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Comparative Characteristics Of The Chemical Structure Of Apples For The Elaboration Of Functional Food Products.

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ABSTRACT

In this article we bring up the results of comparative analysis of the chemical structure of apples in means of species and geographical zone of growing. As a subject of examination we have chosen industrial species of apples grown in the southern part of Russia and in the Republic of Kazakhstan. The results of the analysis have shown that this material can be regarded as raw material for the elaboration of functional food products that reduce the number of chronicle diseases caused by the misbalanced nutrition.

Keywords: Fruits of apples, pectin substances, analytic characteristics, etherification degree, jellied-matter forming and complex forming, carbohydrates, organic acids.

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INTRODUCTION

Practically during all the period of the human existence food was mostly used for the hunger, appetite and taste needs satisfaction. But in the last decade it was determined that the number of chronicle diseases grow because of the misbalanced nutrition. That way the frequency of cardiovascular disease has grown in 8-12 times, endocrine disorders – in 5 times, diabetes has already taken the third place from all world most frequent diseases [1].

According to the domestic and foreign examination of the World Health Organization the health state of population depends on the way of life and its conditions in 50%; in 10-20% it is affected by the heredity (genetic factors); the environment has approximately the same influence and only 8-10% left for the practical work of the health service[2].

Taking all that has been said into account we may see that the organization of rational nutrition is topical in modern society. This can be possible with the extension of the assortment and enlargement of the amount of the functional food products production.

The conception of functional nutrition as an independent scientific and practical direction in the field of healthy nutrition in the modern view appeared in the early 90s. Nowadays “functional food products” define nutritional products that are produced for the regular use in daily meals by the healthy population in order to reduce the risk of the disease development, to keep and improve health by physiological functional nutrition ingredients.

The presence of detoxicant feature components is also actual in modern ecological conditions. According to the Korte-Dubinina scale of the toxic pollution grading that has been recommended by the WHO, heavy metals take the first place in means of negative affection on the organism (135 points) [3].

Such polysaccharides as pectin substances have most detoxicant features in relation to heavy metals [4]. Besides that pectin is a physiological component. This way according to the regulation of EU432/2012 pectin is recommended for the reduction of the cholesterol degree and glucose degree in blood in the amount of 4 to 10g per day [5].

One of the main industrial raw material sources of pectin is apple raw material. In general amount of all pectin that is produced in the world apple pectin composes approximately 30-35% [6].

To our surprise 7500 species of apples were counted nowadays. Apple gardens take extremely vast territory of 5 million ha, this way practically every second fruit tree is apple tree [7]. But in our opinion nowadays apple raw material is regarded insufficiently from the functional features point of view.

This fact defines the necessity of apples examination for the position of functional purpose products elaboration for the organization of rational nutrition.

For the realization of that purpose we set following goals of the studying:

- To examine fractional composition of sugars, organic acids and pectin composition substances;
- To define the structure of vitamins and mineral substances;
- To grade qualitative indexes of emphasized pectins;
- To determine functional directivity of chosen subjects of the study

EXPERIMENTAL PLATFORM AND METHODS OF STUDYING

As an experimental platform we have chosen 2 regions: the South of Russia, Krasnodar region in particular, and the Republic of Kazakhstan, Almaty region. Krasnodar region is situated in the south of Russia, in the south-west part of the Northern Caucasus. The region takes the third place among all the regions of the Russian Federation, and goes right after Moscow and Moscow township in means of the number of citizens.

Kazakhstan is situated on the border of Europe and Asia, most part of the country lays in Asia and less part – in the Western Europe. Such geographical position determines particular features of the chemical composition of the green raw materials. Besides that traditionally these are regions with industrial plantation of apple trees. Famous species are introduced from the USA prevail in the plantation.

As objects of studying we have chosen industrial species of apples that can be found both in Krasnodar region and in the Republic of Kazakhstan (in contin. RK) – Golden Delicious, Aided, and Red Delicious.

The choice of these apple species as the objects of studying is determined by the fact that the area of its plantation in both of regions is the largest among the other apple trees of this time.

Golden Delicious – American species of winter ripening period. For the first time the species was introduced at the market in 1914, the place of its origin is Clay County, West Virginia. The fruit has average size, but can reach bigger sizes favorable conditions; rounded-oblong or frusto-conical (till 250 g) in shape. The peduncle is short; the cuticle is thin, but thick. Ripened fruits have it golden-yellow with light-yellow or red subcutaneous dots, sometimes with ruddiness. The pulp is yellow, tender juicy, wine-sweet, aromatic, of excellent quality (fig.1).

The main values of the species are high crop capacity and world standard quality of fruits.

Low points of the species are the disposition to the fading of fruits during the stocking period, which explains the necessity of processing of this species.

Aided – American species of winter or late-winter ripening period. The main area of the marketing production of fruits of this kind in Russia is Krasnodar region. Fruits of this apple tree are uniformed, rather big, with the average mass from 140 to 190g (but not less than 100g), flat-rounded in shape.

The cuticle of apples has a glossy shimmer and smooth surface, it is rather thin, but very elastic and thick and is covered by the light wax blast. The pulp is creamy, sourish-sweet, thick when turned apart and later – grainy, and gets really friable in the end of the stocking period. The taste is excellent or average. The aroma is presented rather weak (fig.2).

Strong points of the species comprehend high crop capacity and marketing of the fruits, the wellness for the fresh consumption and for different kinds of the processing.

Red Delicious - the species of the American origin. This is one of the most wide-spread species. For the first time the sort appeared at the market in 1874. The place of the species growing is Peru, Iowa State. The fruits are mainly yellow-green. The color of the cover is dark-red, with big white subcutaneous dots. The size of fruits reaches 180-200g. Conical or rounded-conical in shape. The pulp is crispy and very juicy (fig.3).

Strong points of the species – high marketing and consuming qualities of fruits. Low points comprehend the damage of fruits caused by the bitter spots during the stocking process.

The chemical composition of fruits was determined by the wide-spread biochemical methods: soluble dry substances – by the refractometrical method; fractional composition of sugar and acids, the content of mineral substances – by the capillary electrophoreses; the vitamin content – by the fluorometry and HPLC; P-active substances – colometrical method.

The method of the number definition of the pectin substances in green raw materials is based on the pectin extraction from the green raw material and its transferring into the soluted state (Donchenko, 2000). The base of the hydro pectin and protopectin extracts examination in the calcium pectin method and the precipitation of the athyl alcohol. Besides that the content of the carboxyl groups (freed and etherificated), methoxyl and acetyl groups in pectin preparation was also examined.

It is known, that the chemical composition of apples varies a lot affected by the species, and within the limits of one sort it depends on climate and the degree of ripeness.

For the correct grading of the chemical composition of examined species of apple fruits were chosen in the moment of being ripened.

RESULTS AND DISCUSSION

Apples just like other fruits contain water with insoluble and soluble substances. Apples consist approximately from 70-90% of water, 1,3 – 3,3% insoluble substances (cellulose, lignin, cetin, protopectin, insoluble proteins, etc.), 7,5-23% and more of soluble substances (sugars, organic acids, nitrogen soluble substances, hydro pectin, water soluble vitamins, coloring, aromatic and mineral substances, others).

In our objects of studying humidity was varying from 81,3±0,5% (sort Aidared, Aidared (RK) to 84,9±1,2% (Red Delicious sort, Red Delicious (RK)).

The main parts of apples are sugars and organic acids. Results of the studying showed that the general number of sugar in apples varied from 10,3 (Red Delicious sort (RK) to 14,8% (Golden Delicious).

There were 3 kinds of sugars in apples: fructose, glucose and saccharine. By the way, fructose predominated in all sorts. Based on the examination of 6 examples of apples it has been determined that apples compose (in %): fructose – from 5,6 % (Aidared (RK) sort) to 7,5% (Golden Delicious sort), glucose – from 1,16% (Aidared (RK) sort) to 2,3% (Red Delicious sort), saccharine – from 2,1% (Red Delicious (RK) sort) to 5,8% (Golden Delicious sort).

Results of the carbohydrates composition examination have shown that the composition of sugars is higher in industrial species of apples in Krasnodar region.

The variation of the acid composition is noted – from 0,2 to 0,79%. From organic acids malic, tartaric and citric acids were presented in apples. According to the results of the studying there was found 0,25-0,48% of malic acid, 0,365%-0,113% in average; citric acid – 0,087% in average, this way we may say that malic acid composition is 4 times higher than citric acid composition.

The tartaric acid composition was presented from 0,01% (Red Delicious (RK) sort) to 0,04% (Golden Delicious sort).

According to the experiments the composition of malic and citric acids presented in examples is rather high when counted to the percent of the daily degree of the physiological organism security. The average daily security of the organic acids is approximately 2g. Results of the studying give us a reason to determine that examined fruits can be functional source of organic acids, malic and citric acids in particular. The daily degree of rational meal provision of human nutrition varies within the limits of 15, 5 to 29, 6% during the consumption. This corresponds with the requirements for the functional food products in which the degree of the provision in physiologically active compounds has to consist from 10 to 40%.

It is known that malic acid takes an important part in metabolic processes of the human body. Contribute to the complete ferrum assimilation, cooperates with vitamins, solutes in water. Citric acid is necessary part in the cellular respiratory process, because of its bacteriological and antioxidant features. The benefit of citric acid cannot be doubted because it stimulates the refreshing of new cells and this way rise up elastic nature of the skin and reduces deep wrinkles.

Apples also consist of 0, 22 to 0, 70%; 0, 46% of nitrogen compounds in average that are composed from protein substances, amid and ammoniac compounds.

Biological value of food products is graded according to the amino acid composition and its number. In the examined raw material the number of amino acid is not big. The essential part in human organism is played irreplaceable amino acids, acids that cannot be synthesized in this or that organism including human organism. That is why their matriculation with food is necessary in the human organism.

In the table 1 we presented the amino acid composition of the examined examples of apples. Average indexes are given because no crucial differences of this index were seen in the examined species.

According to the data given above, we may see that the amino acids composition is rather various, but its content is very low. By the way all 8 irreplaceable amino acids are given in apple fruits. But they can't be regarded as a functional source of amino acids. That agrees with the following studying [8].

Vitamins take an important part in the treatment of different diseases. Results of experimental examination have shown that apples have satisfactory vitamin composition. Vitamin C composition is the most noted in all of the examples. Vitamin C composition in examined examples is presented in figure 4.

According to the data above, we see that the highest mass fraction of vitamin C is noted in Golden Delicious (RK) sort (12,4 mg/100g), this difference takes place mainly because of the sort differences.

We need to mention, that the daily need of vitamin C in human body -50 mg. Taking this into account we see that fruits of Golden Delicious (RK) apples can be regarded as a functional source of this vitamin for the physiological need satisfaction (approximately 25 % if only 100g of fruit is consumed).

For the competitive grading of vitamin composition in examined fruits we determined the mass content of other vitamins. Experimental data is given below in the table 2.

Experimental data proves rich vitamin composition of apple fruits. By the way, there were found no essential deviation of vitamin content in means of the region of growing.

P- active substances content in examined examples is given in figure 5.

According to the figure the highest content of P-active substances is seen in the Red Delicious sort (130 mg/100g), the lowest – in Golden Delicious and Golden Delicious (RK) sorts. But it should be mentioned that the difference in the number index isn't essential.

We should note that the studying of P-active vitamin substances has become very significant recently. As vitamin P we may define substances of green origin that are different in means of chemical features but have common biological activity.

The main representatives of P-active vitamin substances are flavonoids (catechins, leucoanthocyanins, flavonols, anthocyanins, and copolymer forms of these compounds). From the group listed above apples contain colorless catechins and leucoanthocyanins that have not only capillary strengthening activity but also antitoxic activity. The last feature when is connected with the ions of heavy metals is topical in modern conditions. For the disease prevention and also for the physical and mental activity maintenance P-active compounds are necessary in means of 100-200 mg per day, for the medical treatment the daily consumption increases 5-10 times from 1 to 2g.

The leucoanthocyanins content in the examined species of apples is noted in higher quantities (80-90mg/100g) than catechins.

This way judging by the experimental records chosen objects of studying can be fully regarded as a functional source of P-active compounds. The studying of fat-soluble vitamins content in the examined examples of apple fruits has shown that vitamin E, K and beta-carotene take place there. But their mass fraction is really low, which corresponds with the biochemistry of fruits. This way the vitamin E content varies within the limits of 0, 02-0,06mg/100g, vitamin K – 2, 05-2,2mg/100g, and beta-carotene – 0,03mg/100g.

The nutrition value is also determined by the mineral composition. Mineral substances are irreplaceable components of food.

Because of that we analyzed the content of the main macronutrients such as potassium, calcium, magnesium, sodium, phosphorus, and micronutrients such as ferrum, zinc, cuprum.

The information about the mineral content of the examined species of apple fruits is given in the table 3.

According to the data above we can see that from all the macronutrients the highest content is noted for the potassium (170-290mg/100g), the lowest – for magnesium (3-8mg/100g).

With that the range of the daily provision of potassium consists of 4,5 to 7% during the consumption of 100g. It should be mentioned that despite the fact that the degree of daily provision of potassium is not essential, this macronutrient that guarantees the correct activity of cardio muscle and regulates water-electrolyte balance is recommended for those who suffers from various cardiovascular diseases, especially from the misbalance of the heart-work and hypertonic disease. That why to our mind apple fruits are expedient to be included into the healthy nutrition meals. Besides that this raw material can be regarded as a functional source of potassium during the creation of functional food products.

Ferrum dominates all the micronutrients. Its content composes 2,2mg/100g (for Golden Delicious sort) to 3,7mg/100g (for Aidared (RK)). With that the degree of daily provision of ferrum is within the range of 3, 5-7% during the consumption of 100g of apples. But from the scientific point of view it is no expedient to regard examined species of apples as a source of ferrum. Ferrum that is contained in green raw material products is a chemical form that technically cannot be assimilated in human organism.

Pectin substances are rather significant components of apples. In fresh apples protopectin dominates the soluble pectin and composes 52, 3-97, 0% from the total amount [6]. With that the most of pectin substances is concentrated in the cuticle and in the seed chambers.

The schematic apple structure is given in the figure 6 [9]. It is established that the pectin substances content is spread in the zones in the following way: A – 4, 9-5, 4% to the mass of dry substances; B – 1, 7-1, 8%; C – 4, 9-5, 1%. With that the highest fraction of protopectin is in the cuticle, and water-soluble pectin – in the pulp [6].

Taking this data into account we held extra examination of the fractional composition of pectin substances definition in the fruit cuticle in means of the sort and the geographical area of growing.

Experimental data of functional composition is given in the figure 7.

According to the information given above, we may see that the Aidared (RK) sort dominates other species in means of total content of pectin substances (1, 34%). But it should be mentioned that the essential difference in pectin content hasn't been noted, and the index variation is caused by the species differences.

For the quality indexes of pectin that compose examined apple fruits species we studied their analytic characteristics – the polyhalacturic acid content, the methoxyl and acetyl components, the degree of etherification, jellied-matter forming and complex forming capability.

The polyuronid component content varied with the limits of 52-57%. The degree of etherification of emphasized pectins was within the limits of 59, 6±1, 5% (for Red Delicious/ Red Delicious (RK)) to 74, 5±1, 5% (for Aidared/ Aidared (RK)). With such degree of etherification and polyuronid components pectins are well-soluble and belong to the high etherification group.

The information about the methoxyl component of the emphasized pectin is given in the figure 8.

According to the experimental data we may see that the methoxyl composition is equally high and is within the limits of 10,0-12,2%. Such indexes let us predict the high jellied-matter forming capability of pectin. The jellied-matter forming is proportional in reverse to the acetyl group consistent. The content of the acetyl composition in the emphasized pectin molecule changed from 0, 1 (for Aidared/ Aidared (RK)) to 0, 3% (for Red Delicious (RK)). But during the experiments it has been established [6] that with the content of acetyl groups of 0, 8% to the pectin mass they don't have essential influence on the jellied-matter forming.

With the higher CH₃CO-groups content the reduction of jellied-matter forming is seen because of the steric repulsion of pectin molecules in the solution.

According to the received data pectin secreted from the fruit cuticle of the Aidared (RK) sort has to have the highest jellied-matter forming capability. This supposition has been proved by the experimental data – the jellied matter forming of pectin has got 150° SAG. In the other examples the jellied-matter forming capacity was within the limits of 130-140° SAG.

Complex forming features of secreted pectin has been defined in means of their capability of quantitative binding of plumbum ions Pb 2+. Complex forming capability of pectin has been within the limits of 120 (for Red Delicious/ Red Delicious (RK) to 80mg Pb2+/g of pectin (for Aidared/ Aidared (RK), which corresponds with the records about their degree of etherification.



Fig. (1) – Golden Delicious apple sort



Fig.(2) – Aidared apple sort



Fig. (3) – Red Delicious apple sort

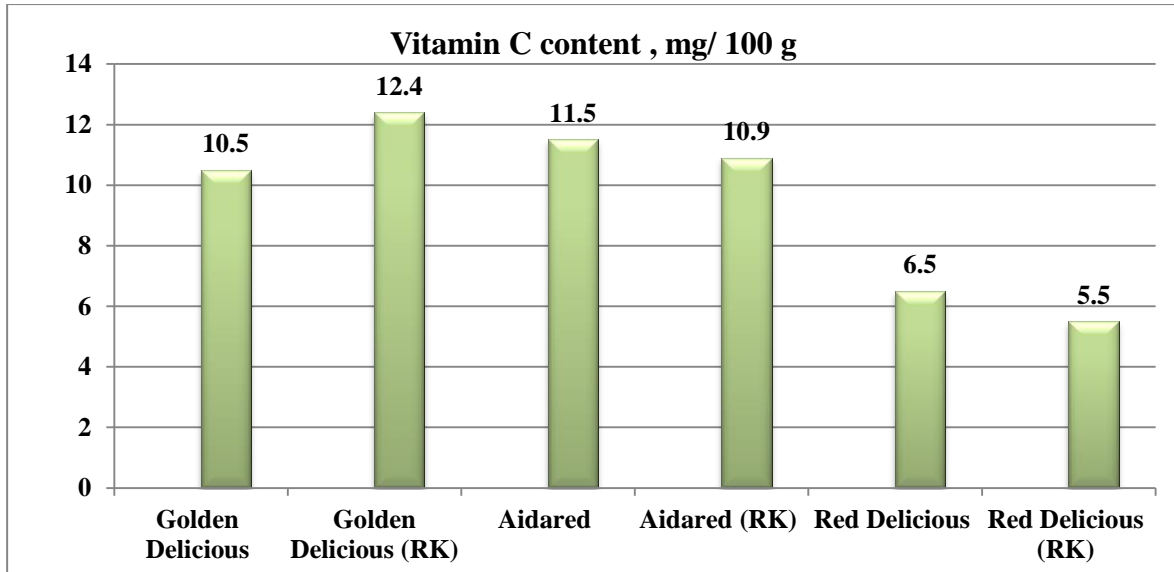


Fig. (4) – Vitamin C content in the examined apple fruits

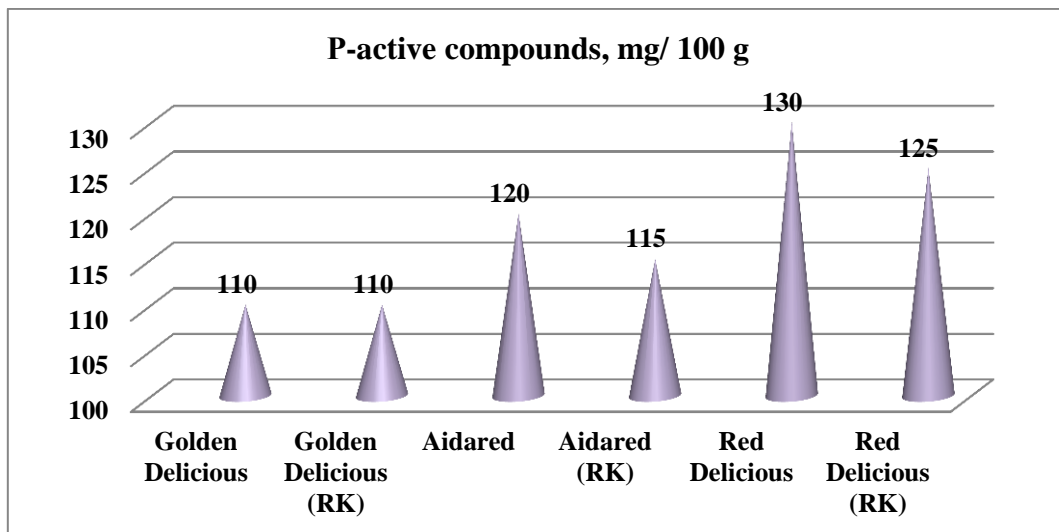
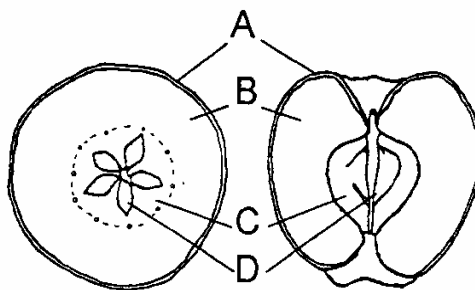


Fig. (5) – P-active compounds content in the examined species of apple fruits



A – epidermis zone; B – outside parenchyma; C – seed chamber parenchyma; D – seeds

Fig.(6) – schematic apple fruit structure

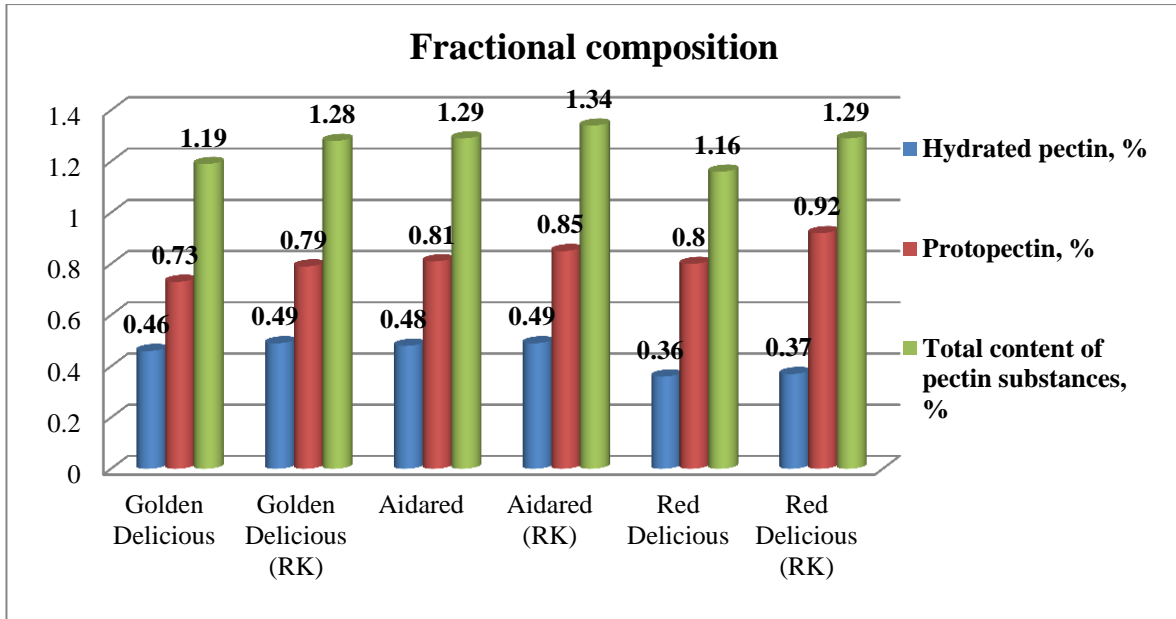


Fig.(7) – Fractional composition of pectin substances in the examined apple fruit species

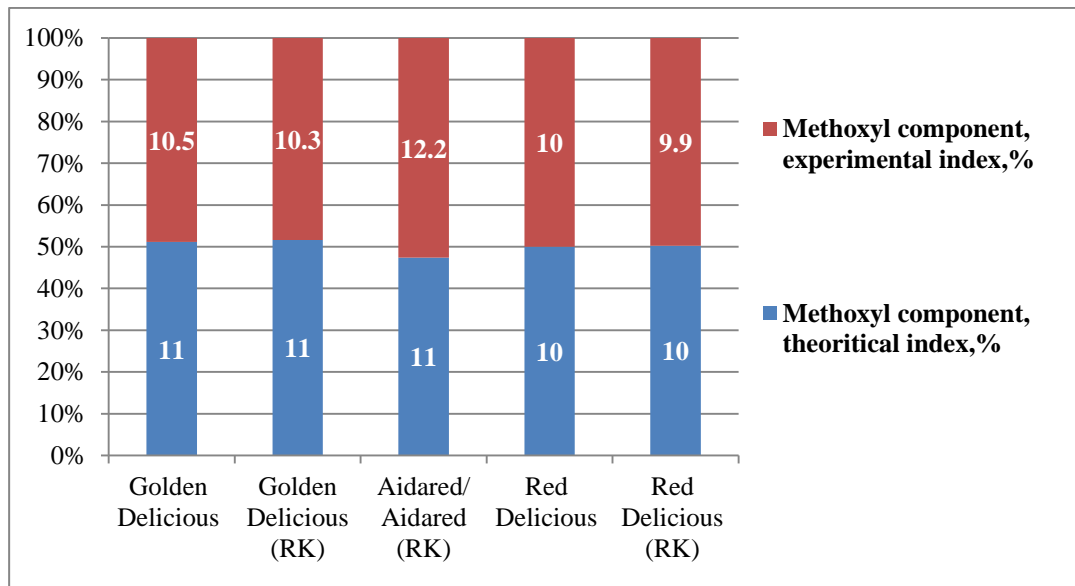


Fig.(8) – Methoxyl component content of pectin substances in the examined apple fruit species

Table 1 – Amino acid composition of examined apple fruits

Name of the substance	Content, mg/100g	Name of the substance	Content, mg/100g
Irreplaceable acids		Replaceable acids	
Valine	0,011	Aspartic acid	0,08
Isoleucine	0,006	Alanine	0,010
Leucine	0,013	Arginine	0,007
Lysin	0,012	Histidine	0,005
Methionine	0,001	Glycine	0,009
Threonine	0,006	Glutamic acid	0,025
Tryptophan	0,001	Proline	0,005
Phenylalanine	0,006	Tyrosine	0,001

Table 2 - Content of vitamins in the samples of apple fruits

Vitamins	Apple fruits species					
	Golden Delicious	Golden Delicious (RK)	Aidared	Aidared (RK)	Red Delicious	Red Delicious (RK)
B1, mg	0,01	0,03	0,01	0,02	0,03	0,02
B2, mg	0,03	0,01	0,02	0,02	0,03	0,03
B3, mg	0,23	0,40	0,28	0,35	0,37	0,38
B5, mg	0,07	0,06	0,05	0,07	0,07	0,06
B6, mg	0,08	0,07	0,07	0,07	0,08	0,08
B9, mcg	1,6	2,0	1,8	1,9	1,7	1,8
H, mcg	0,3	0,2	0,2	0,2	0,3	0,3

Table 3 - Content of mineral substances in the samples of apple fruits

Substances	Apple fruits species					
	Golden Delicious	Golden Delicious (RK)	Aidared	Aidared (RK)	Red Delicious	Red Delicious (RK)
Macronutrients, mg/100g						
Potassium	275	290	250	240	190	170
Calcium	27	29	26	24	18	17
Magnesium	6	4	7	4	8	3
Natrium	21,7	22,6	20,1	19,4	16,7	15,0
Phosphorus	9	11	10	10	12	11
Micronutrients, mcg/100g						
Ferrum, mg	2,2	2,5	3,2	3,7	3,6	3,5
Zinc	120	150	110	130	125	140
Cuprum	100	110	90	100	110	120

CONCLUSIONS

Based on the foregoing we may come to the conclusion that chosen industrial species of apple tree fruits are functional source of pectin substances, carbohydrates, organic acids, vitamin C, P-active compounds and potassium. This way with the consumption of one apple per day physiological need of vitamin C is provided in 50% in average (Golden Delicious (RK) sort), P-active compounds – 90% (Red Delicious sort), potassium – 10-15% (Aidared (RK) and Golden Delicious (RK) sorts).

Endings

This way the results of experimental studying give us a reason for the conclusion about the expediency of regarding apple fruit species as objects of studying as raw material for the elaboration of functional food products.

Contributions

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