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11.1 Study of the antioxidant capacity of water-alcohol infusions of coffee substitutes with improved technology of syrups

Introduction. Coffee is one of the most popular beverages used worldwide owing to its rich flavor and several health effects [356-360]. Coffee is an ingredient in various confectioneries, desserts, alcoholic and non-alcoholic cocktails, syrups for dipping in confectionary production, infusions, flavors, etc [356, 359, 360]. Nevertheless, its caffeine content renders its use rather limited for certain individuals warranting for the development of coffee substitutes with similar flavor though with other health effects [356, 359, 360]. Several coffee substitutes are present in the market belonging to different plant organs to encompass a myriad of phytoconstituents [356]. The production of these coffee substitutes expose them to roasting to mimic that of coffee aroma and flavor, concurrent with chemical changes [356].

Actuality of theme. The high caffeine content limits the use of coffee to those with contraindications, requiring the use of decaffeinated coffee substitutes. Alternative ingredients for coffee (coffee substitutes) are: roasted grains (barley, wheat, rye, oats); roots (chicory, dandelion, beetroot, topinambur, sweet potato, chuffa); seeds (chestnut, oak, beech, turf, pear, baobab, carob); fruit (hawthorn) [359].

In this regard, it is important to use coffee substitutes in the recipes of ready-made dishes of restaurants, which will improve the taste properties, reduce the caffeine content and reduce the cost of finished products. Therefore, various essences and infusions are used to flavor many coffee-flavored confectionery products.

At the current stage, data on the antioxidant properties [356-358] of all recipe components, food additives, biologically active additives and their combinations are not sufficiently studied. Attention should also be paid to the mechanisms of their interaction with rectified ethyl alcohol, as well as the influence of these substances and their combinations on the level of toxicity of beverages and food products. It should be taken into account that some components of food products can increase the toxicity

and other negative effects of ethanol on the human body.

Therefore, these circumstances determine the need for the study of plant raw materials and their use in the production of functional products. Research will concern the ability of plants to exhibit antioxidant properties [357] due to the content of bioantioxidants in their composition: vitamins, bioflavonoids, tannins, organic acids. The relevance of research proves that antioxidant plants improve the body's adaptation, are able to protect against radiation, reduce intoxication, are a preventive measure, have a tonic effect, and are able to protect against the effects of stress.

Materials and methods. Water-alcohol infusions of roasted cereal grains (oats, rye, barley), roots (chicory), seeds (chestnut, oak) and water-alcohol infusions of natural coffee (control) were used in the research. The antioxidant capacity of water-alcohol infusions was determined by the method of redox measurement and *pH* measurement.

Preparation of water-alcohol infusions was carried out in the following way. Plant raw materials, if necessary, were fried, then ground in an electric grinder. Samples of plant material weighing 4 g were placed in glass vials and poured with 100 ml of a water-alcohol mixture with a volume fraction of rectified ethyl alcohol of 40%. The vials were closed with lids and placed in a dry-air thermostat for 48 hours. at a temperature of 40 ºC. The obtained infusions were cooled to a temperature of 20 ºC and filtered.

The active acidity index was measured on a pH-meter «pH-150M» with a combined glass electrode «ESC 10601/4». Redox potential was measured on the pH-meter «pH-150M», in the mode of measuring the potential, with a redoxmetric platinum electrode «ERP-105».

To assess the antioxidant properties of aqueous infusions of plant raw materials used a method [361], based on the difference of redox potential in inactivated inorganic solutions and complex biochemical media. The main criteria of this method were its clarity, simplicity, specificity, reproducibility of results and efficiency. A number of researchers also emphasize that method allows to determine the total antioxidant activity of liquid products, including in total in a complex mixture, and multifunctional

antioxidants [362-369].

Formula (1) holds for inactivated inorganic solutions in equilibrium. This formula links the active acidity of the pH and redox potential [361]:

$$Eh_{min}=660–60\cdot pH, \text{ mV} \quad (1)$$

where Eh_{min} – the minimum theoretically expected value of redox potential;

pH – active acidity of the test solution.

Acquired meanings of Eh_{min} were compared with the actual measurements of Eh_{act} of infusions. The shift of redox potential to the side of the recovered meanings – recovery energy (RE_{inf}) was determined by the formula [361]:

$$RE_{inf}=Eh_{min}–Eh_{act}, \text{ mV} \quad (2)$$

where RE_{inf} – the shift of redox potential to the side of recovered meanings;

Eh_{act} – actual measured of redox potential.

Results and discussion. To evaluate the studied raw materials, we evaluated the control sample – vodka. The control sample (vodka) at t=19°C has a pH value of 7.89, Eh_{min}=186.6 mV, Eh_{act}=71.0 mV, RE_{inf}=115.6 mV. Organoleptic properties of the control sample (vodka): total score Org=9.610 points; color – colorless; aroma – alcoholic; the taste is moderately burning, empty.

Organoleptic and physicochemical parameters were measured after 30 days of infusion. The results of the research are presented in Table 1.

The *pH* level for vegetable water-alcohol infusions ranges from 6.37 (infusion of chicory root) to 7.74 (infusion of rye grain), that is, infusions have reactions from acidic to slightly alkaline. The minimum theoretically expected value of the redox potential of Eh_{min} for vegetable water-alcohol infusions ranges from 195.6 mV (rye grain infusion) to 277.8 mV (chicory root infusion), and the actual measured redox potential of the Eh_{act} infusion is from 74 mV (infusion of roasted oat grains) to 112 mV (infusion of acorns). At the same time, the minimum value of the reducing ability (RE_{inf}) is equal to 116.2 mV and is characteristic of barley grain infusion, and the highest value of 187 mV has the water-alcohol infusion of chicory.

Table 1.

Quality indicators of vegetable water-alcohol infusions

Raw materials/indicators	*Org*, points	*pH*, units pH	Eh_{min}, mV	Eh_{act}, mV	RE_{inf}, mV
Vodka 40% vol. (control)	9.610	7.89	186.6	71	115.6
Infusion of oat grains	7.780	7.37	217.8	78	139.8
Infusion of roasted oat grains	9.760	7.55	207.0	74	133.0
Infusion of rye grain	7.640	7.74	195.6	76	119.6
Infusion of roasted rye grain	9.610	7.35	219.0	70	149.0
Infusion of barley grain	7.420	7.73	196.2	80	116.2
Infusion of roasted barley grain	9.650	7.43	214.2	75	139.0
Infusion of natural roasted coffee	9.855	6.87	247.8	84	163.0
Infusion of chicory root	9.770	6.37	277.8	91	187.0
Infusion of chestnut	6.645	7.37	217.8	89	128.8
Infusion of acorns	6.635	7.02	238.8	112	126.8

Thanks to the infusion of plant raw materials in a water-alcohol environment, beneficial substances (vitamins, minerals, organic acids, polyphenolic compounds) are stored, which lead to an increase in antioxidant properties and an increase in the shelf life of finished products. Water-alcohol infusions of coffee, chicory, oats contain the most important micronutrients – vitamins (E, C, B_1, B_2, B_3, B_6, B9, B_{12}, PP, A), minerals (K, Na, Ca, Mg, P), organic acids, polyphenolic compounds, have high indicators of the energy of recovery, which provides strong antioxidant properties for the human body.

Thus, after conducting an analytical study, plant raw materials, depending on their initial antioxidant capacity, can be ranked into the following structure: infusions with low activity (RE_{inf} up to 100 mV); infusions with medium activity (RE_{inf} from 100 to 200 mV); infusions with high activity (RE_{inf} from 200 mV).

All samples of raw materials after infusion can be classified as infusions with medium activity (RE_{inf} from 100 to 200 mV), among which barley infusion has the lowest value (116.2 mV), and chicory infusion has the highest value (187 mV).

Samples of vegetable raw materials such as unroasted barley, rye, chicory and coffee showed the greatest antioxidant properties. But taking into account the organoleptic evaluation of the studied samples, such samples as coffee, chicory root

and fried oat grains were selected for further research.

Therefore, infusions of plant raw materials are recommended to be used in the technology of decorating semi-finished products in confectionery production to provide the latter with functional and health-giving properties.

In order to improve the syrup for infusing confectionery products, as a result of research, such plant raw materials as natural roasted ground coffee, chicory root and roasted oat grains were selected. Recipe № 97, which is presented in Table 2, was chosen as the improved syrup.

Table 2.

Recipe № 97 composition of syrup for infusing confectionery products

Ingredients	Content, weight %
Granulated sugar	50.04
Water	45.70
Natural roasted ground coffee	1.31
Essence of rum	0.11
Brandy or dessert wine	2.84

The disadvantages of this composition of ingredients are: the given value of the redox potential of the syrup, which should change the speed and direction of redox processes in the body, regulate biological activity and slow down negative processes in the human body; expected (standard) organoleptic indicators; increased cost.

The task of improving the recipe was to create a composition of ingredients for the preparation of processed semi-finished products in confectionery production with the addition of a vegetable water-alcohol infusion. Such a step will increase the redox properties of the product and help increase the immunity of the human body, increase its resistance to the influence of harmful environmental factors, improve metabolism, and have a positive effect on the cardiovascular system. Another advantage of such a recipe composition will be providing finished products with improved consumer properties and the opportunity to reduce the cost of the finished product due to the replacement of part of brandy and natural roasted ground coffee with vegetable water-alcohol infusion.

The set task is solved by the fact that the composition of ingredients for the

preparation of processed semi-finished products in the confectionery industry includes granulated sugar, natural roasted ground coffee, water, rum essence, brandy or dessert wine, as well as a blend of water-alcohol infusions.

Thus, on the basis of recipe № 97, syrup was prepared with a different ratio of ingredients. This composition differs from the original recipe in that brandy was used to blend the syrup and, in addition, a mixture of water-alcohol infusions of natural roasted ground coffee, chicory and oats.

Creating a mixture of syrups included the following stages. The first stage was the preparation of the syrup itself. To do this, granulated sugar was introduced into boiling water at a mass ratio of 1:1.1 and boiled to a density of 1.22-1.25 kg/dm^3 with constant stirring to remove foam, the resulting syrup was cooled to a temperature of 20 ºC and filtered.

Blending of sugar syrup was carried out with the addition of rum essence, brandy and vegetable water-alcohol infusion of natural roasted ground coffee, chicory and oats in a mass ratio of 1:1:1, as a result, a viscous transparent syrup with a moisture content of 46-54% was obtained with rum, brandy smell and coffee tones. Comparative characteristics of control and water-alcohol infusion of natural roasted ground coffee, chicory and oats are presented in Table 3.

Table 3.

Comparative characteristics of brandy and herbal water-alcohol infusion

Raw materials	Volume fraction of ethyl alcohol, %	Solution temperature, ºC	*pH*, units pH	Eh_{min}, mV	Eh_{act}, mV	RE_{inf}, mV	*Org*, points
Brandy 3*	40	20	3.720	436.8	198.0	238.8	9.600
Water-alcohol infusion of natural roasted ground coffee, chicory and oats, in a mass ratio of 1:1:1	40	20	5.69	341.4	141.0	318.6	9.710

Examples of obtaining the composition of ingredients for the preparation of processed semi-finished products in confectionery production are presented in Table 4.

Table 4.

An example of composition

№	Recipe components, weight %					Conclusions
	Granulated sugar	Water	Essence of rum	Brandy	Water-alcohol infusion of natural roasted ground coffee, chicory and oats, in a mass ratio of 1:1:1	
1	49.99	45.64	0.90	3.20	0.27	The composition of the formulation ensures obtaining syrups with satisfactory physico-chemical and organoleptic indicators, but insufficiently enriched with biologically active substances
2	50.01	45.68	0.10	3.01	1.20	The composition of the recipe ensures the production of syrups with good physico-chemical and organoleptic indicators, as well as sufficiently enriched with biologically active substances
3	50.03	45.70	0.11	2.00	2.16	
4	50.05	45.72	0.12	1.01	3.10	
5	50.08	45.74	0.13	0.05	4.00	The composition of the recipe ensures the production of syrups with satisfactory physico-chemical parameters, sufficiently enriched with biologically active substances, but with impaired organoleptic parameters

The composition of the improved recipe of coffee syrup is presented in Table 5.

Table 5.

The composition of the improved formulation of syrup for impregnation of confectionery products

Raw materials	Recipe components, weight %
Granulated sugar	50.01-50.05
Water	45.68-45.72
Essence of rum	0.10-0.12
Brandy	3.01-1.01
Water-alcohol infusion of natural roasted ground coffee, chicory and oats, in a mass ratio of 1:1:1	1.20-3.10

Thus, one of the tasks of this work was achieved by the proposed enrichment of syrup for impregnation of confectionery products. Thanks to the addition of vegetable water-alcohol infusion to the recipe, the redox properties of the finished product were increased, its consumer properties were improved, and the cost of the finished product was reduced.

Water-alcohol infusions of coffee substitutes are promising semi-finished products in the production of sweet desserts, confectionery, alcoholic and low-alcohol drinks, cocktails prepared and sold by restaurants. In addition to expanding the assortment, preserving the traditional coffee taste, it is possible to increase antioxidant properties that slow down negative processes in the human body.

Conclusions.

1. The use of water-alcohol infusions of coffee substitutes in the production of syrups for infusing confectionery is theoretically substantiated and the prospects for their improvement are assessed.

2. Investigated antioxidant capacity of water-alcohol infusions of coffee substitutes.

3. The most promising sources of natural antioxidants were studied for their use in improving the technology of coffee syrup for infusing confectionery products. Attention was paid to coffee substitutes, such as rye grains, barley, oats; coffee beans; chicory root; chestnut and acorn fruits.