Formulation development and production technology of innovative specialized food product under conditions of agriculture digitization

B Tokhiriyon, V M Poznyakovksy and S S Andrievskikh

Ural State University of Economics, 62, March 8 Str., Ekaterinburg, 620144, Russia
E-mail: tohiriyoni@mail.ru

Abstract: The article deals with scientifically based specialized food product formulation under conditions of agriculture digitization. It characterizes the formulation components and their synergetic properties in terms of prolonged anti-oxidant body protection. The authors have developed a new skeleton method of innovative food product pelleting, which ensures its long shelf life and its functional components efficacy. The innovative production technology of new pellet-filled capsules allows programmed release of active substances from a tablet skeleton at specific time and in specific order. It also eliminates oxygen exposure, which, along with low moisture content, prevents oxidative and hydrolytic processes. This technology as well as favorable production parameters provides high usability properties of the product and stability of its biologically active ingredients. The authors determined the product nutrition value, which characterizes the product functional properties. These functional properties are confirmed by field studies. Development of a new specialized product formula and its production technology under conditions of agriculture digitization result in a wider range of functional products, a safer, more effective and useful high quality product, intake of which prevents alimentary diseases development and improves both overall health and working capacity. It is important to note that the new product is certified in accordance with the requirements of international standards of the ISO 9001: 2000 series and GMP rules. It also has a sanitary-epidemiological certificate and is included in the Federal BAA (biologically active additives) List. The developed innovative technology has been tested by the enterprises of the company “Artlife” (Tomsk), which ensures its competitiveness and quality stability.

1. Introduction
Nowadays we can see that developed counties are increasingly using new technologies in food industry and agriculture. These technologies contribute to significant labor productivity rise, production and sales costs reduction, better quality of agricultural specialized food products.

Major strategic trends in food industry development under conditions of agriculture digitization are healthy foods line extension and cutting edge technology. Special attention is paid to nutrition supplements, considering the fact that their intake is the most effective and economically appropriate way to enhance working capacity and maintain health [1-8]. Numerous international and national projects as well as research on nutritiology carried out in Russia and abroad back up this idea [9-13].

We should note that a healthy nutrition trend under conditions of agriculture digitization is supported on the national level by the Presidential Executive Order and Decree of the Russian
Government. Thus, we face the need for new technologies to develop and produce specialized nutrition products and we must determine the parameters of their production [3-5, 14].

2. The purpose of the study
The purpose of the study is to develop a new specialized product (nutrition supplement) ingredient composition and its innovative production technology.

3. Materials and methods
The materials used are plant raw materials, semi-processed materials, laboratory and trial samples of the nutrition supplement.

4. Discussion of the results
Under conditions of digital economy, in particular, agriculture digitization, the product composition has been scientifically substantiated. The ingredients synergetic effects on body metabolism normalization have been thoroughly studied. One tablet contains: peach leaf (extract) – 26.57%; Rhodiola quadrifida (extract) – 19.93%; Zinc Asparaginate – 12.09%; Zinc – 2.25%; Cystine – 7.97%; Ascorbic acid – 9.96%; Quercetin – 2.65%; Rutin – 2.65%; Grape seed (extract) – 1.32%; Copper Asparaginate – 1.16%; Copper – 0.18%; Sodium Selenite – 0.029%; Selenium – 0.013%; Superoxide dismutase – 1.32%; Hesperidin – 5.428%; dry Hibiscus (extract) – 3.06%; Tocopherol acetate – 1.32%; Dihydroquercetin – 1.32%; Beta-carotene – 0.46%; Coenzyme Q10 – 0.32%.

The authors have also developed an innovative technology of pellet-filled capsules production, as well as plant raw materials and biologically active substances processing (Figure 1). The innovative technology consists of the following stages:

Raw material preparation. Incoming raw materials undergo strict control. They can be further used in production only if they get a marker green band on the identifying label according to the technological flow chart requirements. Labeled closed containers are used to transport raw materials. Substances and plant extracts are screened with a 1mm mesh size sieve. Sieve residues are then ground up with a hammer mill and screened again.

Dosing. Raw materials are then weighed; all the prescription ingredients are sieved (sieve 4) and put into separate containers.

Preparing and filtering solutions of active components № 1, 2. Demineralized water is measured out in doses into the reactor and heated up to 70 °C. Weighed ingredients are put into the reactor and dissolved for one hour with the help of a mixer. Then the obtained solution is filtered through a 0.4 mm mesh size sieve and put back into the reactor. The mixer is switched on and dry substrate is added.

Spraying pellets with solution of active components № 1,2. This stage is performed on the unit “HKC-200 TJHutulin”, which is heated up to 70-80 °C. After pellets are loaded the product is heated to the specified temperature. Pellets are sprayed with the obtained solution, taking into account the technological process requirements. Then the obtained product is dried to the specific humidity and cooled to 25°C.

Preparation of semi-finished product № 1. The required amount of water is poured into the homogenizing reactor. Strictly measured little amounts of peach, Rhodiola quadrifida and grape seed extracts are slowly added to water (the mixer is on) and mixed for 15 minutes. Then the mixture is homogenized (the mixer is on). The measured amount of pellets is loaded into the granulating machine. The homogenizing reactor is connected to the granulating machine and the process of applying the suspension to pellets starts. After the process is completed, prepared granules are unloaded.
The obtained granules are sieved through a 2mm sieve.

Preparation of semi-finished product № 2. Equipment: electronic scales, homogenizing reactor, granulating machine in fluidized bed Huttlin.

The required amount of water is dosed into a homogenizing reactor. Measured small portions of ascorbic acid, rutin and quercetin (the mixer is on) are loaded into the homogenizing reactor and stirred for 15 minutes. Then the mixture is homogenized for 10 min (the mixer is on). The weighed amount of pellets is loaded into the granulating machine. The homogenizing reactor is connected to the granulating machine and the process of applying suspension to pellets begins. After the application process is completed, finished granules are unloaded.

Obtained granules are sieved through a 2 mm sieve.

Preparation of semi-finished product № 3. The measured amount of water is dosed into the homogenizing reactor. Weighed small portions of copper asparaginate and sodium selenite (the mixer is on) are slowly loaded into the homogenizing reactor and stirred for 15 minutes. Then the mixture is homogenized for 10 min (the mixer is on). The weighed amount of pellets is loaded into the granulating machine. The homogenizing reactor is connected to the granulating machine and the
process of applying the suspension to pellets begins. After the application process is completed, finished granules are unloaded.

**Pellets classification.** Pellets are sieved through a 1.5 mm sieve. Their quality is controlled visually (there should be no sticking pellets).

**Granulate preparation.** Zinc asparaginate is measured for granulation, then wet granulation (extrusion) is carried out, using collidine solution as a humidifier (humidifier concentration is 9%). The granulate color uniformity is checked.

Granulate drying. Wet granulate is dried at 65°C to a residual moisture content of 5%. Humidity and uniformity of drying are controlled by 10-gram spot samples taken from the upper, middle and lower parts of the drying oven.

Dry granulation is carried out on the granulator-grinder with mesh No. 3. There should be no foreign inclusions.

**Preparation of powdering mixture.** This stage is carried out simultaneously with the dry granulation stage. First, peach leaf, Rhodiola quadrifida and grape seed extracts are measured, then ascorbic acid, rutin, quercetin, next copper asparaginate, sodium selenite, and after that superoxide dismutase, hesperidin, dry hibiscus extract, tocopherol acetate, dihydroquercetin, beta-carotene, coenzyme Q10. The next stage of dosing involves cystine, zinc, copper and selenium. Compliance with the name, quantity and raw materials series is controlled according to the technological flow chart.

**Sieving.** The powdering mixture is sieved through a 1mm vibrosieve. Residues are ground up. Lumps and foreign inclusions are not allowed.

**Mixing.** The powdering mixture is placed in a V-shaped mixer. 100 kilograms are mixed for one hour. There exist certain mixture requirements. The mixture should be uniform. When pressed with a pounder, the mixture cannot have lumps and foreign inclusions. In case of lumps and inclusions, the mixture is re-sieved and mixed again.

Obtaining mixture for tableting. Mixing is carried out sequentially in a V-shaped mixer at the rate of 1 hour per 100 kg: first semi-finished products for dietary supplements, then powdering mixture and regranulate.

At this stage, quality and safety are monitored by conducting microbiological, physicochemical and radionuclides tests, as well as by measuring mixture technological parameters in an accredited production laboratory.

**Tableting and dedusting** are carried out by a tablet rotary machine. During tableting, the average weight is checked every 30 minutes by weighing 20 tablets altogether as well as the weight of a tablet by weighing 20 tablets one by one. Deviations of the average weight and a tablet weight should not exceed ± 5%. The appearance is checked every 60 minutes by examining 10 tablets on both sides: there should be no chips, stratification, bumps, pits and sticking. The tablet should be smooth and strong. Then finished tablets pass through a dust collector and to the film coating stage. Tablets are loaded into the working chamber of the unit (unit type is AC-350). The unit is connected to the homogenizing machine and the process of film coating begins.

Coated tablets must be smooth without any cavities and chips. Their color and gloss must be uniform.

Finished tablets are placed in a container, weighed, labeled and sent to prepacking and packaging. Part of them is sent to an accredited laboratory for quality and safety assessment.

For the first time ever, the developed technology uses an innovative skeleton method of tableting, which excludes the aggressive oxygen exposure, which, along with low moisture content, eliminates oxidative and hydrolytic processes. This effect, as well as sparing production parameters, provides high quality characteristics of the developed product and the safety of its biologically active components that determine its nutrition value and functional properties.

The authors recommend taking two tablets during or after a meal. This dose provides the necessary intake of declared nutrients (table 1).
Table 1. Nutrients content in recommended daily intake

| Vitamins and nutrients | mg     | % RDI |
|------------------------|--------|-------|
| B1 (thiamine)          | 1      | 67 (1.5) |
| B3 (niacin, PP)        | 10     | 50 (20) |
| B5 (pantothenic acid)  | 5      | 100 (5.0) |
| B6 (pyridoxine)        | 2.0    | 100 (2.0) |
| B9 (folic acid)        | 0.4    | 100 (0.4) |
| B12 (cyanocobalamin)   | 0.001  | 33 (0.03) |
| Tocopherol acetate     | 20     | 133 (15) |
| Beta-carotene          | 7      | 140 (5.0) |
| C (ascorbic acid)      | 100    | 111 (90) |
| Coenzyme Q10 (ubiquinone) | 5  | 17 (30) |
| Hesperidin             | 80     | 80 (100) |
| Dihydroquercetin       | 20     | 80 (25) |
| Quercetin              | 20     | 60 (33) |
| Rutin                  | 20     | 60 (33) |
| Magnesium              | 30     | 8 (400) |
| Zinc                   | 17     | 70 (12) |
| Selenium               | 0.1    | 60 (0.06) |
| Copper                 | 1.4    | 140 (1.0) |
| Superoxide dismutase   | 200 U  | 200 U |

The intake of the innovative specialized product in a specified dosage improves metabolism and microcirculatory function, normalizes homeostasis, increases the efficiency of energy processes, reduces hypoxia, and promotes recovery after long-term diseases. All these effects were confirmed in field studies. 35 volunteers took 2 tablets of the specialized product a day. The group included medical doctors, teachers, long-distance coach drivers, and nurses, i.e. people, who are exposed to high level of stress or work night shifts. The control group consisted of 35 people too, but they did not take the nutrition supplement.

Products of lipid peroxidation (malondialdehyde) were studied. The authors established that after 3-week intake of the product the malondialdehyde level dropped substantially by 30.6 %, which proves the activity of free radicals (figure 2).

![Figure 2](image.png)

**Figure 2.** Decrease in the level of lipids peroxidation products (malondialdehyde) after food supplement intake
The results of field studies make it possible to conclude that the nutrition supplement intake improves the body metabolism and microcirculatory function, reduces hypoxia, possesses a tonic effect and pronounced antioxidant effect, promotes recovery after long-term diseases.

Technological documentation has been developed. The formulation and specific technological parameters were tested by the enterprises of the company “Artlife” (Tomsk), which are certified in accordance with the requirements of international standards of the ISO 9001: 2000 series and GMP rules. This fact ensures the product competitiveness and quality stability.

5. Conclusion
The paper deals with the issues of digitization in the production of specialized products based on natural raw materials and plant-based biologically active complexes. Under the conditions of agriculture digitization, the innovative technology has been developed for producing a new specialized product in the form of a biologically active food supplement to provide multifactorial support of the body metabolism. The innovative production technology ensures high safety of biologically active ingredients and their active substances. The developed technology provides synchronous intracellular delivery of active compounds. They affect the same body organ though they have different absorption and transportation mechanisms. The obtained functional properties are complemented by the other biologically active substances in the complex, which enhance the body natural defense and prevent chronic alimentary diseases. The physiological dosage of functional natural ingredients does not cause addiction and has no side effects. Biologically active substances effective concentration contributes to increasing the body resistance to negative effects of various adverse environmental factors. Shelf life and storage conditions have been established, and industrial testing has been carried out.

References
[1] Gerasimenko N F 2017 Methodological aspects of safe balanced nutrition: their role in health and employability maintenance Human. Sport. Medicine 17 (1) 79 –86
[2] Goldberg Ed I 1999 Functional Foods. Designer Foods, Pharmafoods, Nutraceuticals (Gaithersburg: Maryland)
[3] Fulgoni V L, Keast D R, Bailey R L and Dwyer J 2011 Foods, fortificants, and supplements: Where do Americans get their nutrients Journal of Nutrition 141 1847–1854.
[4] Vekovtsev A A, Tokhiriyon B, Chelnakova A A and Posznyakovsky V M 2017 Evidence for Effectiveness and Functional Properties of Specialized Product in Clinical Trials Human. Sport. Medicine 3 (3) 94 – 101
[5] Shukla U N and Manju L M 2018 Biofortification: Golden way to save life from micronutrient deficiency Indian Journal of Agricultural Reviews 39 (5) 202-209
[6] Shukla U N and Manju L M 2018 Biofortification: Golden way to save life from micronutrient deficiency Indian Journal of Agricultural Reviews 39 (5) 202-209
[7] Pokrovsky V I, Romanenko G A, Knyazhev V A, Gerasimenko N F, Onischenko G G, Tutelyan V A and Posznyakovsky V M 2002 Healthy nutrition policy. Federal and regional levels (Novosibirsk: Siberian University Publishing House)
[8] Spence S and Courbasson C 2012 The role of emotional dysregulation in concurrent eating disorders and substance use disorders Eat. Behav. 13 382–385
[9] Goldberg Ed I 1999 Functional Foods. Designer Foods, Pharmafoods, Nutraceuticals An Aspen Publication (Gaithersburg:Maryland)
[10] Milner J A 2002 Functional foods and health: a US perspective British J. Nutrition 88 (I) 151-158
[11] Charles W, Van Way III and Carol Ireton –Jones 2004 Nutrition secrets (Hanley @ Belfus: Inc)
[12] Avstrieviksh A N, Vekovtsev A A and Posznyakovsky V M 2005 Healthy nutrition products: new technologies, quality assurance, efficacy (Novosibirsk: Siberian University Publishing House)
[13] Tokhiriyon B and Posznyakovsky V M 2019 New biocomplex for nutrient-metabolic support of bone tissue IOP Conference Series: Earth and Environmental Science 315 (3, 23) 032020
[14] Fenech M, El-Sohemy A, Cahill L, Ferguson L R, French T C, Tai E S, Milner J, Koh W P, Xie L and Zucker M 2011 Nutrigenetics and nutrigenomics: Viewpoints on the current status and applications in nutrition research and practice *Journal of Nutrition* 4 69–89