IMPROVING THE TECHNOLOGY OF PRODUCING FOOD GRADE DYE FROM RED BEET JUICE

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ABSTRACT: Red beet juice is very useful food product, because it contains significant amount of sugars, mineral substances and vitamins. It is also valuable because it is used for producing food grade dye. Nowadays in order to give to food products a color, close to natural coloring of fruits and vegetables, expensive synthetic dyes are used, which might have cancer-inducing effect when being accumulated by human organism. Therefore improving the technology for producing food grade dye from red beet juice is remarkably important task. Currently for the purpose of obtaining dye from red beet juice, a part of pectin substances, which make the process of juice concentration more difficult, is removed with the help of expensive enzymatic agents. The authors have suggested using natural carbon-bearing adsorbent shungite to purify red beet juice from pectin substances.
Key words: *food grade dye, red beet juice, natural adsorbent, shungite*

INTRODUCTION

Red beet juice is very useful food product, because it contains significant amount of sugars, mineral substances and vitamins. It is also valuable because it's used for producing food grade dye.
Nowadays in order to give to food products a color, close to natural coloring of fruits and vegetables, expensive synthetic dyes are used, which might have cancer-inducing effect when being accumulated by human organism. Therefore improving the technology for producing food grade dye from red beet juice is remarkably important task.
Currently for the purpose of obtaining dye from red beet juice, a part of pectin substances, which make the process of juice concentration more difficult, is removed with the help of expensive enzymatic agents (Tymofeeva V.N. et al., 2002).
The authors have suggested using natural carbon-bearing adsorbent shungite to purify red beet juice from pectin substances (Sheiko and Melnyk, 2009; Sheiko and Melnyk, 2010).
Shungite is a mineral consisting of amorphous carbon and fractured graphite. Its chemical composition is not constant: shungite contains 60-70% of carbon and 30-40% of other elements.
Shungite is the only known mineral to have fullerenes (recently discovered new globular form of carbon existence). Fullerenes' structure is peculiar because carbon atoms in molecules are situated at the tops of regular pentagons and hexagons, which cover sphere's surface and present themselves as closed polygons composed of paired quantity of coordinated carbon atoms.
Fullerenes differ from particles with metallic properties due to the location of electron cloud and ability to change the form of carbon structure.
Sizing of electro-magnetic waves is determined by vibration of electrons which are divided into $\pi-\sigma$ and π- states. During adsorption on electrically neutral surface the localization of fullerenes' π-states takes place, and a particle loses its metallic

properties, and because of that connected electron pair appears in the activated form. Thus mineral shows bipolar properties.
Shungite's important characteristic is the presence of fullerene carbon nanotubes with the diameter of their cylindrical pores constituting 1-6 nanometers and the width - up to several micrometers. The cylindrical surface of tubes is formed by active carbon circles and also has empty pores.
The basis of shungite's structure is a globule composed of graphitic networks, formed into packages. Each package has 6 graphitic flat networks with the quantity of carbon atoms attaining to 300-600 and one curved network, having 400 carbon atoms.

MATERIAL AND METHODS

Shungite to be used for research was prior washed out with cold water and then termoactivated at 100℃ during 90 minutes. Cooled a dsorbent in concentrations of % mass.: 2.44; 3.23; 4.76; 9.09 was put into fresh red beet juice at temperature of 20, 40, 50, 60ºC, mixed during 10, 20, 30, 60 min., filtrated. The content of pectin substances in filtrate was measured in accordance with **calcium** pectate **method under formula:**

$$\cdot \quad ПР = \frac{(g - g_0) \cdot 100 \cdot 0.9235}{V \cdot d}$$

whereas ПР – content of pectin substances in juice, mg/g;
g – weight of weighting cup with precipitate before exsiccation, g;
g0 – weight of empty weighting cup, g;
V – juice volume, cm3;
d – juice density, g/cm3;
0,9235 – coefficient for conversion of calcium pectate into pectic acid.

The obtained results were compared by effect of purification:

$$E = \frac{100 \cdot (K_1 - K_2)}{K_1}$$

whereas K1 and K2 – quantity of target component in juice which was not processed by adsorbent and juice which was processed by adsorbent.
The obtained results are shown in table below.

Table 1. Effect of purification (E,%) from pectin substances in red beet juice by shungite at different adsorbent concentrations, temperature of mixtures, duration of interactions between adsorbent and juice, initial content of pectin substances is 1.9 mg/g

Effect of purification	Adsorbent concentration in juice, % mass															
	2.44				3.23				4.76				9.09			
	Temperature, ºC															
	20	40	50	60	20	40	50	60	20	40	50	60	20	40	50	60
	Duration of juice processing, 10 min															
	Content of pectin substances, mg/g															
Processed juice	1.8	1.8	1.7	1.7	1.8	1.7	1.7	1.6	1.7	1.6	1.5	1.5	1.6	1.6	1.5	1.4
E, %	5.3	5.3	10.5	10.5	5.3	10.5	10.5	15.8	10.5	15.8	21.0	21.0	15.8	15.8	21.0	26.3
	Duration of juice processing, 20 min															
Processed juice	1.7	1.7	1.6	1.6	1.5	1.5	1.4	1.3	1.5	1.4	1.3	1.2	1.4	1.3	1.2	1.2
E, %	10.5	10.5	15.8	15.8	21.1	21.1	26.3	31.6	21.1	26.3	31.6	36.8	26.3	31.6	36.8	36.8
	Duration of juice processing, 30 min															
Processed juice	1.6	1.6	1.5	1.5	1.4	1.4	1.3	1.2	1.5	1.3	1.2	1.1	1.4	1.3	1.1	1.1
E, %	15.8	15.8	21.1	21.1	26.3	26.3	31.6	36.8	21.1	31.6	36.8	42.1	26.3	31.6	42.1	42.1
	Duration of juice processing, 60 min															

Processed juice	1.6	1.6	1.5	1.5	1.4	1.3	1.2	1.2	1.5	1.3	1.2	1.1	1.3	1.2	1.1	1.1
E, %	21.1	21.1	26.3	26.3	26.3	31.6	36.8	42.1	21.1	31.6	36.8	42.1	31.6	36.8	42.1	42.1

RESULTS AND DISCUSSIONS

The obtained data shows that adsorption of pectin substances from red beet juice by shungite takes place already at temperature of 20ºC. If temperature rises the process is somewhat accelerated. The rise of temperature of processing juice over 60ºC is unreasonable because coloring components are destroyed and that causes the changes in juice color.
Comparing the obtained results and their practical efficiency the authors determined optimal parameters, concluding that the optimal parameters for processing juice by shungite is adsorbent concentration of 4.76% mass, temperature of processing 50, 60º C, duration - 30 min. Under such conditions 36.8%-42.1% of pectin substances are removed.
The mechanism of adsorbing pectin substances from red beet juice by shungite is explained not only due to the fact that impurities infiltrate the mineral's pores, but also due to ion-exchange adsorption in places where reactive centers of fullerenes are formed and hydrogen bonds with pectin molecule are created.
Shungite's selectivity is explained not only because of the existence of micro-, mezzo- and macropores, but also because nanotubes participate in adsorption processes and there are pores in between them, created when packages are formed, and also because of free non-compensated charges which appear on adsorbent's surface.
The next phase of research was determining the content of coloring substances of red beet juice, processed by shungite at temperature of 50ºC. Preparation of shungite was performed in the same way as for adsorption of pectin substances. The content of coloring substances was determined according to standard methodology – reaction of Neubauer-Levental. Estimation of mass content of coloring substances was performed under formula:

$$X = \frac{(M_1 - M_2) \times K \times 0{,}004157 \times O_1 \times 100}{H \times O_2}$$

whereas X – mass content of coloring substances,%;
M1 – quantity of 0.1 normality of solution of potassium permanganate, used for the first titration, cm3;
M2 - quantity of 0.1 normality of solution of potassium permanganate, used for the second titration, cm3;
O1 – volume of the primary extraction, cm3;
H – quantity of juice used for experiment, cm3;
O2 – volume of the secondary extraction, used for titration, cm3;
0.004157 – coefficient which takes into account correlation between potassium permanganate and juice coloring substances.

The research was performed and its results are showed in figure 1.

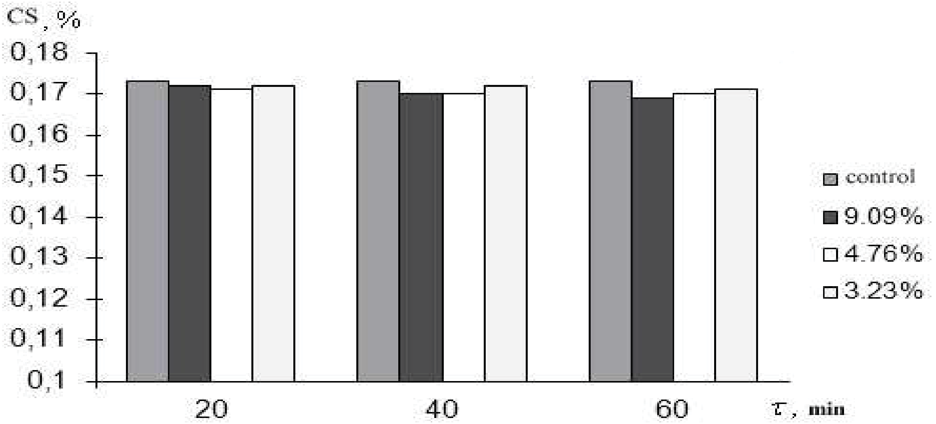

Figure 1. Quantity of coloring substances (CS) in juice processed with shungite depending on the duration of its processing at temperature of 50ºC.

Analysis of data presented in fig.1 gives grounds to state that content of coloring substances in red beet juice, after it was processed by shungite, practically does not change. This can be explained by the fact that the basis of coloring substances in red beet juice is anthocyanins (Saburov and Antonov, 1951; Tanchev S.S., 1980). By their structure they are chains of glicosides, composed of heterocyclic compounds. By their chemical nature they are surface active substances. On interphase border anthocyanins' molecules are situated in such a way that hydrophilic group remains in liquid state. Hydrophobic effect takes place and thus coloring substances are not adsorbed by shungite.
The authors improved apparatuses and technological scheme for producing food grade dye from red beet juice by installing two adsorbing devices with shungite which work in regime of sorption-desorption.
After part of pectin substances are removed in adsorbing device, red beet juice is placed in vacuum evaporator where it is concentrated around 6 hours. Concentration of juice by its evaporation takes place with discharge of 0.055 – 0.060 MPa and temperature of 55-60ºC, concentrated red beet juice, already as food grade dye, is packed in the sealed container, made of dark glass. The level of pH in the obtained food grade dye does not exceed 4.5.
The used adsorbent is sent for regeneration, utilization.

CONCLUSIONS

It was established that shungite effectively adsorbs pectin substances from red beet juice and does not adsorb coloring substances. The technology of producing food grade dye was improved by additional purification of red beet juice from pectin substances by shungite. The obtained optimal technological parameters for purifying juice with shungite are as follows: adsorbent's concentration constituting 4.76% mass., temperature is 50-60ºC, duration of processing is 30 min. Apparatuses and technological scheme of producing food grade dye is supplemented with two adsorbing devices with shungite, which work in regime of sorption-desorption. The used adsorbent is recommended to be regenerated, utilized.

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