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Features of Chemical Composition of Aromatic Raw Materials CO_2-Meals

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Abstract.

The scope of the paper was to develop the technology of flour confectionery for functional purposes using phytonutrients. The subject of the research were CO_2-meals obtained after extraction with liquid food carbon dioxide from medicinal and aromatic raw materials at a temperature of 31.2 °C and a pressure of 7.38 MPa at Karavan, LLC in the city of Krasnodar. Based on the conducted research of the chemical composition of CO_2-meals, the authors have found that they are a valuable raw material for the production of flour confectionery for functional purposes, given the high content of proteins, vitamins, minerals, as well as pectin and especially dietary fibers, which play an important role in the composition of products for functional purposes. It was shown that the content of toxic elements in CO_2-meals of herbal aromatic raw materials is significantly below the permissible standards set by the "Medical and Biological Requirements and Sanitary Norms for the Quality of Food Raw Materials and Foodstuffs". The authors have scientifically substantiated and experimentally confirmed the expediency of using CO_2-meals of aromatic raw materials in the production of flour confectionery for functional purposes.

Keywords: CO_2-extracts, CO_2-meals, herbal raw material, phytonutrients.

INTRODUCTION.

Since we should not expect an improvement in the environmental situation in the near future, and it is not necessary to abandon the use of chemical additives in food technology, the dietary components able to reduce the negative impact of harmful nutritional factors on human health and help to improve the overall condition of the body become an alternative.

According to the D. Potter 's theory [1], 7 basic types of functional ingredients are effectively used at the present stage of market development:

- Food fibers (soluble and insoluble);
- Fat-soluble and water-soluble vitamins (A, group B, D, etc.);
- Mineral substances (such as calcium, iron);
- Polyunsaturated oils and fats (vegetable oils, fish oil, omega-3 and omega-6 fatty acids);
- Antioxidants: (Ascorbic acid - vitamin C and alpha-tocopherol - vitamin E.);
- Oligosaccharides (substrate for beneficial bacteria); and
- Other groups (microelements, bifidobacteria, etc.).

Treatment with medicinal herbs has always attracted the attention of people. To fully and deeper understand the reasons that have caused the amazing permanence of the use of medicinal plants in comparison with other medicinal products, first of all, it is necessary to consider the issues related to the origin and history of phytotherapy.

Reference publications and papers on the history of human use of plants for treatment usually assert that the people got acquainted with their medicinal properties in a deep antiquity [2]. To confirm this, it is pointed out that many medicinal plants were known in Ancient Egypt several millennia ago.

Our digestive, hematopoietic, excretory and other organs have undergone a long period of development. However, the creation of the type of metabolism, the structure of all organs, the adaptation of each organ to the performance of strictly specific functions were determined by a sophisticated natural complex of substances necessary for the vital activity of the human organism that existed in the surrounding plant world, since plants served as the main food for a man and its ancestors.

The method of treatment and prevention of diseases using herbs has no contraindications. Medicinal herbs have no side effects, do not cause allergies, drug disease or withdrawal syndrome [3,4,5,6]. This is a highly effective treatment for children, especially those suffering from cold-related diseases, increased nervous excitability, or insomnia [3, 7, 8, 9]. For middle-aged people, herbal infusions help not only to improve well-being, but also to reduce the dosage, and in some cases, to refuse to administer potent unsafe chemotherapy drugs. The prevention of diseases and the treatment of pregnant women with herbal infusions that do not have an embryotoxic effect on the fetus are of interest [7].

In Russia, as in other countries, there is a steady trend of increasing interest in the consumption of food products and preventive preparations made of environmentally safe herbal raw materials. Natural herbal raw materials, such as medicinal herbs, fruits and berries, as well as potherbs and odoriferous plants, biologically active beekeeping products won the recognition and find extensive application in the food and medical industry. Demand for plant-based biostimulants and bioenergetic additives is increasing [4]

As part of the perspective herbal raw materials for obtaining food and biologically active additives, products obtained by extraction with liquid food carbon dioxide - CO_2 -extracts and CO_2-meals from various plant raw materials are of practical interest in the confectionery industry. The natural flavor of CO_2-extracts and CO_2 -meals has been retained for a relatively long time, giving a specific taste to the products. Studies show that CO_2-

extraction products contain a complex of vitamins, provitamins and biologically active substances present in the plant at the time of extraction, and are preservatives and antioxidants [3, 10, 11].

All the above allows us to conclude that the use of CO_2-extracts and meals as a biologically active additive in the confectionery production is promising, but it requires a complex of technological studies, including the determination of formulations, the dough-making parameters and the allowable storage duration.

The scope of the paper was to develop the technology of flour confectionery for functional purposes using phytonutrients.

The subject of the research were CO_2-meals obtained after extraction with liquid food carbon dioxide from medicinal and aromatic raw materials at a temperature of 31.2 °C and a pressure of 7.38 MPa at Karavan, LLC in the city of Krasnodar.

METHODS

At the first stage of the study, the chemical composition and properties of CO_2-meals obtained by extraction with liquid food carbon dioxide were studied in order to justify the possibility of their application for the creation of flour confectionery with increased consumer properties for functional purpose.

The protein mass fraction was determined using the N2/protein DKL8 quantification system manufactured by VELP SCIENTIFICA, Italy. The biological value of a sainfoin seeds powder was studied by experimental determination of the amino acid composition using the "KAPEL-105M" capillary electrophoresis system manufactured by Lumex, Russia [12].

The mass fraction of fiber was determined on the FIBRETHERM FT12 fiber analysis machine manufactured by Gerhardt, Germany in accordance with GOST 10846-91. The mass fraction of fat was determined on the SOXTHERM SOX414a automatic unit for solid-liquid extraction manufactured by Gerhardt, Germany [13].

The mass fraction of carbohydrates, including mono- and disaccharides, was determined chromatographically using a high-pressure liquid chromatograph in the acetonitrile-water mixture (77:23). The diterpene glycosides were quantitatively determined on a Germany-produced densitometer, by staining intensity calculation.

The mass fraction of macro- and microelements (potassium, sodium, calcium, magnesium, iron, manganese, chromium, zinc and copper) in dry leaves of stevia and skimmed aromatic raw materials was determined by atomic absorption spectrophotometry (AAS) using AAS-1 analyzer manufactured by Zeiss, Germany.

The mass fraction of metals (potassium, sodium, calcium, magnesium, iron) in CO_2-meals was determined by atomic absorption spectroscopy [14]. This is a method of quantitative elemental analysis by atomic absorption spectra. Radiation is transmitted in the range of 190-850 nm through the layer of atomic vapors of the sample obtained using an atomizer. As a result of the absorption of light quantum, the atoms are transformed into an excited energy state. The so-called resonance lines characteristic of a given element correspond to these transitions in the atomic spectra.

The results of the experiments were evaluated using modern methods of static reliability calculating using the Statistica 6.0, Microsoft Office Excel 2007 and Mathcad software.

All the studies were carried out on the equipment of the Food and Chemical Technologies Research Center of the FSBEI of Higher Education "Kuban State Technological University".

RESULTS

The first stage of the study was the determination of the chemical composition of the used CO_2-meals: called Repertories No. 1, 2, 3. Repertory 1 includes medicinal and aromatic plants, such as coriander, oregano, peppermint, thyme, lemon balm, sweet almonds, agrimony, nutmeg, lime blossom, chamomile and sweet clover. Repertory 2 includes the following medicinal and aromatic plants: tutsan, coriander, oregano, nutmeg and cloves. Repertory 3 includes the following medicinal and aromatic plants: orange peel, coriander, cinnamon, nutmeg and cloves.

These herb repertories are used in the traditional medicine for the prevention and treatment of colds, in cases of inflammation of the gastrointestinal tract, and for strengthening the immune system. CO_2-meals of Repertories 1 and 2 are used in the production of dessert wines as biologically active additives, as well as natural flavors and dyes. The investigated compositions of CO_2-meals of medicinal and aromatic plants, fully lack the synthetic essences, flavors and colorants, and their taste and aroma are provided by natural medicinal and aromatic herbs.

The composition of medicinal and aromatic plants of Repertory 1, Repertory 2 and Repertory 3 is provided in Table 1.

Table 1: Composition of medicinal and aromatic plants repertories

Indicator name	Content in repertories, %		
	Repertory 1	Repertory 2	Repertory 3
coriander	18.0	24.0	13.5
oregano	12.0	30.5	-
peppermint	9.0	-	-
thyme	12.0	-	-
melissa	9.0	-	-
sweet almond	4.5	-	-
argimony	9.0	-	-
nutmeg	9.0	20.0	15.5
lime blossom	9.0	-	-
chamomile	4.5	-	-
clover	4.5	-	-
tutsan	-	20.5	-
cloves	-	5.0	7.0
orange peel	-	-	34.0
cinnamon	-	-	30.0

To determine the possibility of using CO_2-meals of medicinal and aromatic plants in the production of flour confectionery, the chemical composition of these products was determined by the content of the mass fraction of moisture, proteins, lipids, dietary fibers, nitrogen-free extractives, tannins of minerals and vitamins.

The test results are shown in Table 2.

Table 2: Chemical composition CO_2-meals of medicinal and aromatic plants

Name of indicators	Content of substances in CO_2-meals		
	Repertory 1	Repertory 2	Repertory 3
Mass			
fraction,%:	8.30	8.10	9.8
moisture	7.51	8.59	6.74
ash	2.08	1.90	4.06
lipids	8.70	6.40	5.58
proteins	36.50	35.35	34.3
carbohydrates,	28.63	31.91	29.66
incl.	1.85	1.44	1.89
fiber	2.10	4.30	2.8
pectin	34.81	35.36	36.7
tannins			
nitrogen-free extractives			

Analysis of the data in Table 2 shows that the CO_2-meals of medicinal and aromatic plants contain lipids, proteins, carbohydrates, fiber and pectin. The high content of carbohydrates, including fiber, which is recommended to be introduced into the composition of food products for the functional purpose, and its content in CO_2-meals of medicinal plants is from 28 to 32%, depending on their composition should be noted.

Table 3 shows the vitamin composition of the investigated CO_2-meals investigated.

Table 3: Vitamin composition CO_2-meals of medicinal and aromatic plants

Name of indicators	Content of vitamins in CO_2-meals		
	Repertory 1	Repertory 2	Repertory 3
Vitamins, mg/100 g:			
C	9.5	7.85	5.46
PP	8.0	8.5	9.2
P	2.5	3.41	4.67
B_1	11.25	9.47	8.2
B_2	36.1	35.4	31.5

Taking into account that the biological value is also determined by the amino acid composition of the proteins, it was of interest to determine it in the raw material examined. Table 4 provides data on the composition of essential amino acids of CO_2-meals of medicinal and aromatic plants.

Table 4: Amino acid composition of CO_2-meals of medicinal and aromatic plants

Name of amino acids	FAO/WHO Reference Scale		Repertory 1		Repertory 2		Repertory 3	
	A	C	A	C	A	C	A	C
Valine	5.0	100	5.7	114,	5.3	106.0	5.1	102.0
Isoleucine	4.0	100	4.3	107.5	3.9	97.5	3.7	92.5
Leucine	7.0	100	7.9	112.8	7.2	102.8	6.8	97.2
Lysine	5.5	100	4.5	81.8	3.9	71.0	4.8	87.3
Methionine + cystine	3.5	100	3.0	85.7	2.8	80.0	3.5	100.0
Threonine	4.0	100	3.7	92.5	3.5	87.5	3.9	97.5
Phenylalanine + tyrosine	6.0	100	8.3	138.3	7.8	130.0	7.4	123.3
Tryptophan	1.0	100	1.7	170.0	1.4	140.0	1.5	150.0

Table 5: Composition of mineral elements of CO_2-meals of medicinal and aromatic plants

Name of elements	Content of substances in CO_2-meals		
	Repertory 1	Repertory 2	Repertory 3
Mass fraction:			
Macroelements, mg/100g			
Sodium	82	75	69
Calcium	1,199	1,078	1,097
Phosphorus	585	598	474
Magnesium	514	575	547
Potassium	5,196	5,100	5,070
Microelements, mg/kg			
Iron	54	48	51

Table 6: Microbiological safety indicators of CO_2-meals of medicinal and aromatic plants

Indicator name	Admissible levels	Indicator value		
		Repertory 1	Repertory 2	Repertory 3
The number of mesophilic anaerobic and facultative-anaerobic microorganisms, CFU/g, not more than	$5x10^4$	$(1.5\text{-}2.0)\times10^2$	$(1.5\text{-}2.0)\times10^2$	$(2.0\text{-}2.5)x10^2$
Coliforms (in 0.01 g)	not allowed	not allocated		
Pathogenic m/o, including salmonella	in 25.0 g not allowed	in 25.0 g not allocated		
Mould, CFU/G, not more	100	35-40	28-32	30-35

Table 7: Sanitary, chemical and radiological safety indicators of CO_2-meals of medicinal and aromatic plants

Indicator name	Admissible levels	Indicator value		
		Repertory 1	Repertory 2	Repertory 3
Toxic elements, mg/kg:				
Copper	5.0	0.07-0.09	0.07-0.09	0.07-0.09
Lead	0.5	0.090-0.095	0.093-0.102	0.085-0.100
Zinc	10.0	1.40-1.52	1.37-1.48	1.38-1.50
Arsenic	0.2	0.004	0.004	0.003
Mercury	0.02	0.001	0.001	0.001
Cadmium	0.03	0.004	0.003	0.004
Pesticides, mg/kg				
Hexachlorocyclohexane (α, β, γ-isomers)				
DDT and its metabolites	0.5	not detected		
	0.1	not detected		
Radionuclides, Bq/kg:				
Cesium-137	130	Absent		
Strontium-90	50	Absent		

The assessment of the amino acid composition of the proteins of CO_2-meals of medicinal and aromatic plants has shown that they include all the 10 essential amino acids, and lysine (vel. 81.8%) is the limiting amino acid - Repertory 1, (vel. 71.0%) - Repertory 2, and (vel. 87.3%) - Repertory 3.

Taking into account the need to enrich the flour confectionery products with mineral elements [15], the mineral composition of CO_2-meals of medicinal and aromatic plants was determined, and is presented in Table 5.

The analysis of the data presented shows that all repertories of CO_2-meals of medicinal and aromatic plants have a high content of micro- and macroelements.

Based on the analysis of Tables 2-5 on the biological and physiological value of CO_2-meals, it can be concluded that the use of CO_2-meals of medicinal and aromatic plants as a special biologically active additive in the production of functional products is effective.

According to SanPiN (Sanitary Rules and Regulations) 2.3.2. 1078 – 01 "Hygienic requirements for safety and nutritional value of food products", as well as MG 2.3.2.721 - 98 "Determination of the safety and efficacy of biologically active food additives", the evaluation of the safety of additives includes the study of their sanitary and chemical safety indicators, and sanitary and microbiological monitoring and control of radiological indicators.

Taking into account that microbiological purity is one of the main requirements for flour confectionery, microbiological indicators of CO_2 -meals of medicinal and aromatic plants were determined.

Table 6 shows the microbiological safety indicators of CO_2-meals of medicinal and aromatic plants.

Table 7 shows the sanitary, chemical and radiological safety indicators of CO_2-meals of medicinal and aromatic plants.

According to the results provided in Table 7, the content of toxic elements in CO_2-meals of herbal aromatic raw materials is significantly below the permissible standards set by the "Medical and Biological Requirements and Sanitary Norms for the Quality of Food Raw Materials and Foodstuffs". Organochlorine pesticides and radionuclides were not detected.

The data provided show that the CO_2-meals of medicinal and aromatic plants correspond to all the safety requirements for additives and plant products, and there are no obstacles to their use for food purposes.

Taking into account that the repertories of skimmed spicy aromatic raw materials will be used in the production of flour confectionery, it is necessary to obtain products in the form of fine powder with the maximum preservation of biologically valuable substances during processing in a rotor-roll disintegrator.

An increase in the surface area of a mechanically treated solid is often considered as a reason for the increase in chemical activity due to treatment.

Mechanical activation is used to modify the physical and chemical properties of substances included in the composition of medicinal and aromatic plants that determine their biological activity and stability. The biological availability and biological activity of these substances depend primarily on the solubility of the biologically active substance. In many cases, biologically active substances have too low solubility and are not absorbed by organisms. The simplest method to adjust the rate of dissolution and the biological activity of substances is the formation of optimum-sized particles.

To confirm the proposed assumption, the specific surface area of the crushed products, as well as the particle size distribution, was determined.

It should be noted that the repertory of skimmed aromatic raw materials does not contain substances that adversely affect the organoleptic characteristics, so the processing temperature in the rotor-roll disintegrator was constant and corresponded to 25^0C, while the pressure was varied in the range from 5 to 20MPa.

Figure 1 shows the data on the dependence of the specific surface area of the crushed products on the pressure in the contact zone of the working elements of a rotor-roll disintegrator.

The granulometric composition of BAA from skimmed aromatic raw materials obtained by crushing in a rotor-roll disintegrator differs somewhat depending on the type of repertory but is mainly represented by particles with a size of 5 to 30 microns, which is commensurated with the size of the flour particles.

It was established that the treatment of CO_2-meal of medicinal and aromatic plants in a rotor-roll disintegrator at a temperature of 25^0C and a pressure of 10 MPa makes it possible to obtain products with a high degree of grinding while maintaining their physiological ingredients.

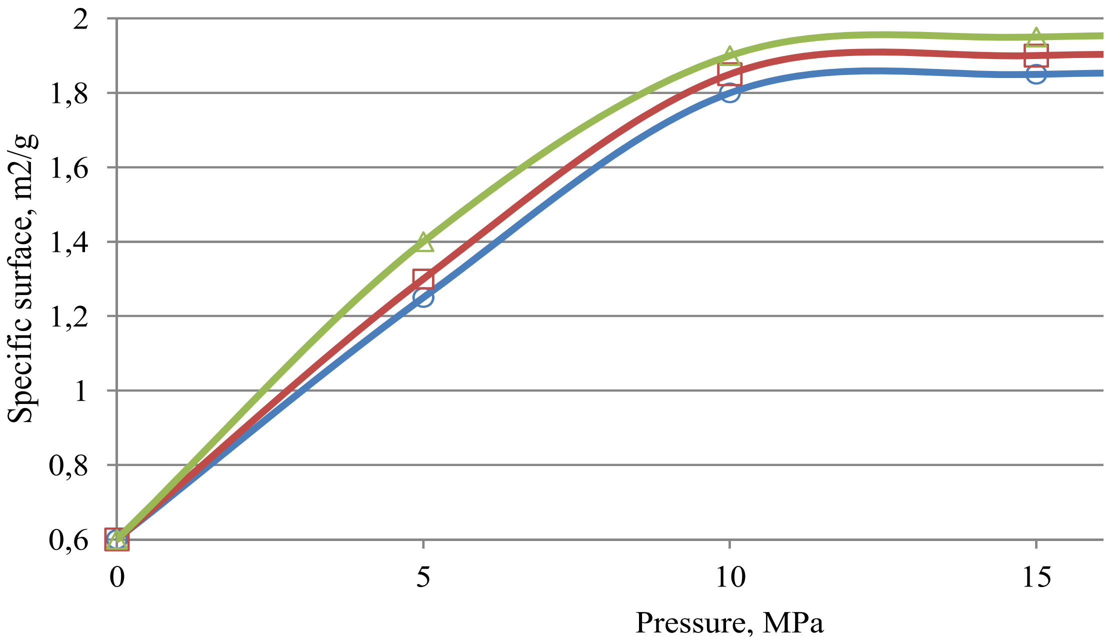

Figure 1: Dependence of the specific surface area on the pressure in a rotor-roll disintegrator

Discussion

Based on the conducted research of the chemical composition of CO_2-meals, it has been found that they are a valuable raw material for the production of flour confectionery for functional purposes, given the high content of proteins, vitamins, minerals, as well as pectin and especially dietary fibers, which play an important role in the composition of products for functional purposes.

It has been shown that the content of toxic elements in CO_2-meals of herbal aromatic raw materials is significantly below the permissible standards set by the "Medical and Biological Requirements and Sanitary Norms for the Quality of Food Raw Materials and Foodstuffs".

It has been shown that the treatment of CO_2-meals of medicinal and aromatic plants with the use of the mechanochemical activation method makes it possible to obtain BAA having high consumer properties, as well as nutritional value and physiological activity.

Conclusion

The expediency of using CO_2-meals of aromatic raw materials in the production of flour confectionery for functional purposes has been scientifically substantiated and experimentally confirmed.

The experimental data obtained allowed recommending the BAA under research for the production of functional foods.

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