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HERBAL SHAMPOOS BASED ON VEGETABLE WASTE PRODUCTION

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Abstract

Currently, much attention is paid to the development of consumer products based on secondary resources, in particular using production waste. One of the perspective directions of using of plant waste products is their use for making shampoos. This article presents the results of studying of influence of tinctures of blueberry leaves tall (*Vaccinium corymbosum*) and seed buckwheat grass (*Fagopyrum esculentum*) on the index of quality of the developed shampoos. An anionic surfactant (SLES, IFRAPON LOS 2 N 70 trademark) was introduced into the composition of the developed shampoo. This is due to variety of causes, for example, it has a more gentle effect on the scalp and hair compared to other sorts of surfactants. Physicochemical parameters characterizing the basic properties of water solutions of anionic surfactants, such as foam number, foam stability, pH, and conditional viscosity, are determined. It was determined that optimal concentration of anionic surfactant for introducing shampoo into the composition is 0.02 % (mass). It was also determined that optimal condition of tincture of blueberry leaves and tincture of buckwheat grass in the composition of shampoo is 10 % (vol.). Thus, the introduction of tinctures of said plant raw materials into shampoos provides technological index of shampoos at the level of indicators established in GOST 31696–2012, and the biologically active substances contained in tinctures certainly have a positive effect on the scalp and hair of consumers

Keywords

Shampoo, anionic surfactant, sodium laureth sulfate, tincture, blueberry leaves tall, seed buckwheat grass

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Introduction. Currently, the problem of resource depletion is very relevant. Therefore, the development of methods for producing consumer products from previously unused waste is the basis of the most modern technologies. One of these technologies is the production of herbal shampoos using plant waste products.

The composition of shampoos includes the following groups of substances: surface-active substances (surfactants) as the main component; stabilizing and emollients; biologically active substances (BAS); a variety of flavors, solvents, dispersants, etc. It should be noted that the use of plant-based BAS in shampoos helps to solve a number of problems, namely: to increase the shelf life (use as preservatives); give additional useful properties (antioxidant, regenerative), etc. [1, 2].

It is known that shampoos with plant-derived biologically active substances are able to refresh, soften and tone the surface of the hair and scalp, can improve its blood supply and regeneration, strengthen hair and stimulate their growth. As a source of biologically active substances, various plant raw materials are currently widely used. For example, to normalize the condition of the scalp, extracts of brotherwort (*Thymus*), sage (*Salvia*), oregano (*Origanum*), thyme (*Thymus*), rosemary (*Rosmarinus*), ginseng (*Panax*), chamomile (*Matricaria*), common balm (*Melissa*), phyllanthus emblica (*Emblica officinalis*), licorice (*Glycyrrhiza*) [3–6] and others.

However, in our opinion, it is very prospecting to use waste products as plant raw materials.

As the vegetable raw material we selected: seed buckwheat grass (*Fagopyrum esculentum*) and blueberry leaves tall (*Vaccinium corymbosum*). The choice of this plant material is explained by the fact that it is rich in biologically active substances. Blueberry contains a BAS complex, namely according to [7–11]: vitamins C, B1, B2, B6, A, P, flavonoids, tannins, anthocyanins, proteins, tocopherols, fatty acids, macrocells (potassium, calcium, magnesium, sulfur, phosphorus), trace elements (iron, copper, zinc, manganese) and others. Buckwheat, in turn, is also rich in biologically active substances [12–17]: anthocyanins, proanthocyanidins, flavonoids (dominance of routine), flavonols, vitamins, organic acids (citric, malic, oxalic), as well as benzoic and phenol-carboxylic acids, etc.

Besides, at present, this plant material has not found wide application. For example, buckwheat grass is either burned or turned under in the fields, and blueberry leaves are destroyed after picking.

It should be noted that when developing shampoos, anionic surfactants were used; this is due to the fact that shampoos containing this particular type of surfactant are the most popular among consumers. This, in turn, can be explained

by a number of advantages of anionic surfactants compared to cationic surfactants: they irritate and degrease the skin less (although they are more powerful allergens compared to cationic surfactants [18]), since the pH value is close to the values of the hydrogen index specified in GOST 31696–2012 (5.0–8.5); easily combined with biologically active substances (effective nutrition of the scalp); resistant to hardness salts of water and easily dissolved; have good foaming ability and washing ability; stable in storage at a temperature not lower than 5 °C; wash off well and do not leave taint on hair and skin; make hair soft, give it shine [18].

Thus, the aim of the work was to develop new herbal shampoos using plant waste products.

Data and methods for solving problems, accepted assumptions. As a raw material for obtaining tinctures, dried blueberry leaves tall and seed buckwheat were used. The raw materials were exposed to air-shadow drying — the raw materials were laid out under canopy.

The harvesting of blueberry leaves tall was carried out from plants cultivated on the territory of the Vitebsk region, Sharkovshchinsky district, GLFU Postavy Forestry (harvested July 2018). Water was used as an extractant. The ratio of raw materials: extractant = 1: 40.

We also used the aerial part of buckwheat of the cultivar Marta cultivated on the territory of the Grodno region of the Republic of Belarus. Raw material samples were collected in 2017. Water was used as an extractant. The ratio of raw materials: extractant = 1: 20.

Tinctures from plant materials were obtained as follows.

1. Weighed chopped (3–5 mm) blueberry leaves and placed in a chemical glass, poured water at room temperature and infused for 45 minutes. The infusion was filtered through a funnel with a gauze filter. The leaves were again flooded with water (t = 100 °C). Extraction was carried out for 18 hours. Then both infusions were mixed.

2. Weighed chopped (3–5 mm) grass of buckwheat sowing (leaves, stems), placed in a round bottom flask, filled with water (t = 100 °C). Boiled for 2 hours in a water bath under reflux. It was filtered through a funnel with a gauze filter.

As an anionic surfactant, water solution of sodium laureth sulfate (SLES, trademark IFRAPON LOS 2 N 70) was selected. The choice of this particular surfactant is explained by its high efficiency, low price and, most importantly, it has a less aggressive effect on the skin of the consumer [19].

To study the effect of the concentration of anionic surfactants on the properties of its water solution (in the range from 0.01 to 5.00 % (mass.), ln c from –4.6 to 1.6), the main physicochemical parameters of the obtained solutions

were determined (foam number (foaming ability), foam stability, pH and conditional viscosity (consistency)).

Foam number: the height of the foam column obtained by the free fall of 200 cm^3 of water solution of the product from a height of 900 mm onto the surface of the same solution.

Foam stability: the ratio of the height of the foam column after 5 minutes of its existence to the foam number.

The foam number and foam stability were carried out in accordance with GOST 22567.1–77 [Synthetic detergents. Method for determining foaming ability].

The pH value was carried out by the potentiometric method using a Hanna instruments pH 211 microprocessor pH meter.

To determine the consistency of the developed shampoo, the viscosity of the used surfactant solutions was measured using a VZ-246 viscometer in accordance with GOST 9070–75 [Viscometers for determining the viscosity of paints and varnishes].

Discussion of the results obtained. *Studying the effect of the concentration of anionic surfactants on the properties of its water solution.* It was established (Table 1) that higher concentration of surfactants leads to higher foam number. According to GOST 31696–2012 [Cosmetic and hygienic washing products. General technical requirements] the value of the foam number for shampoos should be at least 100 mm. Therefore, the concentration of surfactants in the shampoo should be at least 0.02 % (mass.).

Another important requirement presenting by consumers for shampoos is foam stability. In the course of studies, it was determined that with an increase of the concentration of surfactants, the stability of the foam increases to a certain value, and then decreases. The highest foam stability was recorded for the sample with a surfactant concentration of 0.10 % (mass.). In accordance with the data of GOST 31696–2012, the stability of the foam should be at least 80 % (see Table 1), so it can be noted that all the samples tested passed the test for this index.

Table 1

The dependence of the performance of water solution of anionic surfactants on its concentration

The concentration of surfactants, % (mass.)	Foam number, mm	Foam stability, %	Conditional viscosity, s
0.01	68	91.10	11.55
0.02	120	93.03	11.08

End of Table 1

The concentration of surfactants, % (mass.)	Foam number, mm	Foam stability, %	Conditional viscosity, s
0.05	180	94.67	10.35
0.10	228	95.64	10.60
0.50	242	93.69	10.53
1.00	256	93.18	10.36
5.00	256	91.41	10.97

Further studied the kinetics of the destruction of the foam for 15 minutes. The results of the study are presented in Fig. 1.

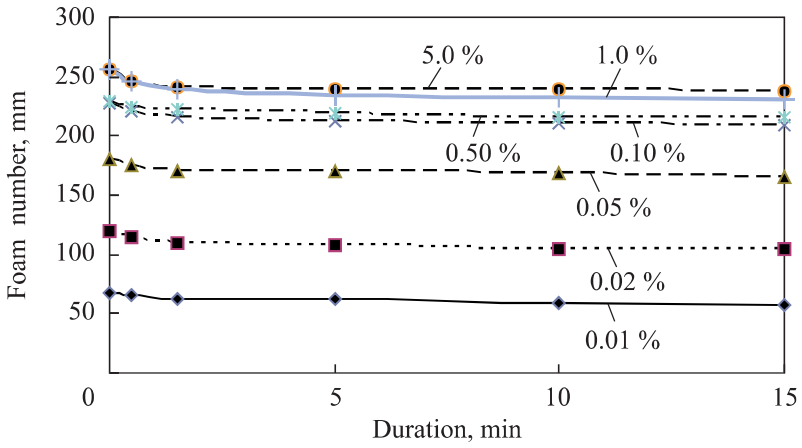

Fig. 1. The dependence of the foam number on the concentration of surfactants

From the data obtained, it is seen that the foam number in all solutions remains practically unchanged for 15 minutes, a noticeable decrease in the foam number only during the first 90 s. Thus, it can be noted that all surfactant solutions form stable foam. However, a solution with a surfactant concentration of 0.01 % (mass.) does not meet the requirements of GOST 31696–2012.

Another important indicator of shampoo quality for consumers is pH. In accordance with GOST 31696–2012, the pH value for hygienic detergents can vary in a fairly wide range from 5.0 to 8.5. However, a strong deviation from the optimal pH level can lead to drying out and irritation of the skin. Fig. 2 shows the dependence of pH on the concentration (mass.) of surfactants in solution.

To give shampoos the desired consistency, thickeners are introduced into its composition, such as: polyacrylic acid, cellulose ethers, etc. Currently, the market for shampoos is very diverse: dry (powder), liquid, creamy and gel-like. Each form of release has advantages and disadvantages. When developing

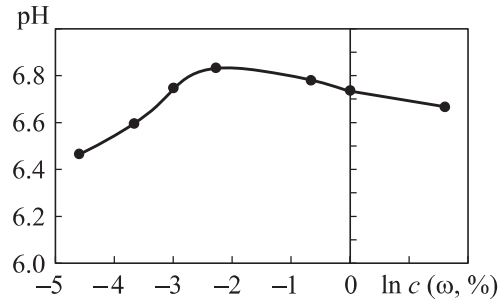

Fig. 2. The dependence of pH on the concentration of surfactants

shampoos, we decided not to introduce additional thickeners to give a more natural product. The results of determining the dependence of the conditional viscosity of the solution on the concentration of surfactants are presented in table 1.

Thus, having analyzed all the data obtained, for further studies, the concentration of anionic surfactant was selected 0.02 % (mass.) in the composition of the shampoo.

Effect of concentration of tincture of blueberry leaves on the properties of water solution of anionic surfactant. For the study, samples of solutions with tinctures containing 0.02 % (mass.) of anionic surfactant and from 10 to 60 % (vol.) tinctures of blueberry leaves were prepared.

The obtained sample solutions were daffodil, due to the content of pigments in the composition of the leaves: carotenoids. Physicochemical parameters were determined for all samples. The data obtained are presented in Fig. 3.

Studies have shown that an increase in the amount of tincture in the solution leads to an increase in the foam number (Fig. 3, *a*), reaching its maximum at a concentration of tincture of 60 % (vol.). It was found that the tincture content in the system also affects the stability of the resulting foams (see Fig. 3, *a*). It should be noted that with increasing concentration of tincture in the solution, the stability of the foam slightly decreases. The maximum value of stability is observed in a solution with a tincture concentration of 10 % (vol.). However, all the obtained foams are highly stable; their stability is in the range of 88–98 % which corresponds to the standard indicators for shampoos.

The pH value (Fig. 3, *b*) of the studied solutions practically did not change with an increase in the tincture content. The average pH value is 3.6. A sharp change in pH of the solution with addition of tincture of blueberry leaves can be explained by the presence in it of a sufficiently large amount of organic acids (malic, citric, benzoic, nicotinic, ascorbic) [20]. When tincture content in the solution in the amount of 10 % (vol.) the equilibrium point is reached, a further

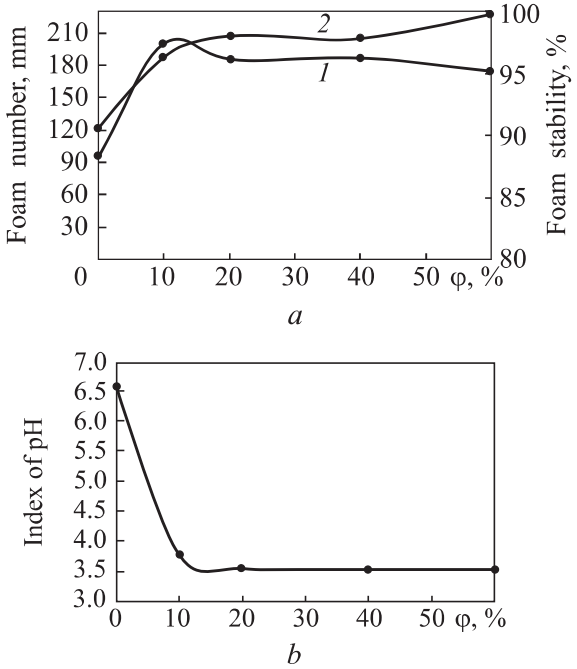

Fig. 3. The dependence of physicochemical parameters on the concentration of tincture of blueberry leaves in solution:
a foam stability (*1*) and foam number (*2*); *b* pH

increase in the tincture content in the solution, as shown by studies, doesn't lead to a change in pH. The color change of the obtained solutions depending on the concentration of tincture of leaves is shown in Fig. 4, *a*.

In order to achieve a pH value (5.0–8.5), in accordance with GOST 31696–2012, a 10 % potassium hydroxide solution was added to the resulting solutions which led, as can be seen from Fig. 4, *b*, to a color change solutions.

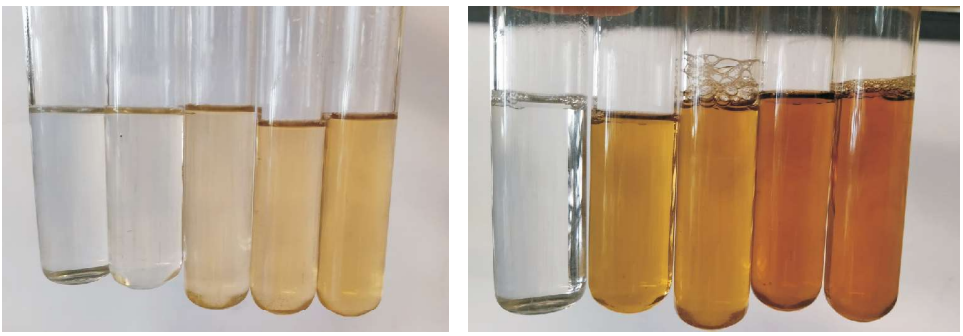

Fig. 4. Change in color of solutions depending on the concentration of tincture with the addition of potassium hydroxide solution

In the test samples containing tincture of blueberry leaves, foam stability was determined for 15 minutes. The results are presented in Fig. 5.

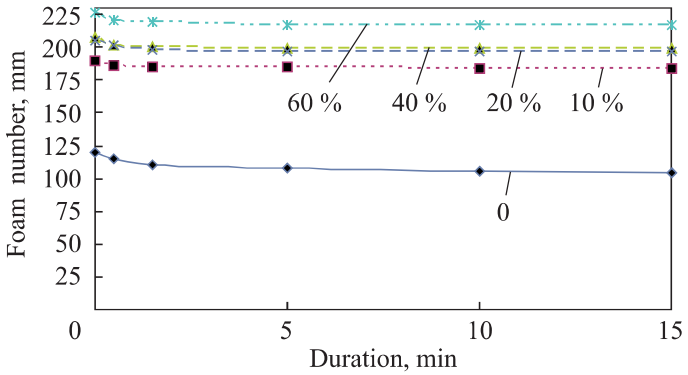

Fig. 5. The dependence of the foam number on the concentration of tincture of leaves of blueberry

From the presented data it is seen that the foam number in each sample is stable for 15 minutes. In the obtained samples containing tincture of leaves, a slight decrease in the foam number during the first 60 s is noticeable. The results of determining the viscosity of samples containing tincture of blueberry leaves are presented in Table 2.

Table 2

The dependence of the conditional viscosity of the solution on the concentration of tincture of blueberry leaves

Concentration of tincture of blueberry leaves, % (vol.)	Conditional viscosity, s
0	10.60
10	10.50
20	10.65
40	10.65
60	10.50

As studies have shown, to ensure indicators satisfying GOST 31696–2012, the concentration of the investigated tincture in the solution can be in the range from 10 to 60 % (vol.). However, from an economic point of view, the most optimal is 10 % (vol.) concentration of tincture of blueberry leaves.

The effect of the concentration of tincture of buckwheat grass on the properties of water solution of anionic surfactants. Samples of solutions with tinctures containing 0.02 % (mass.) of anionic surfactants and from 10 to 60 % (vol.) of tinctures of buckwheat grass were obtained.

The obtained samples also were daffodil, due to the content of pigments in the composition of the leaves: carotenoids. Physicochemical parameters were determined for the samples. The data obtained are presented in Fig. 6.

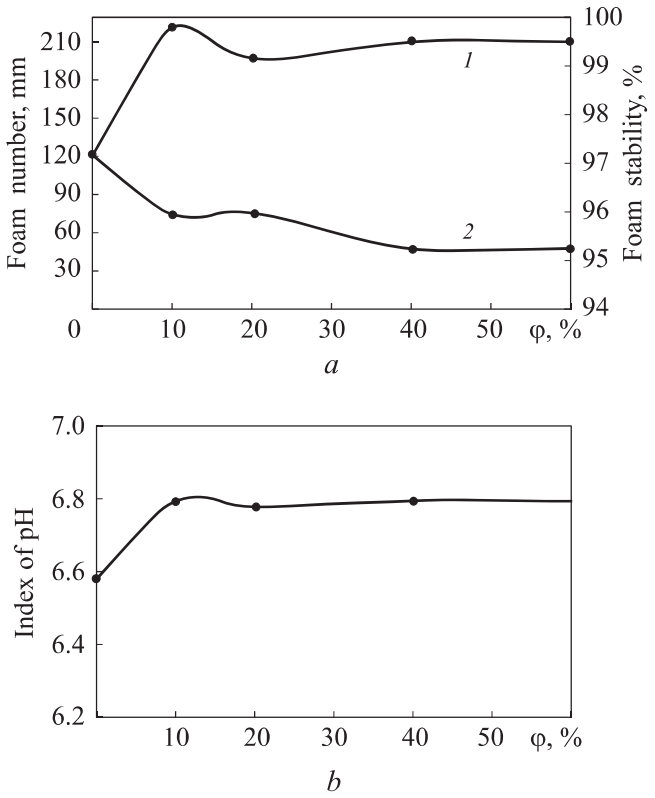

Fig. 6. The dependence of physicochemical parameters on the concentration of tincture of buckwheat grass:
a foam number (*1*) and foam stability (*2*); *b* pH

Studies have shown that the maximum value of the foam number is observed in a solution containing 10 % (vol.) of tinctures.

It was found that the presence of tincture in the system also affects the stability of the resulting foams. It should be noted that with increasing concentration of tincture in the solution, the stability of the foam decreases. The maximum value of stability is observed in a solution with a tincture concentration of 20 % (vol.). However, all the foams obtained are highly stable and their stability is in the range of 95–97 %.

The pH value of the studied solutions practically did not change with increasing tincture content. The average pH value is 6.80 which correspond to the required values for hygienic detergents.

In the prepared solutions containing tincture of buckwheat grass, the kinetics of foam resolution for 15 minutes was determined. The results are presented in Fig. 7.

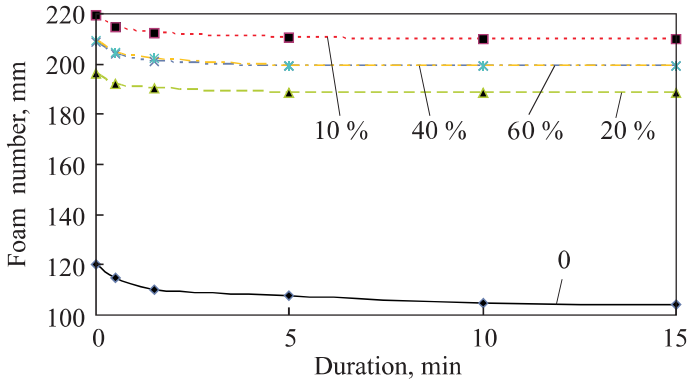

Fig. 7. The dependence of the foam number on the concentration of tincture of buckwheat grass in solution

From the presented data it is seen that the foam number in each solution is stable for 15 minutes. In the obtained solutions containing tincture of buckwheat grass, a slight decrease in the height of the foam during the first 90 s is noticeable.

The results of determining the viscosity of the prepared solutions containing tincture of buckwheat grass are presented in Table 3.

Table 3

The dependence of the viscosity of the solution on the concentration of tincture of buckwheat grass

Concentration of tincture of buckwheat grass, % (vol.)	Conditional viscosity, s
0	12.53
10	10.86
20	10.60
40	11.04
60	11.34

As studies have shown, to ensure the indicators presented to shampoos (GOST 31696–2012), the concentration of the investigated tincture in shampoo can be in the range from 10 to 60 % (vol.). However, from an economic point of view, the most optimal is 10 % (vol.) concentration of tincture of buckwheat grass.

Conclusion. Thus having analyzed all the results presented in the work, we can conclude that plant tinctures of blueberry leaves and buckwheat leaves have a different effect on the properties of water solutions of anionic surfactants

(SLES, IFRAPON LOS 2 N 70 trademark). For example, the pH in solutions with tincture of blueberry leaves decreases from 6.6 to 3.5 (this can be explained by the presence in the tincture of acids (malic, citric, folic, ascorbic, etc.) [10]), when a tincture of buckwheat herb is added to the shampoo, this indicator does not change significantly from 6.6 to 6.8. It can also be noted that solutions with the studied plant extracts comply with the requirements for hygienic detergents in accordance with GOST 31696–2012. However, in the case of using tincture of blueberry leaves, it is necessary to carry out additional pH correction, which naturally complicates the process and increases the cost of the final product. Therefore, in order to compose and prepare shampoo, a sample with the content of tincture of buckwheat leaves will be selected in the future.

The article is dedicated to the memory of Bondarenko Zh.V. (Assoc. Professor, Department of Chemical Processing of Wood, Belarusian Technological State University) which was the ideological inspirer and leader of this work.

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