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TECHNOLOGY OF FUNCTIONAL JUICE-CONTAINING NON-ALCOHOLIC DRINKS

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Abstract

Functional foods are becoming a strategic sector of food industry of 21th century. They are produced with employment of innovation technologies to improve qualitative adequacy of dietary intake by providing compliance of their chemical composition with human organism.

Beverages are the important element of food supply. They are claimed to be the most promising food system in feeding the human organism with such micronutrients as vitamins, mineral substances, antioxidants, organic acids and other active biological substances. Their deficiency disrupts immune status, reduces resistivity to infections, increases disease risks.

The basic tendency of the non-alcoholic beverage market is reduction of ordinary lemonad sales with growing sales of functional beverages. The market of "healthy" drinks in Ukraine and throughout the world is steadily growing, and its special beverage segment is not completely formed. Therefore, search for new kinds of raw materials with medical and preventive properties is an urgent task to obtain functional drinks with various physiological effects - energetic, bactericidal, immunoresponsive etc.

The purpose of this research is to scientifically ground the technology of juice-containing non-alcoholic whey-based beverages using wheat germs and pectin-zostera cellulose plus physically active basic material such as hydro-fullerenes. The unique qualities of the beverages made on the basis of hydro-fullerenes are due to their biological effects, which is evident from the research results.

Functional compositions based on fruit raw products were balanced in compliance with daily food requirements of a human in vitamins - antioxidants, mineral substances, and food fibers.

The receipt scheme took into account such properties of whey protein as its ability to relieve stress and neurosis and to normalize human emotional activity. Moreover, it is a reliable means for heart disease prevention and curing rheumatism and hypertension. Whey protein improves work of kidneys and liver, curbs atherosclerosis, stimulates blood circulation, prevents inflammation in bowels and stomach. Wheat germ cellulose slows down access of digestive enzyme to carbohydrates. It saves the organism from glucose jump in blood improving insulin synthesis, which stimulates fat formation. Cellulose decreases cholesterol and atherosclerosis and reduces cancer risks in large bowels. Pectin-zostera has antiulcer effect, normalizes gastrointestinal tract, enhances the feeling of being sated, and eases the organism at low-calorie diets. A very important peculiarity of pectin-zostera is its ability to decrease cholesterol content in blood and to provide anti-sclerosis properties. Of particular interest are the research data concerning anti-tumor and geroprotective potential of zostera. Majority of authors emphasize the multifunctional effect of this pectin on the human organism.

Key words: *Drinks, health and welfare, nutritional correction, fiber wheat germ, whey, pectin.*

1. Introduction

Beverage is an optimal kind of food product with balanced composition capable of making positive effect on human body. By expanding the range of 'useful' and 'functional' beverages we'll be able to control the process of enriching the human organism with biologically active substances. Providing the market with the required drinks we get accessible means of making any age group of consumers healthier [1-3]. From the technological point of view, beverages make a practical model for creation of new products, particularly, using natural raw materials.

This group of products improves protective functions of the living organism, corrects water-salt exchange,

normalizes gastrointestinal tract, digestion of other products [4-5].

Consumption of fruit juice is not always available to all social groups due to its high price and low percentage of natural juice - 38 - 42% in apple processing, 20-36% in citrus plants processing, 10 - 57% for vegetables. At this time, production of cereals is cheaper than that of fruit and berries. That's why combination of fruit or vegetable raw materials with plant products of ground or sea origin (10 - 40%) is vital. But juice-plant mixing considerably changes structural and mechanical behavior. Various additives enhance preventive effect, make the product more functional, and stabilize structure of fruit-berry stuff. A considerable contribution to solving the problem of natural additive production and realization was made domestic and foreign scientists Barkhatov V.Y., Tuzhilkin V.I., Martin Chaplin, Trowell H.

The available chip raw material for non-alcoholic production is curd and under-curd whey. These are waste products, which are rich in biologically active elements. Increased demand in milk products leads to annual increase of whey by-products. Comparative data of whey production in various countries in 1973- 2011 period are given below.

Table 1. Comparative data of whey production in various countries in 1973- 2011

Country	Whey production, thousand tons			
	1973	1990	2000	2011
China	3960	125342	368950	805700
France	6200	251427	541324	985114
Russia	15921	469879	1657132	2649158
Ukraine	2616	395420	952691	1142345

The presented data show that production of whey has been increasing since 1990. High nutritional and biological value of whey is due to its having protein, carbohydrates, vitamins, mineral salts, phosphatides, sterol, hormones, immune bodies, organic acids, non-protein nitrogen matter etc. Whey composition changes and depends on composition and properties of primary products. Available data show that, at the average, 8.6 - 21.8% of fat, 20.3 - 25.0% of protein, 88.0 - 94.0% of milk sugar, 59.0 - 65.2% of mineral substances is transformed into whey.

Carbohydrates in whey are mainly represented by milk sugar - lactose (non-hydrated), and after-hydrolysis products - glucose-galactose mixture (0.1 - 1.0%). At present, milk sugar is widely used in food industry due to its valuable properties. Thus, lactose is used to regulate product sweetness, color stability and flavor.

Whey mineral substances contain cations K^+, Na^+, Ca^{2+}, Mg^{2+} etc., anions of lemon, phosphoric, milk, hydrochloric, sulfuric and carbonic acids.

Whey contains a variety of vitamins. Water-soluble vitamins change from milk to whey almost completely; in some cases, they may be even more plentiful than in milk due to their synthesis by lactic acid bacteria. Curd whey contains about 50% of fat-soluble vitamins.

Juices with various additives possess enhanced nutritional and physiological value due to better storing conditions for vitamins, mineral, pectin and tanning material, cellulose, dyeing and aromatic materials. The most topical issue on the subject is making beverages which are resistant to external influence and decay of their ingredients, for example, when affected by microorganisms. Hydro-fullerenes were chosen as the new substance with biological activity or stabilizing properties and acting as antioxidant. Practically all achievements in creating biologically active matters deal with organic chemistry and compound chemistry which are based on two elements - carbon and hydrogen. Recent discovery of carbon frame systems supplements organic compounds with a new class - closed compounds. They consist exceptionally of carbon atoms and are named fullerenes. The fulleren molecule has a unique structure which determines its chemical inertness. To obtain water-soluble forms of fullerenes which retain biological activity was a difficult task [8]. A group of researchers obtained aqueous solution of hydro-fullerenes (C60HyFn), which is a complex of highly resistant water structures. Their formation and stability is provided by presence of specific structures of pure carbon. Biological activity of fullerens, which was tested on numerous models, is evident.

2. Materials and Methods

The materials under research were milk whey (DSTU 4553:2006); pectin-zosterin (TU 9254-001-56293592) of the limited company 'Akvamer'; wheat germ cellulose (Tu 9197-004-72551266-07) of the limited company 'Agrofirma 'TEMP'.

Degree of wheat germ cellulose and cellulose with pectin-zosterin swelling was studied according to the author's method - the researched object swells in the proper liquid followed by its centrifuging for 1 min at speed 1000 rpm. Further, the percentage of bound liquid in the studied object mass is defined.

Hydro-fullerenes were chosen to study their effect on stability of the beverages with biologically active materials in comparison with carbonized water drawn in schungites ground to nanoparticles. Schungite grinding was carried out by the cryogenics method with subsequent particle size measurements using laser dispersion analyzer HORIBA LA - 910 (Germany). Particle size was 40 - 50 nm.

3. Results and Discussion

3.1 Functional non-alcoholic juice-containing beverages with milk whey base

Analyses of scientific sources showed that the dominant tendency in the technology development of functional beverages is their production on the basis of natural products - fruit, vegetable juices, milk whey, and vegetable natural raw materials.

Human diet should include ballast substances such as cellulose and pectin. They are physically significant elements of food which prevent many human diseases, including those which are provoked by ecological factors, growth of stress, low disease immunity. When creating the beverage, as the ballast substance we chose a combination of ground and sea by-products, namely - wheat germ cellulose and pectin-zosterin.

To determine operating practices for introducing cellulose in the recipe, we studied the degree of swelling for wheat germ cellulose - pectin-zosterin system 10:1 in the corresponding liquid base. As a liquid base for the drink 'Laif', milk whey combined with pumpkin and apple juice with the ratio of 9.0:6.5:4.0 respectively was chosen; for the drink 'Naslszhdenie' - milk whey milk whey in combination with carrot and orange juice with the ingredient ratio of 8.0:6.0:5.0 respectively; for the drink 'Klubnichka' - milk whey in combination with cranberry juice and strawberry pure with ingredient ratio of 9.5:4.0:6.0 respectively. The results of the study are shown in the Fig. 1, 2, 3.

The experiments show that liquid base does not significantly influence on the degree of swelling of wheat germ cellulose - pectin - zosterin system. Maximum water cut is achieved in 15 minutes for milk whey liquid base with pumpkin and apple juice and milk whey with cranberry juice and strawberry pure and in 45 minutes for milk whey liquid base with carrot and orange juice. Degree of swelling at HM = 1:20 makes 140 - 160%, for HM = 1:25 shows 177 - 190%, for HM = 1:15 the system takes 130%. So, the ratio in the recipe of wheat germ cellulose and pectin-zosterin with liquid base HM must be 1:20-25. It was the case with the proposed beverages 'Laif', 'Naslazhdenie' and 'Klubnichka'.

To develop polynutrient composition of gero-dietetical non-alcoholic beverage we have chosen ingredients having high content of biologically active substances, namely, fruit (or vegetables, or berries), dairy products, cereals (wheat germ cellulose). The obtained gero-dietetical composition produces a new positive biological effect or enhances the previous one, thus improving biological value of the ingredient components. Vegetable additives help obtain new products having good organoleptic characteristics and corresponding functional properties.

Development of a technological system model for production of non-alcoholic juice-containing whey-based beverages allows to analyze basic processes which take place at all the stages of the technological process, and to determine their behavior. From the systems approach technology of making non-alcoholic juice-containing beverages "Laif", "Polunichka" and "Naslazhdenie" are represented as an integral system.

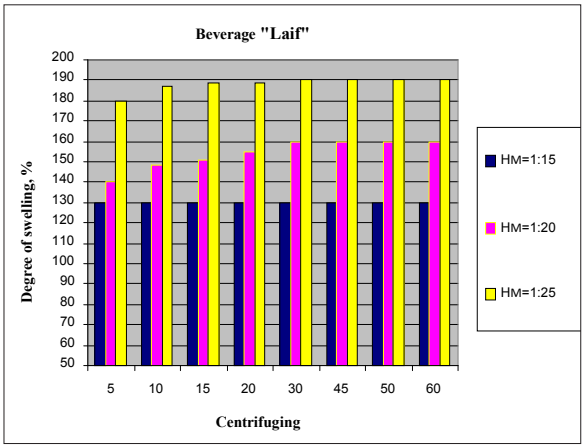

Figure 1. Degree of swelling of wheat germ cellulose - pectin - zosterin system as a function of time in liquid base for beverage 'Laif'

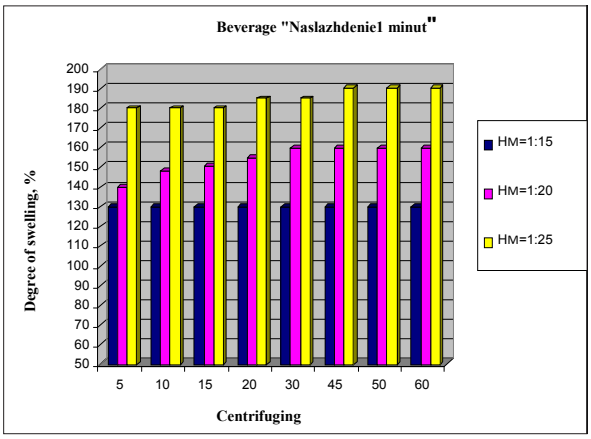

Figure 2. Degree of swelling of wheat germ cellulose - pectin - zosterin system as a function of time in liquid base for beverage 'Naslazhdenie'

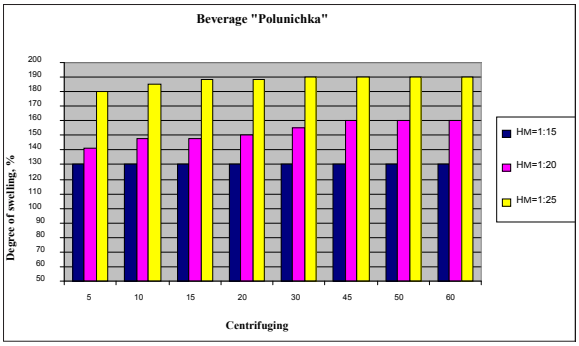

Figure 3. Degree of swelling of wheat germ cellulose - pectin - zosterin system as a function of time in liquid base for beverage 'Klubnichka'

Within this system, we singled out principal subsystems C1, C2, C3, and subsystems B, A, functioning of which predetermined obtaining basic product of the system, i.e. formation of the non-alcoholic beverage (Fig. 4).

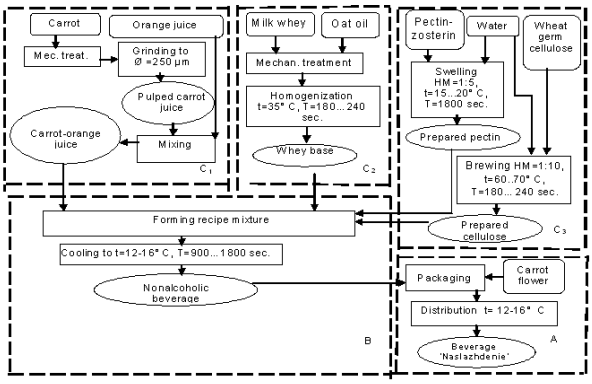

Figure 4. Technological diagram of making gero-dietetical non-alcoholic juice-containing beverage "Naslazhdenie"

Making beverages of subsystems C1, C2 allows for obtaining prescribed basic mixture of ingredients which are essential for further developing and production of semi-finished beverages: pumpkin and apple puree with whey basis in the beverage "Laif", carrot and orange puree with whey basis in the beverage "Naslazhdenie", berry and strawberry puree with whey basis in the beverage "Polunichka". Food ingredients in the blends obtained within subsystems C1 and C2 are carrots, pumpkin, orange, apples, and cranberries.

Subsystem C3 provides hydration of seafood pectin and preparation of cellulose from wheat germs to be introduced into the base mixture. To reach homogenous structure, cellulose requires brewing at 90 ^{0}C with hydromodulus of 1:10 and duration of 1-1.5 hours. Preparation of pectin-zosterin includes swelling at 18 - 20 ^{0}C with hydromodulus of 1:5 during 30 minutes. Subsystem B provides mixture with prescribed properties and composition, specified dispersion, biological assets, and organoleptic properties. Within a subsystem, prescribed mixture is obtained due to combining prepared components C1, C2, C3 with succeeding cooling of the ready product at t = 16 ^{0}C during 15-20 min. Subsystem B provides obtaining gero-dietetical beverage which meets standard requirements for quality. It can be achieved due to the effect of technological factors on beverage properties. Subsystem A involves making a finished product. The aim of this subsystem is to make a finished product with prescribed properties, qualities and corresponding vitamin and mineral composition.

3.2 Functional non-alcoholic juice-containing beverages on the basis of hydro-fullerenes with succinic acid additives

Food products - rich in calcium, magnesium, potassium, sodium - form chemical compounds of alkaline nature. These products include milk, milk products, fruit, berries, vegetables, as well as wheat and barley flour with ESO treatment. The ratio of water to juice in the accepted recipe 'Apple-wheat hydro-fullerene beverage with succinic acid additives' was approximately 15:1 (Fig.5).

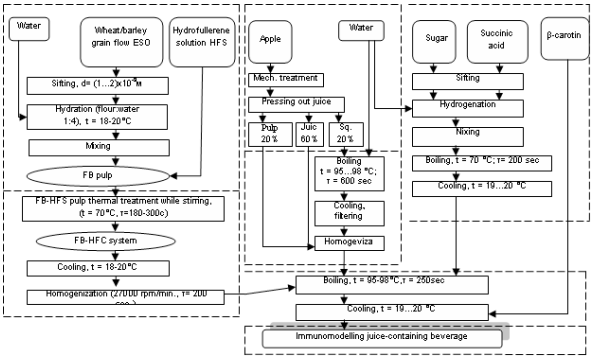

Figure 5. Technological chart of immune modeling juice-containing beverage

Technology of the beverage production foresees heat treatment, which changes its thickness. At the temperature up to 100 ^{0}C the viscosity of the grain system increased by almost 60%. Continuous heating at these conditions led to further rise in viscosity, which did not become less after cooling. It was due to using biopolymers. To further retain nutrients in the 'Apple-wheat hydro-fullerene beverage with succinic acid additives' we studied conditions for heat treatment of flour ESO. According to the manufacturing scheme it must be boiled in hydro-fullerene solution at t = 70 ^{0}C and cooled (Fig. 6). It is shown that boiling time for wheat flour ESO is 300 sec, for barley flour ESO is 250 sec, for oat flour ESO is 180 sec.

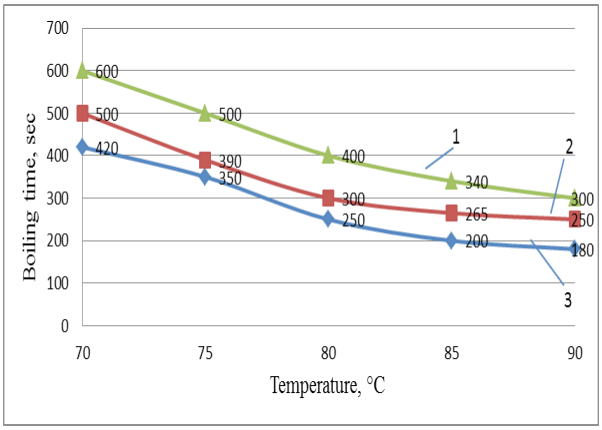

Figure 6. Boiling time of grain products ESO hydrated in hydro-fullerene: 1 - wheat flour ESO, 2 - barley flour ESO, oat flour ESO

Introduction of hydro-fullerene into the functional beverage led to improved stability of the product, microbiological contamination (Table 2). Results in Table 2 show that in the sample products there was non-uniform reduction in colonies of generated units of all used microorganisms within 7 days after inoculation. It resulted from antimicrobial effect of hydro-fullerenes and schungite water - fullerene - like structure which produces self-preservation effect.

Hydro-fullerene-based beverage was tested on rats and its biological activity was proved at the mitochondrial level.

Table 2. Effectiveness of antimicrobial properties of fullerene-like structures in the sample functional beverage

Tested crops	Microbe load after innoculation, lg КУО/мL	Lg of initial microbe load decrease			
		hydro-fullerenes		schungite	
		2 day	7 day	2 day	7 day
Staphylococcus aureus	2,50	1,2	1,55	1,8	2,3
Pseudomonas aeruginosa	3,30	2,15	2,37	2,50	2,58
Candida albicans	3,08	2,37	2,61	2,85	2,78

4. Conclusions

- The proposed technology of gero-dietetical non-alcoholic juice-containing beverages on the basis of milk whey can be used for elderly people diet to prevent metabolic processes of the aging organism, regulate blood formation organs, bowels and liver functions, support immune system.
- The use of grain products ESO in hydro-fullerene solutions in new juice-containing beverages make it possible to obtain beverages which are durable, have good consumer rate and valid functional properties.

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