should be used for food products of therapeutic and preventive nutrition.

At the same time, taking into account the different composition of active compounds of medicinal raw materials, it can be combined with traditional types of tea. This, in turn, will significantly increase the efficiency of using natural raw materials in pectin prevention and pectin therapy of the population.

Herbal tea has been known since ancient times as a drink of General strengthening, immunosupporting, and in some cases, therapeutic action. The rich composition of the blends sometimes meets the daily need for various essential micro-and macronutrients.

Group I

Group II
Figure 3. Complexing ability of medicinal raw materials.

Herbal teas are stored for about 1 year in compliance with the temperature regime, humidity level and requirements for ultraviolet radiation.

Compositionally, herbal teas are made up, as a rule, on the basis of a basic component with the addition of various herbal recipe components.

Figure 4. Classification of raw materials according to the given coefficient of complexation (the first group).

As a basic component, we studied the leaves of black and green tea. Experimental data are shown in table 2.

Table 2. Flavonoid compounds of black and green tea, % a.d.m.

| Compounds                                      | Black tea | Green tea |
|------------------------------------------------|-----------|-----------|
| Total content of phenolic substances, mg of gallic acid/100 g | 617       | 1177      |
| The total content of flavonoids, catechin mg/100 g            | 347       | 385       |
| Total tannin content, mg of catechin/100 g                    | 115.8     | 112.73    |
Green tea is distinguished by the content of phenolic compounds and flavonoids. At the same time, the tannin content is higher in black tea.

4. Conclusion

Selected samples of medicinal raw materials: Acorus calamus, Elecampane, Eleutherococcus, Polygonum aviculare, oregano, St. John's wort, motherwort, arrow, dill, Bidens tripartita L., purple Echinacea, dioecious nettle, peppermint, plantain large, aronia, hawthorn, Rosehip, marigold medicinal, chamomile and Siberian fir needles have shown that in addition to the known pharmacological properties, it can be considered in herbal teas as a raw material containing pectin substances. The content of total pectin in the studied medicinal raw materials ranges from 1.31% in the root of Eleutherococcus to 12.90% in rosehip fruits. At the same time, the content of soluble pectin is in rosehip fruits (3.3%), in yarrow grass (2.4%), in nettle leaves (1.8%), in Echinacea purpurea grass (1.7%) and in St. John's wort grass (1.3%). The content of protopectin ranges from 0.4% in dill herb to 9.6% in rosehip fruit.

It should also be noted that the pectin substances of medicinal plants belong to the group of low-esterified pectins (E<40%), which indicates the possibility of their use as complexing agents.

It was found that the highest content of phenolic compounds and flavonoids is found in green tea (1177 mg of gallic acid/100 g and 385 mg of catechin /100 g, respectively) as the basic component of the phytocomposition. At the same time, the tannin content is slightly higher in black tea (115.8 mg of catechin /100 g).

The results of experimental studies have confirmed the feasibility of using black and green tea as a base component with high antioxidant properties. It is known that tea bioflavonoids have a wide range of pharmacological properties, such as immunostimulating, antitumor, cardio-, radio-, hepatoprotective, antithrombic, anti-allergic, and antiviral [18]. Most of them have P-vitamin activity, that is, the ability to reduce the fragility and permeability of capillary walls. Among food sources of flavonoids, tea takes a special place, since, on the one hand, it is one of the main sources of flavonoids, and on the other hand, it is the second most consumed drink after water.

References
[1] Barnaulov O D 2018 Reviews of clinical pharmacology and drug therapy 16(1) 71-8
[2] Lebedev V P 2003 Clinical herbal medicine (Novosibirsk) p 368
[3] Minaeva V G 1991 Medicinal plants of Siberia (Novosibirsk: Nauka) p 431
[4] Martinchik A N, Maev I V and Yanushevich O O 2005 General nutrition science (Moscow: Medpress-inform)
[5] Kurashvili V A 2002 The role of nutrition in disease prevention Journal of natural medicine 2 15-8
[6] Bagchi D, Lau F and Ghosh D K 2010 Biotechnology in Functional Foods and Nutraceuticals (New-York: CRC Press)
[7] Vasser J and Voragen A G 1996 Pectin’s and pectinases (Amsterdam: Eisseur Science)
[8] EU 432/2012 2012 Commission Regulation Official Journal of European Union
[9] Shevcuk V YU 2013 Pathobiochemical justification of the use of pectin gel for the prevention of abdominal adhesions (experimental study) (Krasnodar)
[10] Popov S V 2010 Immunomodulatory action of pectin polysaccharides (Syktyvkar)
[11] Popov S V, Popov S V and Ovodov YU S 2013 Biochemistry 78(07) 1053-67
[12] Pochlebkin V V 1969 Tea its history properties and use (Moscow: Food industry)
[13] Karpovich N S, Donchenko L V, Nelina V V, Kompancev V A and Mel’nik G S 1989 Pectin Production and application (Kiev: Harvest)
[14] Afshar F H et al. 2012 Comparision of the total phenol, flavonoid contents and antioxidant activity of methanolic extracts of Artemisia spicigera and A. splendens growing in Iran Pharmaceutical sciences 18(3) 165-70
[15] Rohman A et al. 2010 Antioxidant activity, total phenolic, and total flavonoid of extracts and fractions of red fruit (Pandanus conoideus Lam) Int. Food research journal 17 97-106
[16] Rebaya A et al. 2015 Total phenolic, total flavonoid, tannin content, and antioxidant capacity of Halimium halimifolium (cistaceae) *Journal of applied pharmaceutical science* 5(1) 52-7

[17] Donchenko L V and Firsov G G 2007 Pectin: main properties, production and application (Moscow: DeLi print)

[18] Afonina S N, Lebedeva E N and Setko N P 2000 Biochemistry of tea components and features of its biological effect on the body (review) *Orenburg medical bulletin* 4(20) 17-33