The use of plant extracts in the production of whey beverage

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Abstract. At present, in the dairy industry there are a number of unresolved issues, one of them is the processing of secondary raw materials, namely whey curd. Processing of dairy whey in Russia, despite numerous developments in this area, is held back for various reasons. Production and introduction of whey drink will allow to extend the assortment of functional products and due to resource-saving technology will allow to solve the problem of processing of secondary raw materials. The results of researches on making extracts of vegetative raw material by different methods are resulted in the article and the optimum one which allows to enrich maximal extract with biologically active substances is chosen. The technology of whey beverage with the use of plant extracts is developed. The influence of extracts from vegetable raw materials on the nutritional value of whey drink has been determined.

1. Introduction
The desire to provide people with a wide range of functional products makes manufacturers find new types of raw materials with previously unused food additives. Such food additives help to balance the composition and increase the functional properties of the produced product [1]. This can be seen in the whey beverage industry, as recycling of secondary raw materials is becoming increasingly important. There is low investment in this industry, environmental services do not pay proper attention, the population is not informed about all the usefulness of whey products. Whey is not utilized and recycled properly, because most industries do not have their own treatment facilities, and is poured into the environment, which harms it. Global recycling of secondary raw materials will help to solve such an important and urgent problem.

The use of plant raw materials with antioxidant activity is of most interest for the production of functional beverages. The regulation of homeostasis of the human body is closely related to the antioxidant system, which is important for free-radical oxidation, which is an important part of the vital activity of all cells and tissues in the body and does not allow the cell structures to collapse. An important group of natural antioxidants are bioflavonoids, which are found in raw materials of plant origin. The antioxidant effect of these compounds is due to their structure. In the presence of other antioxidants such as ascorbic acid and vitamin E, bioflavonoids can act in synergy with each other and enhance the antioxidant effect [2].

The active substances in whey are about 6-7%, yet its value is undeniable. Dairy whey contains all the essential amino acids. Whey contains 3.5 times more free amino acids and 7 times more essential free amino acids than cheese whey. This difference can be explained by the fact that curd production involves more intensive hydrolysis of milk proteins than cheese production. The carbohydrates in whey are the same as in milk - monosugars, oligosugars and aminosugars. Almost all the salts and trace
elements of milk go into the whey: magnesium, calcium, phosphorus, potassium, iron, zinc, copper, cobalt.

The water-soluble and fat-soluble vitamins in the milk pass into the serum. The vitamin content of the whey decreases during storage. But in general, milk whey is a biologically complete product by the set and absolute content of vitamins.

From organic acids in the whey were found lactic, citric, nucleic and volatile fatty acids - acetic, formic, propionic, butyric acids.

Serum contains enzymes such as hydrolases, phosphorylases, cleavage, redox, transfer and isomerization enzymes. Lysozyme and lactoperoxidase present in whey can enhance antioxidant processes in the body. The energy value of whey is 101.3 kJ/g, or 36% of the energy value of whole milk [2].

The natural use of dairy whey, particularly curd whey, is limited. Milk whey drinks are refreshing, thirst-quenching and dietary as they contain mineral elements necessary for human nutrition, including calcium (120 mg/100 cm³). One of perspective directions of perfection of technology of whey based drinks is an opportunity of improvement of consumer properties, regulation of biological value by introduction in structure of vegetative extracts or their compositions.

The whey drinks enrichment with biologically active substances gives them antioxidant properties preventing the appearance of many pathological states and increasing the shelf life of ready products without using traditional artificial food additives - preservatives.

It is advisable to use as natural antioxidants - flavonoids of plant raw materials of regional origin, growing in sufficient quantities.

Rose hips contain ascorbic acid, vitamins B2, K, P, riboflavin, carotenoids, flavonoids, anthocyanins, pectins, organic acids.

The composition of eleutherococcus is also diverse, it contains aleutherosides, coumarin derivatives, flavonoids, polysaccharides, essential and fatty oils, resins, trace elements. The chemical composition of eleutherococcus stimulates the central nervous system, increases mental and physical performance, enhances visual acuity, improves hearing, lowers blood sugar levels, increases appetite. Eleutherococcus is ranked among the group of adaptogens, which have the properties of adapting the organism to the action of adverse factors and increasing the body's resistance [3].

Pine conifers are rich in antioxidants in the form of vitamins C and A; contains provitamin A, which increases the body's resistance to infections and is essential in the prevention of cancer; phytoncides, which includes essential oils that also have antimicrobial properties. Pine needles are rich in flavonoids in the form of rutin, quarzetin and its glycosides. These substances have antioxidant protection along with immunomodeling and immunostimulating properties [4].

The results of chromatographic study of pine needles and their extracts, including Florentine water were presented by a team of authors: T.V. Khurshkainen, V.I. Terentyev, N.N. Skripova, N.N. Nikonova and A.A. Korolev [5].

Obtaining extracts on the basis of plant raw materials provides the maximum yield of the complex of biological substances, as well as improves the way of its application, dosage and storage.

Thus, using extracts of vegetative raw materials in whey beverage production it is possible to enrich the market with the wide assortment of functional products, to reduce expenses for raw materials purchasing, making it by yourself and to solve the ecological problem of secondary raw materials processing.

The majority of enterprises for production of vegetative extracts widely use technology of long infusion of raw materials with an extractant as which basically use alcohol solutions with mass fraction of alcohol 40-80%. Also extraction in carbon dioxide CO2, extraction in the presence of an electric field, extraction under high pressure are used. But all these methods are characterized by complexity and the use of complex equipment.

Considering theoretical bases of obtaining extractive substances, it was found out that maceration and steam distillation are optimal among them.

The most frequently used and simplest method of extraction is maceration. It proceeds as follows - fine plant raw materials are poured with an extractant at room temperature, or higher. This can take anywhere
from 15 minutes to several days. At the beginning of the maceration process, the extraction is quite rapid, but then slowly falls until there is an equilibrium in the concentration of the substance, which is dissolved inside the extracting agent. This method does not need any special apparatus design and is quite simple [6].

The water condensate obtained by removal of vapors of organic compounds from raw materials of plant origin is called florentine water. The method of hydro- or steam distillation produces florentine water, diverts the vapors and condenses them. Its value is established in possibility of reception of other valuable substances, and also in its high biological activity [7].

2. Goals and objectives
The purpose of this work is to find the optimal extraction conditions to ensure the maximum extraction of physiologically active substances, increasing the nutritional value of whey beverage by making extracts that include flavonoids, which are natural antioxidants.

To achieve the goal it is necessary to determine the main stages of the research: development of test samples using different methods of extracts; determination of physico-chemical parameters; analysis and evaluation of the results with subsequent conclusions.

3. Methods and materials
Production of experimental samples was carried out in the laboratory conditions of TPP VolgGTU department. Sequence and interrelation of stages of serum beverage research is reflected by flowchart in figure 1. To achieve the goal of the work it is necessary to perform the following stages.

1) Analysis of scientific and technical literature and patent review.

The composition of the main raw material - whey curds, and the composition of plant raw materials containing bioflavonoids was studied. Methods of extraction were studied.

2) Experimental-analytical stage.

2.1) The choice of extraction method.

To select the optimal method of extraction a control sample containing only whey without plant filler and three experimental samples with the addition of extracts obtained by different methods were developed. Experimental samples were made with the ratio of whey and vegetable raw materials 1:5 and 1:10. When extracting raw materials, various temperature and time modes were used.

I prototype - insistence at room temperature 20-25°C for 12 hours;
II experimental sample - insistence at temperature 90°C for 12 hours;
III experimental sample - steam distillation for 6 hours.

2.2) Analysis of physico-chemical parameters of whey drink

The effect of extracts obtained by different methods on the quality parameters of the drink was studied.

Mass fraction of dry matter, titratable acidity and vitamin C content were determined by conventional methods.
4. Results and discussion

4.1. Production technology for whey beverage and prototypes

Using normative and technical documentation - GOST 33957-2016 "Milk whey and beverages based on it. Acceptance rules, sampling and control methods", we determined the mass fraction of dry substances by drying, titratable acidity - by the method based on neutralization of acids contained in the products with caustic sodium solution with phenolphthalein solution.

Initially curd whey was clarified by separation. Degreasing is necessary because fat during storage negatively affects the quality of the drink. Protein in the whey at a low pH value causes turbidity and sludge formation. A small amount of protein should remain in the whey, as it stabilizes the foaming. The product itself is produced according to the following scheme: the reserved whey is subjected to thermal coagulation by heating to 93°C and soaking for 20-30 minutes, then it is cooled to 40°C and passed through the centrifugal separator. Clarified whey
is pasteurized at 72 °C with an exposure time of 15-20 seconds, at the same time carrying out preparation of components. The prepared components are added to a part of the clarified whey and kept for 20-30 minutes to obtain concentrate, passed through a cylindrical filter and added to the rest of the clarified whey, which is stirred for 20-30 minutes, then poured and packaged.

Eleutherococcus, rose hips, and pine needles extracts were used to produce the drink. Extracts were prepared on the basis of whey curds. The collection of herbal raw materials consisted of equal parts (by mass).

Preliminary vegetative raw materials were subjected to drying and crushing. The importance of preliminary technological operations is to accelerate resorption processes, and to create optimal conditions for obtaining an extract.

The dried raw material is crushed to particles with a diameter of 1-2 mm, these sizes are considered optimal, as it eliminates the possibility of unnecessary burden of the body unnecessary substances (plant cells).

4.2. Analysis of physicochemical parameters of the whey drink

Table 1 shows the physico-chemical parameters at a ratio of raw materials 1:5.

**Table 1.** Physico-chemical parameters of whey drink with a ratio of raw materials 1:5.

| Indicator                  | Reference sample | III prototype | II prototype | I prototype |
|----------------------------|------------------|---------------|--------------|-------------|
| Mass fraction of solids, % | 5.5              | 18.95         | 14.38        | 9.26        |
| Titratable acidity         | 60               | 34            | 32           | 33          |

Table 2 shows the physico-chemical parameters at a ratio of raw materials 1:10

**Table 2.** Physico-chemical parameters of whey drink at a ratio of raw materials 1:10.

| Indicator                  | Reference sample | III prototype | II prototype | I prototype |
|----------------------------|------------------|---------------|--------------|-------------|
| Mass fraction of solids, % | 5.5              | 25.27         | 21.98        | 18.36       |
| Titratable acidity         | 60               | 32            | 33           | 30          |

As can be seen from the results of the analysis, produced samples differed in the mass fraction of dry substances and titratable acidity. Comparative assessment of the completeness of extraction of physiologically active substances was determined by the content of dry substances. At a ratio of raw materials 1:5 the content of extractive substances, judging by indicators of the mass fraction of dry substances, is insignificant. The optimal ratio is 1:10, in which the yield of extractive substances is high enough. The concentration of vitamin C in these samples is presented in table 3.

**Table 3.** Vitamin C concentration in whey drink with raw material ratio 1:10, mg%.

| Indicator                  | Reference sample | III prototype | II prototype | I prototype |
|----------------------------|------------------|---------------|--------------|-------------|
| Mass concentration of vitamin C, mg% | 0.5              | 139.13        | 114.87       | 148.75      |

The content of antioxidants in the whey drink at a ratio of raw materials 1:10 is presented in table 4.

**Table 4.** Antioxidant content in whey drink with raw material ratio 1:10, %.

| Indicator | Reference sample | III prototype | II prototype | I prototype |
|-----------|------------------|---------------|--------------|-------------|
| Querticin | 0                | 0.661         | 0.264        | 0.453       |
| Catechin  | 0                | 0.348         | 0.126        | 0.248       |
Quercitcin and catechin are substances of flavonoid group with strong antioxidant effect. Based on the data in the table, we can conclude that the highest percentage content is in experimental sample III, which in synergy with vitamin C, which is also in sufficient quantities in experimental sample III, gives a strengthening antioxidant effect.

Thus, the content of extractive substances is higher in Experimental Sample III compared to the others. Extractive substances mean primarily flavonoids, which are contained in large quantities in plant raw materials, and it is they in sufficient volume go to the extract made by the method of steam distillation. This sample also contains a sufficient amount of vitamin C, which in synergy with flavonoids complement each other's antioxidant activity. We can conclude that steam distillation is the optimal method for obtaining extracts from plant raw materials, in particular rose hips, pine and eleutherococcus, because this method passes a sufficient amount of physiologically useful substances in the extract. Methods of maceration or infusion are not characterized by a sufficient content of the mass fraction of dry substances, respectively, and physiologically active substances, due to prolonged exposure to high temperatures, these methods are long-term and inconvenient when used inline.

5. Conclusions
The optimum way of reception of extracts is the steam distillation distinguished by the greatest transition of dry substances, the given way is simple in execution and excludes long influence of high temperatures on raw materials that allows to save its useful properties as much as possible.

The whey drink enriched with vegetable extracts has functional properties, has a low cost price due to the use of secondary dairy raw materials and expands the range of new functional food products.

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