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Innovative Encapsulation Technology of Sweet Dishes Enriched With Wheat Germ Juice

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Abstract
The influence of electrochemically activated water on the wheat germination process and the pretreatment of the material by electromagnetic field of extremely low frequencies (EMF ELF) were studied. Main technological modes of the improved technology of wheat germination by hydroponic method were established. The estimation of biochemical composition and quality indicators of wheat germ juice was developed. The presence of biologically active agents in wheat germ juice: polysaccharides, mineral substances, vitamins and the absence of antinutrients condition a wide spectrum of effects on a human body. Antioxidative activity in terms of the equivalent amount of gallic acid is 189,4 mg/ dm^3. It is established that the amount of antioxidants in wheat germ juice is much higher than in some berries, vegetables and fruits. The technology of products based on sprouted wheat grain and its use in the production of encapsulated garnishes for sweet dishes was developed which allows obtaining enriched food products possessing new organoleptic properties, spectacular presentation with undoubtedly innovative merchandise appeal to be introduced into public catering enterprises.

Key words: capsulation; sodium alginate; curd whey; wheat germ juice, electrochemically activated water, electromagnetic field of extremely low frequencies.

Introduction

One of the innovative directions in the technology of catering production is the use of "molecular gastronomy" techniques based on scientific knowledge of properties of food products and the possibility of modifying their consumer properties.

With the advent of "molecular gastronomy," the technological properties of little-known hydrocolloids became more applicable for catering producers, which made it possible to expand their use in the development of innovative food products. One of the methods of this direction is encapsulation of different food masses (sauces, juices, extracts, etc) with the aim of giving new organoleptic properties to familiar dishes and changing the way familiar dishes are served.

Encapsulation is the process of incorporating one material into a shell made of another material to produce particles ranging in size from several nanometers to several millimeters, in other words, immobilizing solid, liquid or gaseous substances into capsules that release the contents at a controlled rate for a predetermined period of time under certain environment conditions. The substance to be encapsulated is called the active substance, or the main product. The material into which the main product is enclosed is called a shell, a membrane, a wall, or a matrix. [6].

Ferran Adrià, the chef at El Bulli restaurant, became the pioneer of encapsulation technology in public catering, using the ability of alginate solutions to form gels by adding Ca2+ ions to them. In gastronomic circles, this method was referred to as "spherification".

Alginates are one of the most preferred ingredients to be used in encapsulation technology. Salts of alginic acid are classified as water-soluble high-molecular-weight compounds used in food industry as a structure-forming agent. The essence of the method is in the interaction of sodium alginate with a bivalent cation, for example, a calcium ion or another polyvalent metal (zinc, aluminum, copper), to form a gel. Diffusion formation of the gel structure is characterized by a high rate of gel formation, and this high-speed curing is used as a method of immobilizing and restructuring food products. Each drop of the alginate solution forms one granule of gel with the inclusion of the active agent. The spatial grid of the gel is formed by the interaction of calcium ions with carboxyl groups and additionally stabilized by coordination links between calcium ions and hydroxyl groups, hyaluronic acid residues (Fig. 1)

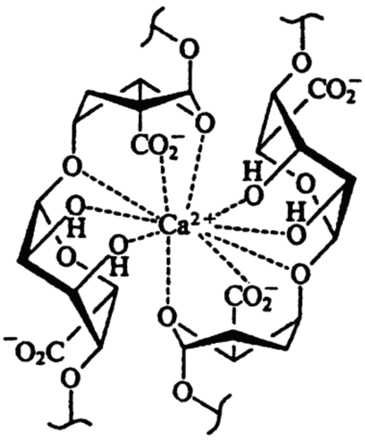

Figure 1 –Formation of a polysaccharide intermolecular complex with calcium ions.

This process of formation of alginate gels is used to produce spheres of small size with a dense shell and a liquid center. The product obtained in this way has the texture and appearance of natural fish caviar but a different flavor and taste [2].

A milk whey is used as a "supplier" of calcium ions (forming a solution), which is a by-product of cheese production, or casein, and is not widely used for commercial purposes, and often simply recyclable. [1].

The choice of curd whey in encapsulation technology by the method of spherification is caused by its high calcium content as compared with cheese whey. Inclusion of curd whey in the composition of the shell increases the nutritional value of a capsule, and its application in the production of encapsulated food products seems to be a prospective direction.

As a source of a biologically active agent in the production of encapsulated food products having high consumer properties, the use of wheat germ juice is of special interest, as it has bactericidal properties, high biological activity which facilitates the process of digestion, improves metabolism, increases physical productivity of a body [4, 5].

An essential factor restraining the mass use of wheat germ juice in the population's nutrition is the lack of well-founded germination technologies which are able to provide short terms of germination and microbiological cleanness of geminating material.

Nowadays, hydroponics is widely used, meaning the technology of growing grain seeds on porous porous moisture- and air-intensive environments. This technology allows to reduce the production area significantly, but does not affect the time costs for obtaining wheat sprouts.

A solution of the problem of high quality and competitive healthy food enriched with wheat germ juice is the development of improved technology based on the combined use of physical factors (electrochemically activated water (ECHA-water) and electromagnetic field of extremely low frequencies (EMF ELF) in hydroponic germination of wheat grains. [3].

Materials and Methods

The mass fraction of proteins was determined using Kjeldahl method; the mass fraction of carbohydrates including monosaccharide and disaccharides was determined using permanganate and photocolorimetric methods. Food fibers were determined by volumetric method as the sum of indicators of mass fraction for pectin, protopectin, hemicelluloses and cellulose.

The analysis of mineral substances was carried out using physical and chemical methods (optical and electrochemical). The iron content was determined by a colorimetric method based on changes of color intensity of the solution of complex compound of ferrous ion with red phenanthroline. The experiment was done on a photoelectric colorimeter with color filter λ_{max}= (490 ± 10) nm.

The content of copper and zinc in products were determined by an atomic-absorption method based on the ability of free atoms of elements in gases of flame to absorb energy at typical for each element wavelength (for Cu – 324 nm, for Zn – 285, 9 nm) using atomic absorption spectrometer "Quantum=Z. ETA". Calcium was determined on the system "Kapel 103" using the method of capillary electrophoresis based on the migration and separation of cations under the influence of electric field because of their different electrophoretic mobility. The identification and the number of cations under analysis were determined indirectly by recording ultraviolet absorption at wavelength 254 nm. Data processing was carried out with the help of a software package "MultiChrome" [93].

The fixed parameters determining the content of mineral compounds performed by the method of capillary electrophoresis are presented in Table 1.

Antioxidant activity in a sample under examination was determined using a liquid chromatograph "Color Jauza-01-AA" (Scientific Production Association "Chimavtomatica"). The mass concentration of antioxidants was measured using a calibration graph in dependence on the response from the concentration of gallic acid.

In order to identify carbolic acids, the method of analysis of compounding was applied which uses electrokinetic phenomena (electric migration of ions, other charged particles and electroosmosis) for separation and identification of components, e. g. capillary electrophoresis. These phenomena occur in solutions when they are placed in electric fields, predominantly, that of high-voltage. If the solution is in thin capillary, for example, quartz, the electric field interfered along the capillary induces the movement of charged particles and passive flow of liquid which results in the separation of individual components in the probe, since parameters of electric migration are specific for every type of charged particles. At the same time, perturbing factors (diffusion, sorption, convective, gravitational and others) are weakened significantly and thus, the record in separation efficiency can be achieved [93].

The analysis of phenol compounds was carried out with the help of capillary electrophoresis "Kapel-105M" (the group of companies "Lumex") with quartz capillary of the following geometry: effective length was 60 mm, internal diameter was 75 micron. The borax buffer was used as a leading electrolytic conductor (pH=9, 2). The probe was introduced at the pressure of 30 millibar for 5 minutes. Spectrophotometric detection was carried out at the temperature of 24, 9 ºC, operating voltage 23kilovolt, and wavelength 280 nm for 860 seconds. System administration, collection and data processing were performed with a software package "Elforan".

The fixed parameters determining the content of phenol compounds in wheat germ juice performed by the method of capillary electrophoresis are presented in Table 2.

Table 1 – Parameters of capillary electrophoresis when mineral compounds were determined

Time	Component	Height	Start	End	Square	As (0.1)	Rn, n+1
3,237	Ammonium	3,538	3,013	3,257	2220,0	0,0	2,2
3,880	Potassium	7,311	3,573	3,903	592,3	0,0	2,0
4,305	Sodium	3,190	4,217	4,318	90,06	0,1	8,7
5,403	Magnesium	11,425	5,282	5,433	357,0	0,1	8,8
6,530	Calcium	2,381	6,488	6,593	52,18	2,3	0,0

Table 2 – Parameters of capillary electrophoresis when phenol compounds were determined

Time	Component	Height	Start	End	Square	As (0.1)	Rn, n+1
6,840	Rutin	0,300	6,793	6,878	5,816	1,1	7,9
7,627	Syringic acid	0,830	7,563	7,678	17,12	1,0	1,0
7,740	Ferulic acid	1,283	7,688	7,792	26,03	1,1	4,1
8,055	Salicylic acid	0,181	8,037	8,088	1,570	2,0	1,1
8,147	Benzoic acid	0,390	8,095	8,208	11,20	1,2	1,8
8,405	p-Caumaric acid	0,419	8,295	8,473	23,08	0,8	0,7
8,520	Vanillic acid	1,817	8,473	8,630	48,78	1,3	1,4
8,728	Quercetin	0,334	8,670	8,820	9,012	1,2	2,7
9,143	4-Hydroxybenzoic acid	0,141	9,042	9,202	4,225	0,9	5,2
10,048	Caffeic acid	0,248	9,957	10,145	10,74	1,0	5,3
11,080	Gallic acid	0,239	10,958	11,162	10,14	0,7	2,0
11,513	3,4-Dihydroxybenzoic acid	0,380	11,417	11,643	17,45	1,4	0,0

Table 3 – Process parameters of wheat grain germination.

Process stage and process mode	Process mode value
1. Flushing grain by water:	
Water duty	1:1,5
Frequency of flushing, times	2-3
2. Activation of water by the membrane method in a water ionizer to produce the analyte with pH 3.5	
Duration of electrolysis, minutes	15
3. Grain moistening for activation of germination until 30 % of moisture content is reached	
The temperature of air, ^oC	20-22
pH electrochemically activated water (ECHA-water), units	3,5
The temperature of analyte , ^oC	20-22
Water duty	1:2,7
The time of soaking,minutes	5,5
4. Preliminary exposure of wheat grain in electromagnetic field of extremely low frequencies (EMF ELF)	
current intensity, A	10
frequency, hz	20
Time of exposure, minutes	20
5. Activation of water by membrane method in water ionizer	
Duration of electrolysis to obtain catolyte with pH 8,0, minutes	1
6. Grain germination	
Until wheat seedlings reach the length of, mm	120
Temperature of air, ^oC	20-22
Temperature of aquatic environment, ^oC	20-22
pH electrochemically activated water (ECHA-water), units	8,0
Volume of aeration, ml/min	1200
frequencies content of light , nm red blue infrared	 660 430 730
Time of light exposition a day, h	24
Time of germination , h	110

RESULTS

Wheat spring soft varieties "Altaiskaya 105" and "Polba Runo" are used for germination in small quantities on the territory of Krasnodar Region. The complex use of electrochemically activated water (ECHA-water) and preliminary exposure of material to electromagnetic field of extremely low frequencies (EMF ELF) intensifies the germination process and shortens the time of obtaining wheat sprouts “Altayskaya 105” by 34 hours, and for "Polba Runo" by 24 hours as compared with the traditional technology which takes 144 hours for the germination process.

Thus, based on the results of performed studies, process parameters of germination of wheat grain by hydroponic method were established (Table 3).

The technology of hydroponic germination for production wheat germ juice includes three main stages: preparation and preliminary soaking in electrochemically activated water (ECHA-water) with pH 3.5; loading of germination chambers by soaked and EMF ELF treated grain, its germination in artificial light, withdrawal of products when the length of sprouts reaches from 12 to 15 cm (green parts of a plant – sprouts without grain), and extraction of juice by squeezing using the twin screw juice extractor. Wheat germ juice is a cloudy homogeneous liquid of dark-green color.

Objective and accurate evaluation of biochemical properties of wheat germ juice has a big significance for organization and technological process of enriched produce.

Figure 2 presents the chromatographic profile of mineral compounds in wheat germ juice.

The results of evaluation of biochemical composition and quality indicators of wheat germ juice are presented in Table 4.

The presence of biologically active agents in wheat germ juice: polysaccharides, mineral substances, vitamins and the absence of antinutrients condition a wide spectrum of effects on a human body.

Excessive content of free radicals in a body can lead to the development of many diseases, including dangerous and socially important. When there is a disbalance in the antioxidative system, the body requires a therapy with natural antioxidants, which retard or prevent oxidative processes occurring in a human body.

Figure 3 presents the chromatographic profile of phenol compounds of wheat germ juice

Antioxidative activity in terms of the equivalent amount of gallic acid is 189,4 mg/ dm^3. It is established that the amount of antioxidants in wheat germ juice is much higher than in some berries, vegetables and fruits.

Phenolcarbonic acids, flavonols and phenol compounds of unspecified structure are identified in wheat germ juice (Table 5).

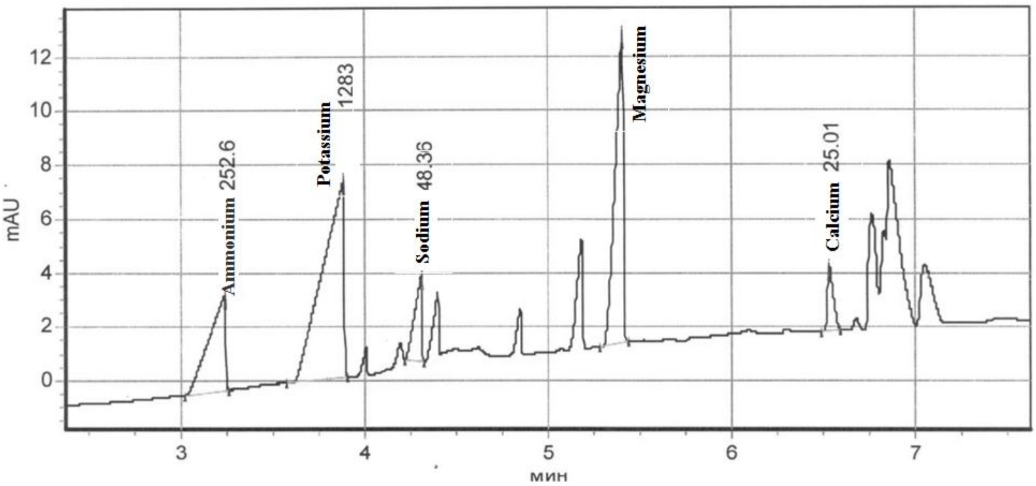

Figure 2 – Chromatographic profile of mineral compounds in wheat germ juice

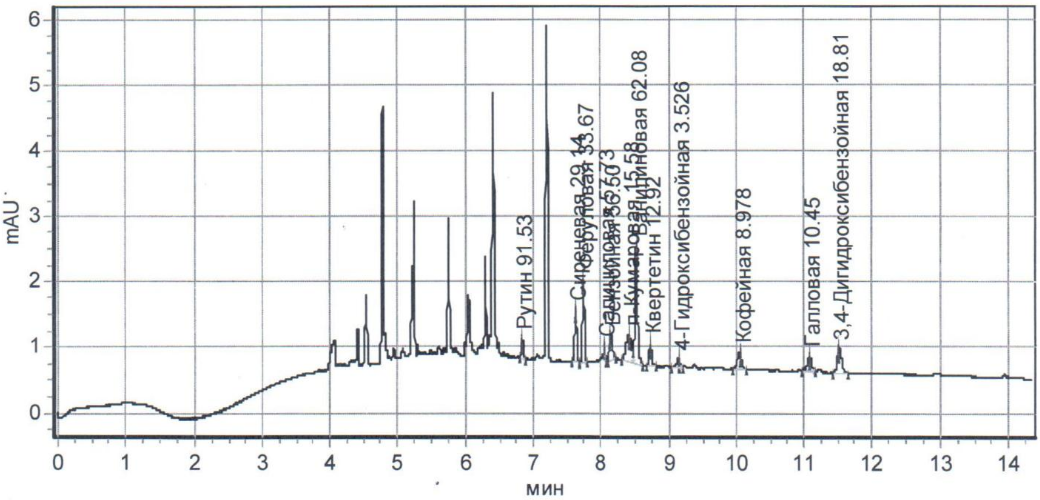

Figure 3 – The chromatographic profile of phenol compounds of wheat germ juice

Table 4 – Chemical composition of wheat germ juice

Name of the indicator	Value of the indicator
Mass fraction, %:	
Protein	1,74
Fats	0,03
Carbohydrates, including	3,36
Monosaccharides	1,51
Disaccharides	1,26
Pectin	0,19
Protopectin	0,30
Cellulose	0,10
Dietary fibers	0,59
Macronutrients , ml/l:	
Potassium	1283
Sodium	48,36
Magnesium	125,50
Calcium	25,01
Trace elements, ml/l:	
Ferrum	15,40
Copper	1,40
Zink	0,17
Vitaimins, mg %:	
Vitamin C	4,71
Vitamin B_1 (thiamin)	0,02
Vitamin B_2 (riboflavin)	0,01
Vitamin B_6 (pyridoxine)	0,90
P- active agents	265,00

Table 5 – Composition of phenol compounds in wheat germ juice

Name of the indicator	Value of the indicator, mg/l
Rutin	91,53
Syringic acid	29,14
Ferulic acid	33,67
Salicylic acid	57,73
Benzoic acid	56,50
P-Caumaric acid	15,58
Vanillic acid	62,08
Quercetin	12,92
4-hydroxybenzoic acid	3,526
Caffeic acid	8,978
Gallic acid	10,45
3,4-dihydroxybenzoic acid	18,81

DISCUSSION

The result of carried out research allow us to recommend juice from wheat sprouts as an ingredient of encapsulated sweet dishes. The technology involves extrusion of a capsule mixture containing wheat germ juice, decalcified curd whey, sodium alginate by axial feeding into a forming solution (curd whey) through a 3-mm diameter outlet (Table 6). In this way, spherical capsules of round-regular shape with a diameter of 5 mm and high organoleptic parameters are produced.

Table 6 – Process parameters of production of encapsulated garnishes for sweet dishes using "spherification" method .

Technological stage and technological mode	Process mode value
1 Preparation of a liquid to be spherified	
1.1 Neutralization of curd whey (to pH ≥ 4.2)	
amount of acidity regulator, %	1,5
1.2 Dissolution of sodium alginate	
concentration, %	1
volume of decalcified curd whey, %	47,5
volume of encapsulated ingredient, %	50
structure-forming agent expanding, min	40
1.3 Mixing of prepared components	
mixing type manual/auto	mixing type manual/auto
time, sec	30
2. Solution degassing	
cooling, C	4±2
time, min	30
3. Preparation of the forming solution (curd whey thermostating)	
time, min	30
temperature, °C	20-22
4. Encapsulation	
ratio of the encapsulated mixture to the forming solution, g/g	1:10
dynamic viscosity of the encapsulated solution, cP	280-1000
outlet diameter, mm	3
capsule diameter, mm	5
capsule residence time in the forming solution, sec	120
5. Spheres washing	
capsule-water ratio, g/g	1:4
time, sec	30
6. Capsule drying	until moisture removal from the surface

CONCLUSIONS

The developed technology of products from germinated grain and its use in encapsulated garnishes for sweet dishes allows us to obtain enriched food products possessing new organoleptic properties, spectacular presentation with undoubtedly innovative merchandise appeal to be introduced into public catering enterprises.

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