

Study of the chemical composition of quinoa during vegetation in the conditions of southern Russia

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Abstract. The results of studies of the fractional composition and antioxidant activity of quinoa leaves are presented. It has been established that quinoa leaves of Russian selection can be used as natural sources of antioxidant substances in the production of functional products, in particular, herbal teas and beverages.

1 Introduction

Quinoa contains a wide range of biologically active substances. Many authors note the high content of antioxidants [1-7], the activity of which is due to the content of flavonol glycosides, phenols, tannins, betaines, terpenoids and ecdysteroids, which contribute to lowering cholesterol levels [8-10].

Quinoa is a rich source of complete protein. Its content, depending on the variety and region of production, can range from 12% to 22%. Proteins are highly digestible [11]. Quinoa protein is characterized by high biological value, its amino acid composition is close to the composition of the "ideal" protein recommended by FAO/WHO. The amount of essential amino acids exceeds their content in wheat by more than 2 times, including the content of methionine by 2 times and lysine and tryptophan by 3 times [12].

Quinoa also contains from 2 to 9% fat, which includes a high content of polyunsaturated fatty acids, fat-soluble vitamins and biologically active compounds. Up to 60% of fats are represented by deficient fatty acids: oleic (ω -9), linoleic (ω -6) and linolenic (ω -3), which make up 25 – 27%, 48 – 51% and 4-5%, respectively. Quinoa fats are characterized by a high content of tocopherols [13]. Due to the high content of tocopherols, phytosterols and other precursors of the steroid family, quinoa fats have high antioxidant activity, prevent diseases of the cardiovascular system and cancer [11,12].

Quinoa seeds contain a large amount of minerals, primarily iron and calcium, potassium and magnesium, manganese and zinc, etc. [13].

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In addition to proteins, fats and minerals, the consumption of pectins is also relevant in the modern world.

Currently, according to experts, there is a steady increase in pectin consumption in the world, the annual increase of which is on average 3.0 – 3.5% per year.

It is well known that pectins have a huge range of useful properties, they are able to create favorable conditions for the proper functioning of the intestinal microflora, have a detoxifying effect.

Pectin substances can be actively used for the prevention and treatment of such socially significant diseases as diabetes mellitus, cardiovascular and oncological diseases [14]. According to the European regulation EU 432/2012 of 16.05.2012, pectin is recommended for lowering cholesterol (6 g/day) and glucose (10 g/day) in the blood.

One of the most important properties of pectin substances is their complexing ability, which is based on the interaction of the pectin molecule with ions of heavy and radioactive metals. Due to this property, it is recommended to include pectin in the diet of persons in an environment contaminated with radionuclides and heavy metals.

Thus, due to its complexing property in relation to metals, pectin is an indispensable substance in the production of food products for preventive and therapeutic nutrition. The optimal preventive dose of pectin should not exceed 2-4 g per day for those in contact with toxic metals, and in conditions of contamination with radioactive elements is at least 15-16 g. This, in turn, determines the expansion of the range of food products containing pectin substances for its inclusion in the daily diet of modern man.

To this end, we have set the following research objectives:

- to study the fractional composition of pectin substances of quinoa leaves;
- to investigate the chemical composition of quinoa leaves;
- to determine the antioxidant activity of the selected research objects.

2 Research Methods

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 a dissolved state. The study of extracts of hydratopectin and protopectin is based on the calcium-pectate method and precipitation with ethyl alcohol.

Chemical composition studies were carried out using standard methods adopted in complex chemical analysis: the total content of nitrogenous substances — by the Kjeldahl method using a FOSS auto-gas analyzer; carbohydrate composition and mineral content – by capillary electrophoresis; vitamin content - by HPLC and fluorometry [15].

Determination of the total content of phenolic substances was carried out according to the method [16] with modification for their tea extracts. The studied extract in an amount of 0.25 cm³ is mixed with 4 cm³ of distilled water and 0.25 cm³ of an aqueous solution of Folin-Chokaltea reagent is added (in a ratio of 1: 1), followed by 0.25 cm³ 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 [17,18] The results are expressed in mg of catechin/100 g of feedstock, determined by the calibration curve.

The leaves of quinoa grown in the conditions of the south of Russia – Krasnodar Territory were chosen as the object of research.

Quinoa leaves were harvested in early June – in the juvenile phase, in September – in the flowering phase and in the seed ripening phase.

3 Results and Discussion

The results of the study of the fractional composition and content of pectin substances in quinoa leaves are shown in Fig. 1.

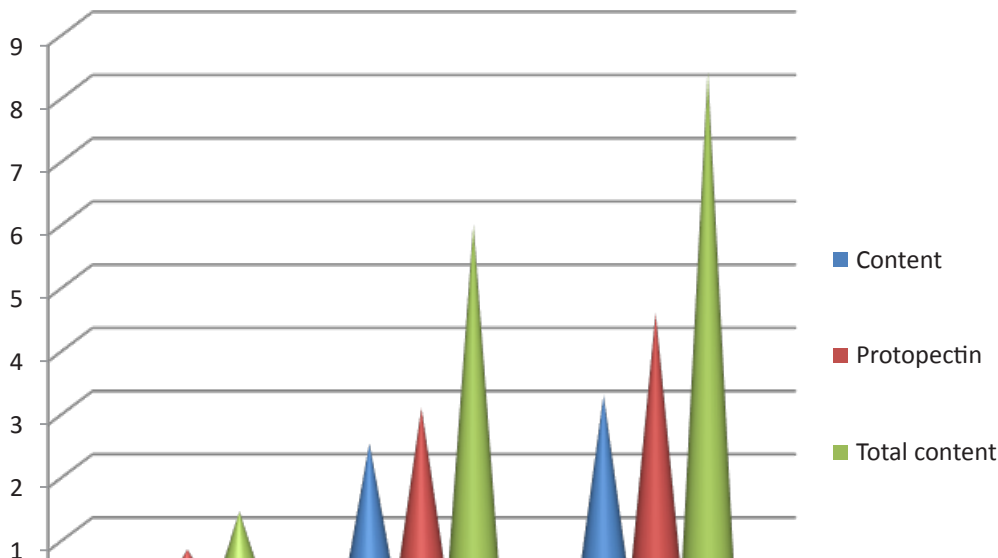


Fig. 1. Fractional composition of pectin substances of quinoa leaves during the growing season

According to the presented data, it can be seen that during the entire growing season there is a change in the total content of pectin substances from 1.36 to 8.3%. A pattern of simultaneous increase in the mass fraction of soluble pectin and protopectin in the phases of quinoa development was also revealed.

The monosaccharide composition of pectin consisted of galacturonic acid - 58%, arabinose – 5.1%, galactose - 7.7%, glucose - 8.6%, xylose - 3.2%, rhamnose - 3.5%, fructose – 5.1%. Pectin had a molecular weight of 26 kD and the degree of esterification – 62%.

The results of the conducted studies have shown that it is most advisable to use quinoa leaves of Russian selection during the flowering period, since the content of pectin substances in this growing season is 5.9%. In this regard, they can be considered as natural sources of pectin substances.

No less urgent is the expansion of the raw material base to increase the range of food products with high antioxidant activity.

As it is known, oxygen is a strong oxidizer, oxidation reactions involving it are a source of energy for most living organisms [19]. However, in the process of metabolism, oxygen compounds are formed, which lead to the destruction of the structure and substance of the cell. Thus, metabolism is disrupted in the cell and throughout the body. The role of antioxidants is to bind and eliminate free radicals from the body.

The body has its own system of combating excessive amounts of free radicals, but it is weakened under the influence of adverse environmental factors. It is known that many plants contain substances that have antioxidant activity [20].

Of particular interest today is a group of bioflavonoids – compounds with a polyphenolic structure. Currently, plant-based antioxidants are widely used in the food industry, especially in the form of extracts.

According to earlier studies, it was found that the leaves of plants of the Amaranth family, to which the quinoa culture belongs, have in their composition such low-molecular phenolic compounds as rutin, quercetin and trifolene, which have a sufficiently high antioxidant activity [21].

In this regard, we have determined the chemical composition of dried quinoa leaves in different growing seasons. The results of the research are presented in Fig. 2.

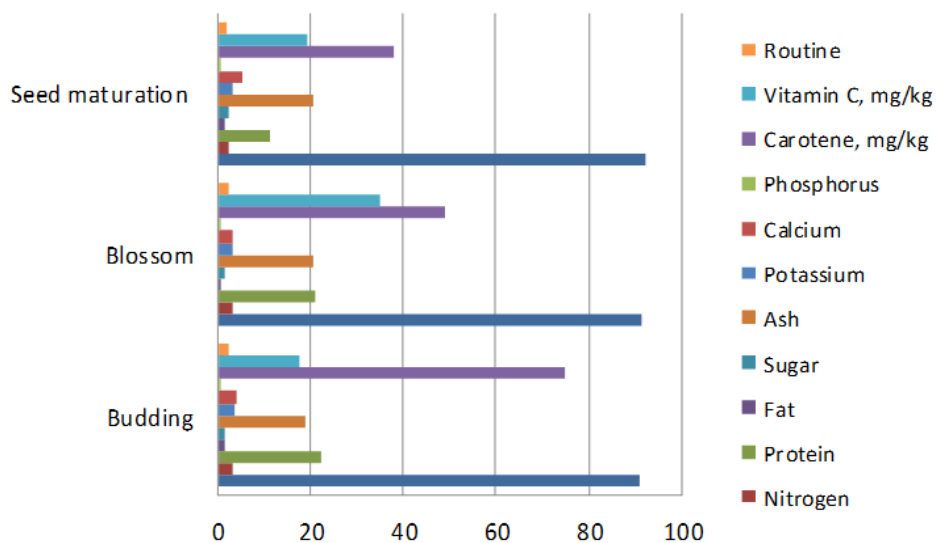


Fig. 2. Chemical composition of dried quinoa leaves

It was found that dried quinoa leaves contain a sufficiently high amount of protein (11.2 – 22.2%), low sugar content (1.4 – 2.4%) and fat (0.8 – 1.5%), as well as a high content of ash residue (18.8 – 20.7%) and calcium (3.05 – 5.42%).

The research results showed that the highest content of proteins and substances with antioxidant activity (such as vitamin C, rutin, carotene) is observed in quinoa leaves during budding and flowering compared to leaves during seed ripening.

Then, studies were conducted on the effect of quinoa leaf harvesting methods on the antioxidant activity of extracts obtained by water extraction. The obtained results are presented in Fig. 3.

According to the data obtained, it follows that the highest AOA is found in the extract from fresh leaves. At the same time, the AOA of the extract from frozen leaves is lower by 8.5%, and from dried leaves – by 46%. This is consistent with the data obtained by Gawlik-Dziki U. Et al. [21]

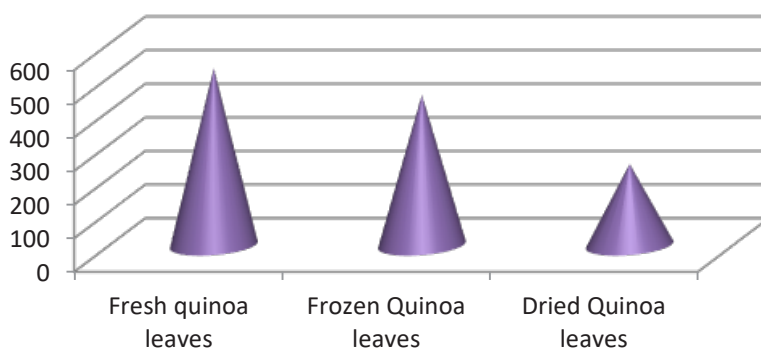


Fig. 3. Antioxidant activity (AOA) of quinoa leaf extracts (standard – quercetin, mg/l)

It is known that the main natural source of phenolic compounds are black and green bayh tea. They are mainly represented by catechins and their gallic esters and make up the most valuable part of the tea leaf. Phenolic compounds include more than 30 compounds similar in nature and make up about 25% of the dry weight of a tea leaf. Catechins account for 60-70% of the total amount of phenolic compounds. The physiological role of catechins is expressed in the ability to reduce capillary permeability to normal, restore elasticity and permeability to their walls. These properties allow you to regulate blood pressure and contribute to the prevention of hypertension.

In this regard, a comparative analysis of the composition of flavonoid compounds in the leaves of black bayh tea and quinoa was carried out. The results are presented in Table 1.

Table 1 Flavonoid compounds of black bayh tea and quinoa leaves, % on a.s.m.

Compounds	Dried Quinoa leaves	Black bayh tea
Rutin	1.10	0.90
Quercetin	0.68	–
Quercetin-3-0- glucoside	0.71	0.52
Quercetin-3-0- galactoside	0.30	0.18
Quercetin-3-0- rhamnoside	0.51	0.30
Dihydroquercetin	0.25	–
Sum of flavonoids	3.55	1.90

According to the data presented in the table, the amount of flavonoids contained in quinoa leaves exceeds the amount of flavonoids of black bayh tea by almost 2 times. At the same time, it was found that the content of quercetin and its compounds is also higher in quinoa leaves than in black tea.

The results of our research have shown that quinoa leaves of Russian selection may be used as natural sources of antioxidant substances in the production of functional products, in particular herbal teas and beverages [22, 23, 24].

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