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Innovative Technology and Food Safety of Fruit Biopowders

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Abstract

A technology has been developed for biopowders production from fruit raw materials grown in the Chechen Republic. The data on vacuum microwave drying of fruit raw materials under the influence of an amplitude-modulated magnetic field with carrier frequency of 180--20 kHz and modulating frequency of 10 to 30 Hz, with magnetic induction value of 5 mt. The proposed regimes of dehydration of fruit raw materials and its subsequent grinding by gas-liquid "explosion", providing the possibility of successful use in dried state in production technology of soft drinks. The peculiarity is the use of ecologically clean fruits of apricots, cherry plums, cherries, pears, melons and plums grown in Shelkovsky district of the Chechen Republic as raw materials. We studied physical and chemical indicators, content of phenolic substances and organoleptic indicators of fruit raw materials, powders and beverages. We also conducted comparative assessment. Under the influence of EMB ELF vacuum microwave drying of fruits contributes to better preservation properties of raw materials and finished powders. Organoleptic evaluation showed that non-alcoholic beverages produced on the proposed technology had intense color and more pronounced flavor of sweetness and acid compared to traditional non-alcoholic beverages. The advantage of this technology is the possibility to transport components for beverage production at unregulated temperature conditions to any location that is close to the consumer and carry out the production of soft drinks there.

Keywords: apricot, cherry plum, cherry, pear, melon, plum, powders, beverages.

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1. Introduction

Food as well as the economic and national security of the country, belongs to the basics of preserving the country. There will be no progressive development of food and processing industry and protection from economic sanctions without a prosperous state of the economy. Agricultural policy of Russia considers food security as a guarantor of uninterrupted supply of healthy food to places of consumption at affordable prices for population.

An updated version of the Food Security Doctrine, introduced by the Decree of the President No. 120 on January 30, 2010, should support national security in the long term until 2020 with a minimum share of domestic fruits and berries up to 70 %.

Food security issues are constantly in the purview of the Government of the Chechen Republic and Federal service for surveillance on consumer rights and human wellbeing (Rospotrebnadzor) bodies.

It is possible to develop a horticultural branch of agriculture in the Republic due to the rational use of unique soil, climatic conditions and a sufficient number of light days. Taking into account the fact that fruits, berries grown in mountainous, and foothill areas have a limited shelf life, the most appropriate solution here is to process them into dry products that have long shelf life and low weight [5, 13].

Some works of famous scientists and specialists are devoted to the analysis of the state of agricultural complex of the Chechen Republic and development of gardening based on the principles of adaptive intensification [1, 2, 4]. Due to high investment attractiveness of mountain gardening development in the Chechen Republic, it is possible to produce environmentally friendly products through processing fruits and berries [6, 10--12]. Currently the country has accumulated considerable experience in the development of gardening and providing the population with fruit and berry products that must be adapted to local conditions [8, 9]. Chechen agrarians and farmers should receive state support for the development of their horticultural farms in remote foothill areas within the framework of regional development programs for agricultural complex of the North Caucasus and Southern Federal Districts [14].

Specialists of Department of Life Safety at Grozny State Oil Technical University named after Academician M.D. Millionshchikov and Department of Food Technology of Animal Origin at Kuban State Technological University proposed a number of innovative technical solutions for complex processing of grapes [7, 15]. The processing of raw materials with low-frequency electromagnetic field is among the most promising technological methods [3, 7, 21]. The use of EMF LF in technological processes of grape processing influences the speed of processing of raw materials and reduces microbial contamination of products.

The experience of foreign farmers in the development of rural areas for growing crops is a considerable issue in the field of efficient cultivation and grape processing [16]. There is also information about the influence of processing methods of raw materials on the change in the content of phenolic substances and other biologically active compounds [17, 18, 20]. Manufacturing techniques and nutritional value of soft beverages from fruit and vegetable powders are described [19].

Authors studied Russian and foreign scientific and technical literature and made a conclusion on feasibility of producing beverages from dry fruit powders and their food and microbiological safety.

2. Purpose of the Study

To substantiate the expediency of processing apricots, cherry plums, cherries, pears, melons, plums into biopowders to produce soft beverages; offer innovative techniques to preserve valuable components of raw materials to maximum extent, and calculate the economic efficiency of soft drinks production based on fruit bio-powders.

3. Research Questions

Researched solved selection issues of fruit varieties with a high content of polyphenols and vitamin C zoned in local growing conditions. They evaluated the method for drying fruit raw materials under the influence of amplitude modulated magnetic field with carrier frequency of 180--20 kHz in modulating frequency of 10 to 30 Hz with magnetic induction value of 5 mt.

4. Purpose of the Study

The development of innovative technological methods in production of dry fruit powders and manufacture of non-alcoholic carbonated beverages on their basis. It was necessary to determine the impact of an extremely low frequency precision generator on intensification of dehydration of fruit raw materials.

5. Research Methods

Researchers used analytical, organoleptic, chemical, physicochemical, biochemical, microbiological methods as well as methods of mathematical statistics in this work. They applied chemical and physico-chemical methods to determine mass fraction of moisture, protein, fat, ash, and mineral substances with standard methods; vitamin composition with fluorimetric and colorimetric methods; yield of textured products with the gravimetric method. Mass concentration of sugars was determined according to

GOST (All Union State Standards) 8756.13.87, dry substances according to GOST 28561-90, content of vitamins and microelements -- according to State Pharmacopoeia, nitrogenous compounds (amine nitrogen, protein) -- according to the method recommended by Gerzhikov V.G., 2003. Organoleptic indicators were studied with an expert method when evaluating on a five-point scale, taking into account weighting factors of each indicator.

6. Raw Materials

Fruits grown in Shelkovsky district of the Chechen Republic were used in this work: Shalakh apricots, Obilinaya cherry plums, Charentais melons, Girlianda cherries, Circassian pear 325 and early Chagekskaia plums. The selection criterion for fruit varieties for biopowders production was an increased content of polyphenols, vitamin C and colorings. Phenolic and dye substances contained in fruits determine the taste and organoleptic properties of products.

Table 1 provides information on content of phenolic compounds and colorings in fruits grown in Shelkovsky district of the Chechen Republic.

Table 1: Content of phenolic compounds and colorings in fruits grown in Shelkovsky district of the Chechen Republic.

Species name	Phenolic compounds, mg/dm^3	Vitamin C, mg/dm^3	Colourings, mg/dm^3
Apricot	868 ±39,17	440±2,35	206 ±11,26
Cherry plum	822 ±21,35	690±2,25	314 ±2,36
Cherry	836 ±24,43	740±2,84	502 ±3,37
Pear	682 ±20,32	620±2,25	248 ±8,20
Melon	581 ±22,06	230±1,12	45 ±1,25
Plum	808 ±20,24	460±2,38	114 ±6,35

Judging by the data of table 1, fruit raw materials selected for experiments contain the increased amounts of biologically active substances.

7. Findings

Authors proposed to use extremely low frequency electromagnetic field for intensifying the process of removing moisture from raw materials [7, 15]. The effectiveness of EMF ELF influence on a plant cell depends on the degree of change in the structure of cellular moisture. When we use conventional drying methods, a surface layer of raw materials has more rapid dewatering. If we use electromagnetic field of given frequency, rapid mass transfer takes place from the central part of an object to the periphery from which moisture that has come to the surface is easily removed using traditional heat transfer media. Researchers also revealed the active effect on moisture of fruit raw materials of amplitude-modulated magnetic field with carrier frequency of 180--20 kHz and modulating frequency of 10 to 30 Hz, and magnetic induction of 5 mt. The combination of the impact on dried raw materials of a microwave electromagnetic field in the range of 2.40--2.45 GHz and vacuum of 60--65 kPa can significantly reduce the process of dehydration of raw materials.

The second innovative technique is the application of a gas-liquid explosion method for ultrafine grinding of dried raw materials. The essence of this method lies in short-term impregnation of dried raw materials with liquid carbon dioxide under pressure of 4.2 MPa and temperature of 28--30 °C. Then there is a subsequent abrupt release of pressure in a sealed apparatus to the atmospheric one. Liquid carbon dioxide that has impregnated all raw materials boils sharply and literally explodes the particles of raw materials to a nano-level (5--20 microns) with a rapid decrease in pressure. At the same time, the method of gas-liquid explosion has a negative effect on parasitic microflora of raw materials and raw materials treated with carbon dioxide becomes almost sterile and safe for use in food as a fortifier.

The results of experiments are the basis for development of technological scheme (Figure 1).

In collaboration with specialists from Institute of Food and Processing Industry of Kuban State Technological University, researchers made a special unit to process fruit raw materials with amplitude or frequency-modulated high-frequency oscillations, and imposition of low-frequency fields. A new technology involves the use of precision extremely low frequency generator (ELF PG). Its frequency was recorded with frequency meter and an oscilloscope.

Amplitude modulation coefficient was calculated with oscillogram:

$$m_{aM} = \left(\frac{(U_{max} - U_{min})}{(U_{max} + U_{min})} \right) \cdot 100\% \tag{1}$$

Field strength is calculated with values of amplitude-modulated signal:

$$U_{aM}(t) = \left[U_m + a(t) \right] \cos \omega t, \tag{2}$$

where $a(t)$ -- information signal; ω -- angular frequency; t -- time; U_m -- amplitude of carrier signal.

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Raw materials ↓	
Delivery, acceptance of raw materials, storage ↓	
Washing ↓	
Inspection ↓	
Removal of inedible parts ↓	
Inspection ↓	
Rinse ↓	
Microwave vacuum drying in ELF ELF field ↓	← ELF ELF generator
Grinding by CO_2 explosion method ↓	
Powder packing ↓	
Storage mode	

Figure 1: Structural scheme of fruit powders production.

As we use extremely low-frequency range from 10 to 30 Hz for modulation, modulated oscillation will look like this:

$$U_{aM}(t) = U_m \left(1 + m_{aM} \cos \Omega t\right) \cos \omega t, \tag{3}$$

where m_{am} -- amplitude modulation factor; Ω -- frequency of modulating signal.

Figure 2 shows a structural diagram of a precision extremely low-frequency generator intended to process fruit raw materials.

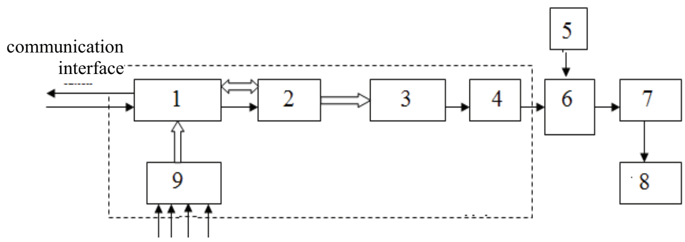

Figure 2: Structural scheme of precision extremely low frequency generator (ELF PG): 1 -- single chip microcomputer, 2 -- RAM, 3 -- digital-analog converter, 4 -- matching amplifier, 5 -- sine wave generator, 6 -- modulator, 7 -- power amplifier, 8 -- inductor, 9 -- analog-digital converter.

Studies results showed that an active effect on moisture of fruit raw materials of amplitude modulated magnetic field with carrier frequency of 180--20 kHz in modulating frequency of 10 to 30 Hz, and magnetic induction of 5 mt.

A synergistic impact effect on dried raw materials of microwave electromagnetic field in the range of 2.40--2.45 GHz and vacuum of 60--65 kPa in depth makes it possible to reduce a dehydration process of raw materials by 2.6 times compared to a traditional method.

When we use a method of gas-liquid explosion for ultrafine grinding of dried raw materials, it makes particles of fine powder with a particle size of 5--20 microns. The peculiarity of this method is short-term impregnation of dried raw materials with liquid carbon dioxide under pressure of 4.2 MPa and temperature of 28--30 °C. Then there is a subsequent abrupt release of pressure in a sealed apparatus to atmospheric one. Table 2 presents a chemical composition of fruit bio-powders.

Table 2: Chemical composition of fruit biopowers.

Characteristics	Apricot	Cherry plum	Cherry	Pear	Melon	Plum
Water, g	10	9	9	10	11	9
Protein, g	5,3	2,3	2,7	2,9	2,7	2,4
Fat, g	0,4	0,7	0,6	0,7	0,8	0,7
Carbohydrates,g	65,3	72,0	71,8	78,1	76,4	70,1
Food fiber	19,0	16,0	15,9	8,3	9,1	17,8
β-carotin, mcg	3500	60,0	23,6	10	17,0	24,1
Vitamin E, mg	5,6	1,8	1,1	0,5	0,8	1,0
Ferrum, mg	3,5	3,0	2,2	1,9	2,3	2,1
Potassium, mg	1720	850	820	870	650	750
Calcium, mg	165	83	102	109	93	101
Sodium, mg	17	10	10,1	9	12,0	10,2
Phosphorus, mg	150	80	82	94	75	82
B_1, mg	0,1	0,04	0,05	0,08	0,05	0,06
B_2, mg	0,2	0,15	0,13	0,12	0,14	0,13
PP, mg	3,0	1,6	0,8	0,6	0,7	0,7
Vitamin C, mg	4,0	3,0	3,7	9,0	2,9	3,6
Calories, kJ	1197,4	1270,7	1270,2	1382,9	1354,8	1240,5

Table 2 shows that a chemical composition of finished bio-powders almost completely preserves their nutritional and biological value of raw materials.

Biopowders obtained with a new technology can be used to enrich the composition of various food products and produce soft drinks based on them.

According to economists of Grozny Canning Plant, it is beneficial to master a technology of producing soft drinks with biopowders.

Table 3 presents calculations of economic efficiency from soft drinks production made based on fruit biopowders.

Table 3: Calculations of economic efficiency from soft drinks production made based on fruit biopowders.

Account cost	Drinks formula		
	Control Apple-cherry drinks	Apricot-cherry plum-pear drinks	Melon-plum-cherry drinks
Raw materials, rub.	63212	65730	68540
Tare and packaging materials, rub.	2290	2290	2290
Salary, rub.	540000	540000	540000
Overhead costs, rub.	696600	696600	696600
General running costs, rub.	804600	804600	804600
Selling expenses, rub.	44500	44500	44500
Profit, rub.	20188	29450	31243
Payback period, years	3,3	3,1	3,1
Return term, years	3,7	3,4	3,4
Product profitability, %	14	16	16,5

Table 3 demonstrates that the use of biopowders as the basis for soft drinks production can increase production profitability and reduce a payback period of products.

Organoleptic evaluation showed that non-alcoholic beverages made on the proposed technology had intense color and more pronounced taste of sweetness and acid compared to traditional non-alcoholic beverages.

8. Conclusion

Researchers carried out the study to substantiate processing feasibility of apricots, cherry plums, cherries, pears, melons, plums into biopowders grown in the Shelkovsky district of the Chechen Republic. They offered innovative techniques, which make it possible to preserve valuable components of raw materials to the maximum extent and determined the impact of an extremely low frequency precision generator on intensification of dehydration process of fruit raw materials. Authors provided the data on vacuum microwave drying of fruit raw materials under the influence of amplitude-modulated magnetic field with carrier frequency of 180--20 kHz and modulating frequency of 10 to 30 Hz with magnetic induction value of 5 mt. The application of a gas-liquid explosion method for ultrafine grinding of dried raw materials helps to get powder particles with diameter of 5--20 microns within short-term impregnation of dried raw materials. They used liquid carbon dioxide under pressure of 4.2 MPa and temperature of 28--30 °C and subsequent sharp pressure drop to atmospheric one. A gas-liquid explosion method has a detrimental effect on parasitic microflora of raw materials and raw materials treated with carbon dioxide become practically sterile and safe to use in food as a fortifier.

Profitability of biopowders from apricots, cherry plums, cherries, pears, melons, plums for soft drinks production has been substantiated. Authors used analytical, organoleptic, chemical, physico-chemical, biochemical, microbiological methods as well as methods of mathematical statistics.

The calculation of economic efficiency of production of soft drinks production based on fruit biopowders has been performed.

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