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Microbiological, Physico-Chemical and Organoleptic Parameters of Apple Juice, Processed by Shungite

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Abstract: This paper is dedicated to results of studying microbiological, physico-chemical and organoleptical parameters of apple juice processed by shungite. Shungite is a natural mineral which has special structural composition, characterized by the existence of fullerenes and nanotubes. This paper explains the methods applied by the authors to prepare shungite for experimental research, to process apple juice by adsorbent, to determine the quantity of microorganisms in juice after it interacted with shungite, weight percentage of dissolvable dry solids, active acidity and quality parameters. In juice, processed by shungite, bacteria, fungi and yeast were detected. The authors made a comparison between microbial population in juice before and after its interaction with shungite. The paper refers to method under which shungite adsorbs bacteria, fungi and yeasts. The authors presented the results of studying dry solids content, active acidity of apple juice, processed by shungite at various temperatures and conducted assessment of apple juice quality after its interaction with sorbent. Through their research, the authors established rational parameters of apple juice processed by shungite under which the maximum reduction of microbial insemination is reached. The research proved that after apple juice interacts with shungite, its dry solids content and active acidity level remain unchanged. This paper confirmed high quality parameters of apple juice processed by shungite. Taking into account the obtained results, the authors concluded that use of shungite to process apple juice does not require expensive equipment, complex maintenance of the processing procedure, which reduce the cost value of a manufactured product.

Key words: Apple juice, shungite, adsorptive processing, microorganisms, quality parameters.

1. Introduction

Fruit and vegetable juices have been traditionally enjoying stable demand. In addition to refreshing ability, nutritional and stimulating effect, harmonious taste, they contain vitamins and range of biologically active substances, necessary for proper and healthy nutrition.

However, juices have the highest water activity (a_w 0.98-0.99) and present themselves as a favorable environment for microbial growth. Content of sugars stimulates the growth and reproduction of lactic acid bacteria, cocci and yeast (*Saccharomyces*, *Hanseniaspora*, *Torulopsis* and *Candida*). Lactic acid bacteria convert apple acid into lactic acid and together with carbon dioxide create a stable turbidity, thus spoiling juice. Acidic environment is favorable for fungal growth, which by neutralizing the acidic environment facilitates the development of putrefactive microorganisms. The molding of the finished product is often caused by fungi of *Penicillium*, *Aspergillus* and *Monilia*. By decomposing fruit acids, they form gluconic and oxalic acid [1, 2].

To prevent microbial spoilage of food products, including fruit juices, various processing methods are used: ultrasound, ultraviolet, high-frequency currents, sterilization or pasteurization, cooling, drying, pickling, fermenting, applying chemical preservatives and others [3, 4].

The above methods fail to ensure that apple juice is not spoilt because the effect of ultraviolet rays only occurs at a depth of 0.1 mm [5]. Some of the mentioned

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techniques are expensive and require special equipment as well as availability of trained personnel [4-6].

One of the priority areas to improve the quality of apple juice is the use of natural dispersive minerals, which have developed porous structure, possess adsorptive and ion-exchangeable capacities, can be regenerated, utilized and are low cost [7-9].

Adsorbents, used for manufacturing food products, have to meet strict sanitary and hygienic requirements, in particular, they must not contain arsenic and fluorine in any form, compounds of mercury, lead and radioactive substances, they must not bring any unacceptable smells, taste into juice or be a source for pathogenic bacteria, viruses and toxins which could cause illness for a human being or lead to the decrease of nutrition value of raw or semi-finished products processed by adsorbents [8, 10]. Carbon-bearing sorbent shungite meets such criteria [11].

Shungite is the only known species of mineral containing fullerenes (new globular form of carbon existence). Feature of fullerenes structure is that atoms of carbon in molecules are located at peaks of regular pentagons and hexagons that cover the surface of the sphere and form closed polyhedrons created by even number of coordinated carbon atoms. Special feature of fullerenes is that they have large number of reaction centers [12-14].

Shungite's ability to adsorb different substances is determined by its surface structure, nature and concentration of surface reactive groups. Another important factor is that this mineral has fullerene carbon nanotubes, which cylindrical cavity diameter is 1-6 nm and length attains up to several microns. The cylindrical surface of tubes is formed by rings of active carbon and has free porous space [13, 15].

The results of the previous studies [16, 17] have established environmental safety of using shungite for processing vegetable juices.

The aim of this work was to study the microbiological, physico-chemical and organoleptic parameters of apple juice processed with shungite.

2. Materials and Methods

Shungite of Karelian deposits was washed with water to attain pH = 6.5 and then it was thermoactivated at 100 °C for 1 h, cooled, and fraction of 1.0-3.0 mm was separated [18].

Shungite (previously prepared in concentrations of 1.0, 1.5 and 2.0 weight percents (% wt)) was placed in freshly-squeezed apple juice, stirred, kept at 40, 60 and 80 °C for 20, 40 and 60 min. After processing, the mixtures were decanted, filtered and filtrates were used to determine quantity of microorganisms and the mass fraction of dry solids (DS).

Quantity of microorganisms in apple juice, processed by shungite, was determined in the following way: samples of apple juice, processed by shungite at various technological parameters, and control sample (freshly-squeezed juice) were diluted (1:1,000, 1:10,000, 1:100,000), from each dilutions 0.1 cm^3 were inoculated in Wort agar (WA) for fungi, and meat infusion agar (MIA) for bacteria [2, 19]. All treatments were incubated for 3 days at 28-30 °C for fungi, and 37 °C for bacteria. After 3 days of incubation, microscopic examination was performed to identify microorganisms and their quantitative estimation.

Mass fraction of dry solids was determined by refractometric method according to ГОСТ 228652-90, active acidity according to ГОСТ 26188-84, assessment of shungite-processed apple juice quality was performed according to ГОСТ 8756.1-79.

3. Results and Discussions

During microscopic examination bacteria (cocci, micrococci), fungi and yeasts (*Aspergillus*, *Penicillium* and *Mucor*) were detected. Quantity of microorganisms, detected in the samples, is presented in Table 1. Permissible quantity of cells (CFU) in 1 g (mL) of a product, which does not affect its microbiological stability during storage and is not dangerous to human health, is 1×10^1-1×10^3.

Table 1 Microorganisms in apple juice processed by shungite (CFU).

Microorganism species	Duration (min)	Temperature (°C)								
		40			60			80		
		Shungite concentration, % wt								
		1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0
Bacteria (cocci, micrococci) (control sample 1.1×10^3)	20	9.0×10^2	8.0×10^2	2.0×10^2	3.8×10^2	1.9×10^2	0.7×10^2	3.3×10^2	1.3×10^2	0.4×10^2
	40	5.4×10^2	7.3×10^2	1.9×10^1	4.1×10^2	0.3×10^2	1.8×10^1	2.6×10^2	0.3×10^2	1.7×10^1
	60	0.5×10^1	n/d	n/d	0.4×10^1	n/d	n/d	$0,3\times10^1$	n/d	n/d
Fungi (control sample 7.6×10^1)	20	5.8×10^1	4.2×10^1	n/d	5.6×10^1	4.0×10^1	n/d	5.1×10^1	4.0×10^1	n/d
	40	4.2×10^1	3.8×10^1	n/d	4.0×10^1	3.8×10^1	n/d	3.9×10^1	3.8×10^1	n/d
	60	3.9×10^1	3.2×10^1	n/d	3.5×10^1	3.1×10^1	n/d	3.2×10^1	3.0×10^1	n/d
Yeast (control sample 8.2×10^1)	20	6.2×10^1	5.3×10^1	5.0×10^1	5.8×10^1	4.9×10^1	4.5×10^1	5.2×10^1	4.8×10^1	4.5×10^1
	40	6.0×10^1	n/d	n/d	6.0×10^1	n/d	n/d	5.0×10^1	n/d	n/d
	60	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d	n/d

*n/d: not detected.

The results of the conducted studies show a tendency of decrease in quantity of microorganisms in 1.5-100 times, and in some samples, processed by shungite under different temperature conditions, processing duration and sorbent concentration, compared with control sample, they were not identified at all. The quantity of bacteria in juice processed at 60 °C and with adsorbent concentration of 2.0% wt, decreases from 1.1×10^3 to 0.4×10^2 and to 1.7×10^1 units when duration of processing constitutes 20 min and 40 min, respectively. Under the same conditions and with 60 min duration of juice processing, bacteria are completely adsorbed by shungite.

Under the studied, technological parameters of processing apple juice by shungite, the quantity of fungi decreases from 1.5 times to 2.5 times, compared with control sample, and with adsorbent concentration of 2.0% wt, fungi are completely removed from the juice.

Yeast was not identified in samples, processed by shungite with concentration of 1.0%, 1.5% and 2.0% wt and with duration of 60 min. In juice, processed by adsorbent for 40 min, small quantity of yeast was identified. As control sample, apple juice, still under the experiment conditions without being processed by shungite, was used.

Such significant reduction of bacteria, fungi and yeasts content in apple juice processed by shungite can be explained as follows: the combined effect of temperature (60 °C and 80 °C) and juice pH facilitated the coagulation of protoplasm protein of the above mentioned microorganisms. As the result, water "cocoon" and ion charge of cells changed, in addition, ζ-potential almost completely disappeared [10, 20]. Having lost charge, bacterial cells were drawn to adsorbent due to the forces of Van-der-Waals-London, resulting in forming aggregates of cells and mineral. Adsorbed by shungite, microorganisms were removed together with sediment.

When processing apple juice by shungite, simultaneously with the adsorption of harmful microorganisms, colloidal substances are also adsorbed, and that in turn promotes clarification of juice [21].

Figs. 1-3 show results of dry solids content in apple juice purified by shungite at 40, 60 and 80 °C depending on the adsorbent concentration and duration of juice processing.

Analyzing the outcomes of the research, presented in Figs. 1-3, we see that the content of DS, after apple juice is processed by shungite with concentration 1.0%, 1.5% and 2.0% wt, at 40, 60 and 80 °C and under duration of 20, 40 and 60 min, does not change when compared with control sample.

The results of the change in active acidity of apple juice, processed by shungite, depending on adsorbent concentration and duration of processing, are presented

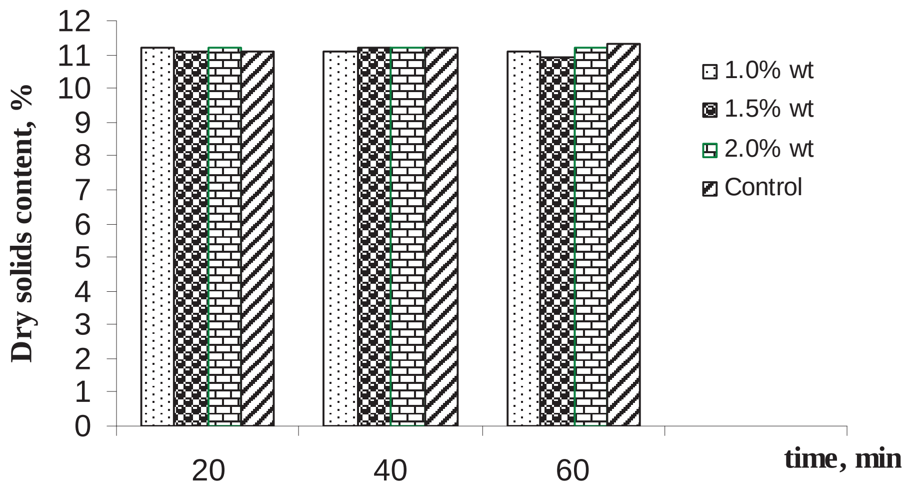

Fig. 1 Dry solids content in apple juice, purified with shungite at 40 °C, depending on the concentration of adsorbent and duration of processing.

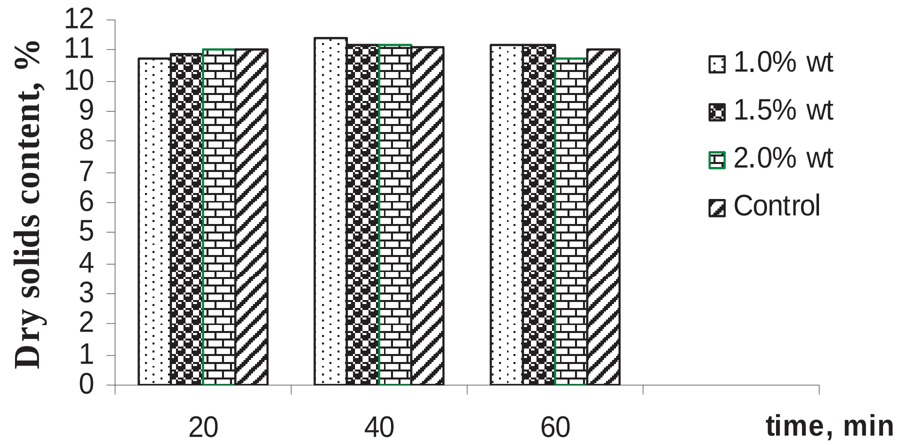

Fig. 2 Dry solids content in apple juice, purified with shungite at 60 °C, depending on the concentration of adsorbent and duration of processing.

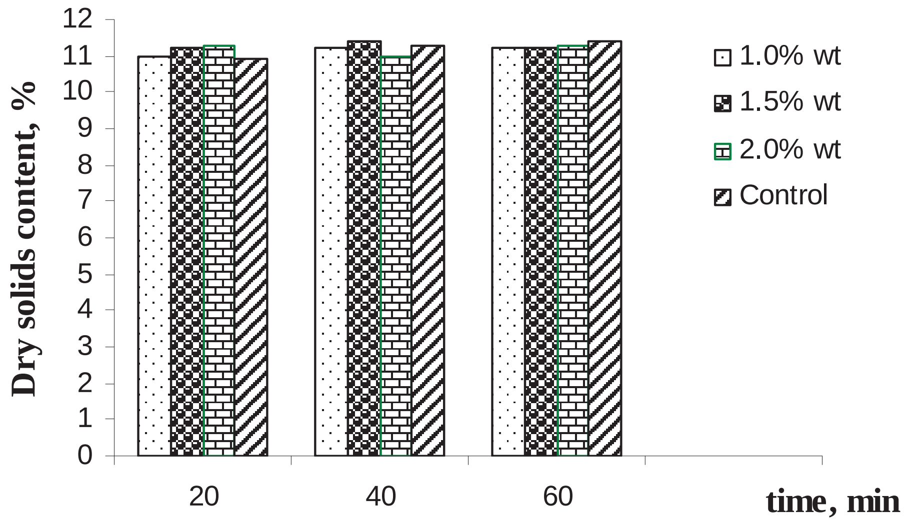

Fig. 3 Dry solids content in apple juice, purified with shungite at 80 °C, depending on the concentration of adsorbent and duration of processing.

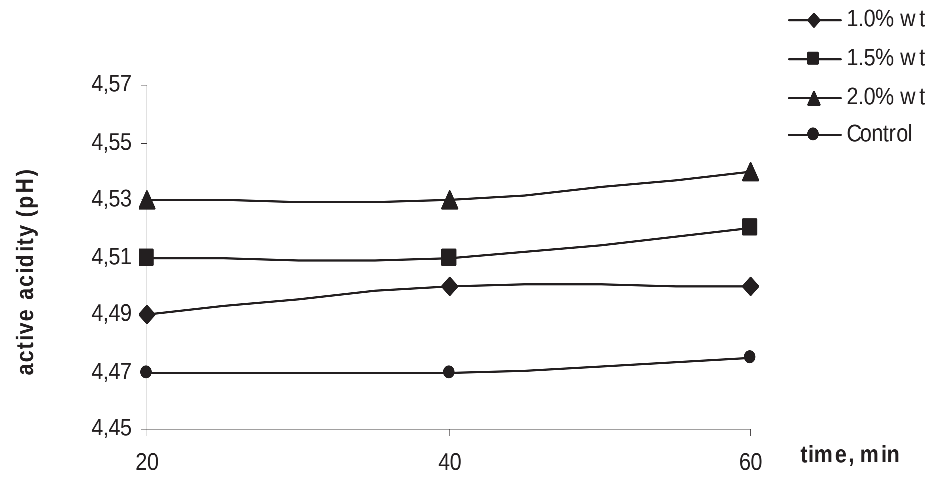

Fig. 4 Active acidity (pH) in apple juice, purified by shungite at temperature 40 °C, subject to adsorbent concentration and duration of processing.

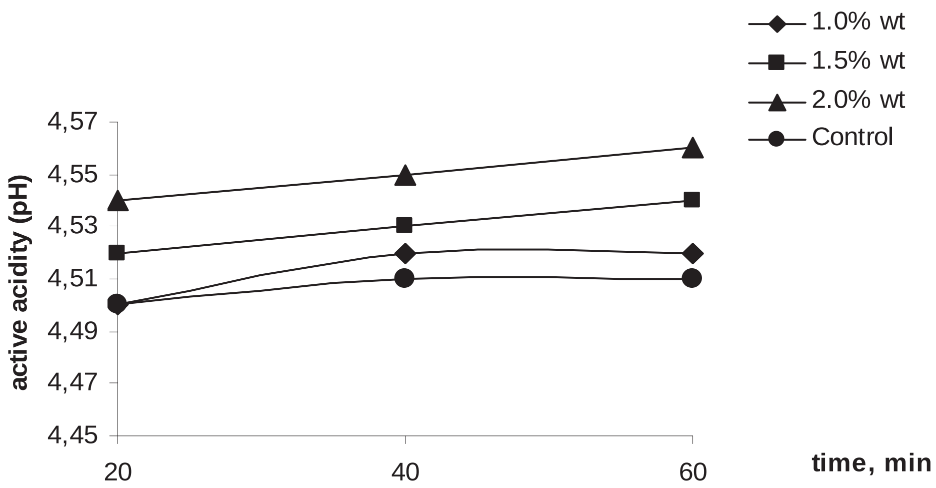

Fig. 5 Active acidity (pH) in apple juice, purified by shungite at temperature 60 °C, subject to adsorbent concentration and duration of processing.

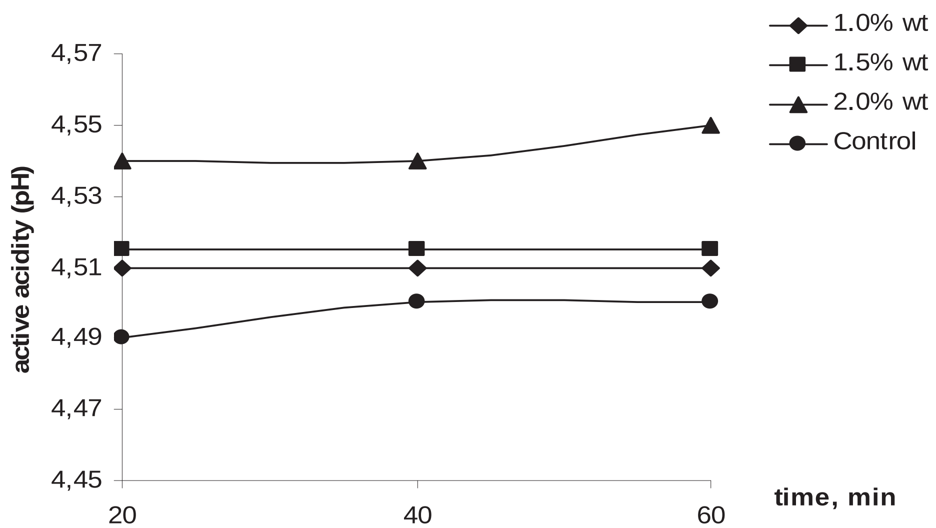

Fig. 6 Active acidity (pH) in apple juice, purified by shungite at temperature 80 °C, subject to adsorbent concentration and duration of processing.

Table 2 Organoleptic parameters of apple juice purified with shungite which has concentration of 1.5%-2.0% wt, during 60 min, at 60 °C.

Parameter name	Characteristics
Visual appearance	Color is light, light amber, appropriate for raw material used for producing juice. Without amorphous sediments, traces of black spots, pulping particles and seeds or other visible defects.
Taste and smell	Pleasant, lightly sour taste, typical apple smell without strange aftertaste or odor.

in Figs. 4-6.

Analyzing the results in Figs. 4-6, we observe insignificant increase in pH of juice medium compared with control sample after its processing by shungite at 40 °C of apple juice-adsorbent mixture during 20, 40 and 60 min. Apple juice pH increases from 4.49 up to 4.52, from 4.51 up to 4.53 and from 4.53 up to 4.54 when juice interacts with adsorbent which has concentration of 1.0%, 1.5% and 2.0% wt, respectively. Similar tendency is observed at 60 °C and 80 °C.

Insignificant change in active acidity with increase of temperature is explained by dissociation of acids present in juice.

Quality evaluation of apple juice, processed by shungite, through organoleptic method, is presented in Table 2.

Results from Table 2 evidence that by visual appearance, taste and smell apple juice, processed by shungite, complies with regulatory requirements and is awarded with 4.9 points out of 5 [22, 23].

4. Conclusions

This work proves the expediency of adsorptive processing of apple juice by shungite with fraction of 1-3 mm. Rational parameters of apple juice processing, under which the maximum reduction of microbial insemination is reached, are shungite concentration of 1.5%-2.0% wt, at 60 °C, duration of 60 min.

Dry solids content and level of active acidity in apple juice, processed with shungite almost do not change, whereas, high parameters of quality of apple juice, processed with shungite, are reached. Juice purified by shungite received 4.9 out of 5 possible points.

Using shungite for apple juice processing does not require expensive equipment, complicated support to technological process, thus lowering costs of the final product.

References

[1] Y. Shobinger, Scientific Principles and Theories, Saint Petersburg, Professia, 2004, pp. 243-265. (in Russian)

[2] A.Y. Zhvirblinskaya, O.A. Bakushinskaya, Microbiology in Food Industry, Moscow, Pischevaya Promyshlennost, 1975, pp. 146-187. (in Russian)

[3] I.F. Myronyuk, O.S. Lukanin, V.O. Zagoryulko, Clearing juices and wine-making materials with the help of suspended floating sorbents on the basis of high-dispersion alumosilica, Agricaltural Sciences Bulletin 3 (2001) 63-67. (in Ukrainian)

[4] O.Y. Vopiyashyn, Micro- and ultrafiltration on ceramic membranes when producing juices, Pischevaya Promyshlennost 7 (2004) 60-61. (in Ukrainian)

[5] A.I. Sokolenko, Physical and Chemical Methods to Process Raw Materials and Food Products, Kyiv, ArtEK, 2000, pp. 103-126. (in Russian)

[6] A.F. Fang-Young, Brightening and filtrating of fruit juices, Dissertation for Candicate of Technical Sciences: 0.5. 18.13, Odessa Technology Institute named after Lomonosov, Odessa, 1960, pp. 46-68. (in Russian)

[7] V.A. Kamarina, T.N. Ivanova, Applying natural zeolites as brightening agent to produce juices, Pischevaya Promyshlennost 11 (1997) 58-59. (in Russian)

[8] N.G. Taran, Adsorbents and Ionites in Food Industry, Moscow, 1983, pp. 34-68. (in Russian)

[9] S.V. Matko, Improving adsorptive refining of apple juice and its coupage: Dissertation for Candicate of Technical Sciences: 6.081.3, National University of Food Technologies, 2008, pp. 120-165. (in Ukrainian)

[10] F.D. Ovcharenko, Adsorbents, Their Origination, Parameters and Application, Leningrad, 1971, pp. 47-62. (in Russian)

[11] A.E. Gorstein, N.Y. Baron, Adsorptive capacities of shungites, Bulletin of Universities and Colleges “Chemistry and Chemical Technologies” 22 (6) (1979) 711-715. (in Russian)

[12] A.Z. Zaidenberg, N.N. Trojkova, V.V. Kovalevskyi, Physical and chemical model of fullerene-like carbon in shungites, Materials of the 2nd International Workshop “Fullerenes and Atom Clusters”, Petrozavodsk, Carelia, 1995, pp. 125-131. (in Russian)

[13] A.V. Eletskyi, B.M. Smirnov, Fullerenes and hydrogen structure, Physical Sciences Achievements 165 (9) (1995) 977-990. (in Russian)

[14] F.R. Curl, E.R. Smally, Fullerenes, Uspehi Nauki 12 (1991) 78-83. (in Russian)

[15] V.V. Kovalevskyi, Shungite rocks-crystallogenesis and nanotechnologies, mineralogy, petrology and minerageny of pre-Cambrian complexes in Carelia, materials of anniversary scientific session, Petrozavodsk 35-36 (2007) 335-339. (in Russian)

[16] L.M. Melnyk, Adsorptive purification of red beet juice from heavy metals ions by shungite, collection of scientific papers food science, engineering and technologies, Plovdiv 1 (2011) 537-540. (in Russian)

[17] T. Sheiko, L. Melnyk, Utilization of shungite for improving quality and safety of juices, in: Annual World Conference on Carbon, Clemson, South Carolina, 2010, p. 16.

[18] S.V. Matko, T.V. Sheiko, L.M. Melnyk, Method of activating natural carbon-bearing mineral shungite, Patent No. 61474, 2011. (in Ukrainian)

[19] T.P. Pyrog, L.R. Reshetnyak, V.M. Povodzinskyi, N.M. Gregirchak, Microbiology of food productions, in: T.P. Vinnycya, N. Knyga (Eds.), 2007, pp. 162-184. (in Russian)

[20] V.T. Emcev, V.K. Shilnikova, Microbiology, Moscow, Agropromizdat, 1990, pp. 91-123. (in Russian)

[21] S.V. Matko, A.V. Kryvorotenko, A.O. Ryabchenko, Method for brightening apple juice, Patent No. 933256, Bulletin No. 14 dated 25.01.11. (in Ukrainian)

[22] D.E. Tilnger, Organoleptic Analysis of Food Products, Moscow, Pyshepormizdat, 1962, pp. 145-167. (in Russian)

[23] Canned food products, methods to determine organoleptic parameters, net weight or volume and weight percerntage of compounds: ГОСТ. (in Russian)