Use of vegetable and fruit powder in the production technology of functional food snacks

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Abstract. The article provides information on the development of formulations and production technology of functional food snacks (bars, tablets, cubes) from vegetables, fruit and secondary raw materials from the production of direct-pressed fruit and vegetable juices for a healthy snack during the day (morning, afternoon, evening) in accordance with the current trend of nutrition: "The right products at the right time". In a balanced diet, a person needs two to three snacks during the day between main meals. Each snack should have an individual combination of proteins, fat, carbohydrates, fiber and with the given parameters of calorie content and antioxidant activity. Developments of the authors of the article are related to vegetable and fruit snacks (bars, tablets and cubes) with low calorie content, which can be used as a light snack “on the go”, as an addition to food or a light snack. Products based on vegetable and fruit raw materials are included in the consumer subcategory in the market of snacks (bars, tablets and cubes) along with snacks made from cereal-muesli, fruit-nut, energy, but they differ significantly from them in low calorie, high fiber and antioxidant content. The scientific component of the development of formulations and technology for vegetable and fruit and vegetable snacks is not to create them with ingredients that no one has used yet, but that these products are required for the healthy nutrition of adults and the full development of children. All researches, developments and manufacture of samples were carried out on instruments and equipment of laboratories and departments of Michurinsk State Agrarian University.

1. Introduction

The creation and manufacturing of functional products are in the focus of attention of scientists and specialists involved in the development of modern technologies and food quality criteria [1].

The development and introduction into production of functional food of a new generation is an innovative direction in the food industry, which is of extremely important real-life impact and social efficiency.

Increased attention is paid to domestic products of natural origin, such as fruit, vegetables, cereals as the main raw material for the production of healthy and functional diet, due to their availability, renewability and consumer preferences by all groups of the population.

In the Laboratory of Functional Nutrition Products, at “Food Technology and Commodity Science” and “Production, Storage and Processing Technologies of Crop Production” departments of Michurinsk State Agrarian University of the Tambov Region, different researches have been conducted for more than 10 years in the field of creating new additives, semi-finished products and...
functional and prophylactic purposes from plant materials, including secondary raw materials, high in antioxidants. Based on the results of such researches, the development of technological recommendations (TR) on the organization of production processes, technological instructions (TI), standards of organizations (SO) for the processing of local plant materials, including on waste-free resource-saving technologies, as well as industrial production of food additives, semi-finished products and products of functional and preventive purposes are carried out [2, 3, 4].

To expand the range of functional additives, semi-finished products and food products from local plant materials: apples, carrots, pumpkins, beets, broccoli, zucchini, viburnum, mountain ash, sea buckthorn, cornel, nightshade sunberry, Jerusalem artichoke, hawthorn, scientists and technologists of Michurinsky State Agrarian University have already developed and transferred to industrial production standards of organizations (SO) and technological instructions (TI) for more than 100 types of functional food products: fruit drinks, jellies, jams, pastes, pastries, thermally stable fillings, marmalade, marshmallow, fruit mixes, snacks, chips, powders, candied fruits, bars, fruit leather, sweets, sugarplums, bread. The novelty of the developed technological solutions for the production of this range of food products is confirmed by the obtained patents of the Russian Federation for inventions in an amount of more than 30.

The aim of the research is to develop formulations and technology for new types of snacks based on fruit and vegetable raw materials for functional nutrition.

2. Research materials and methods

The objects of research are samples of fresh and dried local plant materials, including secondary raw materials from the production of direct-pressed juices (apple, carrot, beet and pumpkin squeezed): cauliflower and broccoli, sweet pepper, carrots, beetroot, leaves of rhubarb, lettuce, Chinese cabbage, parsley and dill, onions, zucchini and cucumbers with uncoated skin and with undeveloped seeds, red greenhouse or ground tomatoes with dense pulp, Jerusalem artichoke, apples, oranges and lemons with skin, as well as bars, tablets and cubes based on them.

The researches were conducted according to the methods of such authors as A. I. Ermakov, V. V. Arasimovich, N. P. Yarosh and other authors [5]; professor I. M. Skurikhin, and academician of RAMS, professor V. A. Tutelian, [6]; A. Ya. Yashin, N. I. Chernousova [7].

3. Results and discussion

Innovative low-waste technologies have been developed to produce new types of vegetable and vegetable-fruit snacks using effective technological methods to reduce the loss of biologically active substances in the final product. Functional dried ingredients with a residual moisture content of not more than 10% are prepared from fresh vegetable and fruit raw materials, mainly from “organic production”, and then powder is made from them. Innovative low-waste technologies consist in the use of squeezing from the production of apple, pumpkin, beet and carrot juices for the production of snacks, which undergo microwave processing to increase nutritional value and then dry to a residual moisture content of 8-10% and then powder is made from them.

Vegetable, fruit and vegetable bars, tablets and cubes are fast-food products (snacks), which are largely composed of vegetable mass, which allows being classified as snacks for a healthy and functional diet. In various versions of these snacks, the proportion of vegetable mass is from 50 to 80%, at least one or more vegetables, as well as in the form of a mixture of vegetables and fruit.

New types of vegetable and vegetable-fruit snacks were evaluated by organoleptic and physico-chemical indicators, nutritional value and antioxidant activity (table 1-4).

A comparison of the nutritional and energy values of functional snacks with those of other snacks showed that vegetable and vegetable-fruit snacks are less calorie (100-181 kcal/100g) compared to cereal, nut, candied snacks (300-450 kcal).
Table 1. Average nutritional and functional values of 100 g of snacks, depending on the recipe components.

| Name of a product                                      | Protein, g | Fat, g | Carbohydrates, g | Food fibers, g | Antioxidants, mg/100g | Energy density, kcal/kJ |
|--------------------------------------------------------|------------|--------|------------------|----------------|------------------------|-------------------------|
| Sweet pepper with carrots and rhubarb                   | 7.0        | 0.5    | 26.0             | 18.0           | 495                    | 137/571                 |
| Tomatoes with paprika and zucchini                      | 6.0        | 0.8    | 22.0             | 15.0           | 388                    | 119/498                 |
| Zucchini with tomato and herbs                           | 5.0        | 1.0    | 26.0             | 14.0           | 134                    | 133/556                 |
| Lettuce                                                | 7.0        | 0.9    | 16.0             | 12.0           | 187                    | 100/418                 |
| Broccoli with Jerusalem artichoke and dill              | 13.0       | 1.0    | 26.0             | 19.0           | 366                    | 165/690                 |
| Cucumber with lettuce and dill                          | 6.0        | 0.8    | 19.0             | 14.0           | 188                    | 107/447                 |
| Pumpkin with lemon and orange                           | 2.0        | 0.5    | 41.0             | 14.0           | 155                    | 113/472                 |
| Carrots with apples and paprika                         | 5.0        | 0.3    | 32.0             | 18.5           | 139                    | 151/630                 |
| Beetroot with apples and lemon                          | 5.0        | 0.3    | 36.0             | 16.0           | 144                    | 181/757                 |
| Broccoli with paprika, lemon and orange                 | 9.3        | 1.0    | 21.0             | 19.0           | 245                    | 165/690                 |

Table 2. Average vitamin and mineral composition of 100 g snacks, depending on the recipe components.

| Name of a product                                      | L-ascorbic acid content, mg/100g | Daily maintenance, mg/100g | Satsatisfaction of daily maintenance, % | Carotenoid content, mg/100g | Daily maintenance, mg/100g | Satsatisfaction of daily maintenance, % | P-active materials content, mg/100g | Daily maintenance, mg/100g | Satsatisfaction of daily maintenance, % | Potassium content, mg/100g | Daily maintenance, mg/100g | Satsatisfaction of daily maintenance, % | Calcium content, mg/100g | Daily maintenance, mg/100g | Satsatisfaction of daily maintenance, % | Magnesiunm content, mg/100g | Daily maintenance, mg/100g | Satsatisfaction of daily maintenance, % | Ferrum content, mg/100g | Daily maintenance, mg/100g | Satsatisfaction of daily maintenance, % |
|--------------------------------------------------------|-----------------------------------|-----------------------------|----------------------------------------|-------------------------------|-----------------------------|----------------------------------------|--------------------------------------|-----------------------------|----------------------------------------|-------------------------------|-----------------------------|----------------------------------------|-------------------------------|-----------------------------|----------------------------------------|-------------------------------|-----------------------------|----------------------------------------|-------------------------------|-----------------------------|----------------------------------------|
| Sweet pepper with carrots and rhubarb                   | 350 70 500                        | 6.9 6 115 3.2 20 16         | 10773500 31 164 1000 16 101 400 25 2.8 14 20 |
| Tomatoes with paprika and zucchini                      | 280 70 400                        | 9.0 6 150 3.2 20 16         | 11243500 32 138 1000 14 89 400 22 2.9 14 21 |
| Zucchini with tomato and herbs                           | 99 70 141                         | 3.5 6 58 3.5 20 17.5       | 11953500 34 140 1000 14 80 400 20 2.8 14 20 |
### Ingredients Table

| Name of a product | L-ascorbic acid | Carotenoid | P-active materials | Potassium | Calcium | Magnesium | Ferrum |
|-------------------|-----------------|------------|--------------------|-----------|---------|------------|--------|
|                   | content, mg/100 g | Daily maintenance, mg/100 g | Satisfaction of daily maintenance, % | content, mg/100 g | Daily maintenance, mg/100 g | Satisfaction of daily maintenance, % | content, mg/100 g | Daily maintenance, mg/100 g | Satisfaction of daily maintenance, % | content, mg/100 g | Daily maintenance, mg/100 g | Satisfaction of daily maintenance, % | content, mg/100 g | Daily maintenance, mg/100 g | Satisfaction of daily maintenance, % |
| Lettuce           | 140 70 200 11,0 6 183 4,6 20 23 1551 3500 44 367 1000 37 182 400 45,5 4,4 14 31 |                          |                   |           |         |            |           |                          |                   |                   |           |         |            |           |                          |                   |                   |
| Jerusalem artichoke and dill | 280 70 400 2,8 6 47 5,5 20 27,5 1690 3500 48 223 1000 22 117 400 29 6,3 14 45 |                          |                   |           |         |            |           |                          |                   |                   |           |         |            |           |                          |                   |                   |
| Cucumber with lettuce and dill | 147 70 210 8,7 6 145 3,8 20 19 1593 3500 45,5 268 1000 27 142 400 35,5 4,3 14 31 |                          |                   |           |         |            |           |                          |                   |                   |           |         |            |           |                          |                   |                   |
| Pumpkin with lemon and orange | 85 70 120 6 6 100 2,2 20 11 892 3500 25,5 110 1000 11 62 400 15,5 1,8 14 13 |                          |                   |           |         |            |           |                          |                   |                   |           |         |            |           |                          |                   |                   |
| Carrots with apples and paprika | 71 70 101 30 6 300 3,5 20 17,5 1054 3500 30 118 1000 12 142 400 35,5 4,4 14 31 |                          |                   |           |         |            |           |                          |                   |                   |           |         |            |           |                          |                   |                   |
| Beetroot with apples and lemon | 76 70 109 2 6 33 6 20 30 1155 3500 33 138 1000 14 77 400 19,0 6,3 14 45 |                          |                   |           |         |            |           |                          |                   |                   |           |         |            |           |                          |                   |                   |
| Broccoli with paprika, lemon and orange | 190 70 271 2,3 6 38 4,5 20 22,5 1000 3500 28,5 132 1000 13 136 400 34 4,8 14 34 |                          |                   |           |         |            |           |                          |                   |                   |           |         |            |           |                          |                   |                   |

100 g of snacks contains from 71 to 350 mg of L-ascorbic acid, which satisfies the daily need for it by more than 100% and allows recommending the use of snacks for one meal less than 100 g (30-50 g), while the antioxidant activity is 134-495 mg/100g, which corresponds to products of a functional orientation according to GOST P 52349-2005 “Functional food products. Terms and definitions” and GOST P 54059-2010 “Functional food products. Functional food ingredients. Classification and general requirements.”

Unlike other snacks (cereals, nuts, candied fruit), vegetable and vegetable-fruit based snacks practically do not contain sucrose and their carbohydrates are by fructose by 90%. The high content of L-ascorbic acid, dietary fiber, and antioxidants in the snacks is ensured by the concentration of fruit and vegetable raw materials upon manufacturing of dried ingredients. This indicates the advantage of
innovative technologies, including waste-free resource-saving technologies, obtaining functional snacks in front of the traditional and evidence-based basis of the expected beneficial effect on the state of the human body with the systematic use of such products.

Based on the results of the research, NTD (SO and TI) for the industrial manufacture of new products have been developed: the organization standard (SO) “Snacks from fruit and vegetables”. This standard applies to snacks (bars, tablets and cubes) made on a vegetable and vegetable-fruit basis with the addition of salt, spices, vegetable fiber, pectin, a water-retaining component of glycerin and packaged in consumer containers. Snacks are intended for direct consumption as separate dishes.

Snacks are made of functional products, intended for the systematic use in the composition of food diets by all age groups of a healthy population, reducing the risk of developing diseases associated with nutrition, maintaining and improving health due to the presence of physiologically functional food ingredients. The designation of the product when ordering it and (or) in other documents is “Bar “Pumpkin with Lemon and Orange” SO 00493534 - 048-2018”.

Depending on the raw products and materials used, the following snacks are produced:

- vegetables - “Sweet pepper with carrots and rhubarb”, “Tomatoes with paprika and zucchini”, “Zucchini with tomato and herbs”, “Lettuce”, “Broccoli with Jerusalem artichoke and dill”, “Cucumber with lettuce and dill”;
- vegetable and fruit - “Pumpkin with lemon and orange”, “Carrot with apples and paprika”, “Beetroot with apples and lemon”, “Broccoli with paprika, lemon and orange”.
- According to organoleptic indicators, snacks must meet the requirements specified in table 3.

Table 3. Organoleptic indicators of snacks.

| Name                  | bars                                                                 | tablets                                                                 | cubes                                                                 |
|-----------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|---------------------------------------------------------------------|
| Appearance, form      | Rectangular or oval with a flat surface, uniform in thickness, whole, without broken edges, retaining their shape when wrapping, packing in containers and transportation. | Rectangular, flat, with a flat surface, uniform in thickness, whole, without broken edges, retaining their shape during wrapping, packing in containers and transportation. | Square with a flat surface, uniform in thickness, whole, without broken edges, retaining their shape when wrapping, packing in containers and transportation. |
| Color                 | Specific to the color of the raw materials used, which is part of the bars. Darker or lighter shades are allowed.           | Inherent to the raw materials and spices used in the bars. Foreign flavor and smell are not allowed. |                                                                   |
| Taste and smell       | Inherent to the raw materials and spices used in the bars. Foreign flavor and smell are not allowed.                       | Dense, with inclusions of crushed particles of vegetables, fruit, herbs and spices. Slight crumbling is allowed. | Dense, with inclusions of crushed particles of vegetables, fruit, herbs and spices, when pressed easily kneading. |
| Consistency           | Dense, with inclusions of crushed particles of vegetables, fruit, herbs and spices. Slight crumbling is allowed.           |                                                                        |                                                                    |

According to physical and chemical indicators, snacks must meet the requirements specified in table 4.

Table 4. Physical and chemical characteristics of snacks.

| Indicator name          | Bars and tablets on a vegetable and vegetable-fruit basis | Cubes on a vegetable and vegetable-fruit basis |
|-------------------------|----------------------------------------------------------|-----------------------------------------------|
| Mass fraction of vegetable and fruit parts, %, not less | 65±0.5                                                   | 75±0.5                                       |
than

| Parameter                                    | Value          |
|----------------------------------------------|----------------|
| Mass fraction of moisture, %, no more than   | 35±0.5         |
| Mass fraction of mineral impurities, %, not more than | 0.05±0.01     |
| Foreign matters                              | not allowed    |

The method of production of vegetable and fruit and vegetable snacks is as follows: prepared and chopped fresh vegetables and fruit are dried first at an air temperature in the drying chamber of 75°C, then dried at a temperature of 55°C; fruit and vegetable marquées are subjected to microwave heating to a temperature of 90-95°C and dried in an infrared dryer at a temperature of 60-65°C. The dried raw material is ground to a powder state with a particle size of 1-2 mm. The resulting powder is dosed by weight, in accordance with the snack recipe, fed to the mixer with the rest of the recipe components: pectin, salt, ground black pepper, allspice, paprika, coriander and other ground spices, microcellulose, glycerin (in the form of a 50% aqueous solution). Dense, ready-made mass is served for molding into bars, cubes and tablets. Molded products are packaged and stored at a temperature of 0 to 25°C and a relative humidity of not more than 75%: term of preservation of bars and tablets is 12 months; term of preservation of cubes is 24 months.

4. Conclusion
The recipes for new types of food products were modeled and developed on vegetables and fruit and vegetables basis: snacks with a given chemical composition and functional orientation: bars, tablets, and cubes, vegetables and fruit and vegetable snacks.

New types of snacks are characterized by low calorie content and a high content of dietary fiber, vitamin C and antioxidants. Innovative resource-saving low-waste technologies for producing new types of snacks have been developed using effective technological methods to reduce the loss of biologically active substances of the final product.

References
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