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## Quality management of the apiproduct from the drone larvae

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**Abstract.** The paper deals with the process of the apiproduct quality management, reflects the organization of its production and the factors that form and preserve the native properties of a highly biologically active product from the drone larvae. Possibility of the apiproduct manufacturing at the small innovative enterprise “Apiproduct” (SIE “Apiproduct” Ltd.) in two forms – as a paste and a powder – is demonstrated in the article. The main qualitative indicators – the organoleptic (color, taste, smell and consistency) and the physicochemical (mass fraction of water, proteins, fats, sugars, amino acids and fatty acids, vitamins and minerals) ones have been studied. According to the results of the organoleptic tests of the paste and powder, it has been identified that these are the pasty and powdery substances of the light yellow with a pleasant bread taste, without any foreign tastes and smells; they completely dissolve in water, their pH is 5.8 ... 7.0, and they do not contain any mechanical impurities. According to the results of physical and chemical studies, it has been established that this is the paste with a solids content of 23.2%; it contains 13.2% of proteins, up to 9.5% of sugars and 1.2% of fats. It is established that the powder is characterized by a significant content of proteins (51.2%), vitamins and minerals, the content of which is 4 times higher than in the paste. The contained protein refers to a full-fledged one, and on the lysine, tryptophan and histidine it exceeds the level of ideal protein on the FAO/WHO scale by several times. The apiproduct contains up to 5% of fats and 28 higher fatty acids. The quantitative composition of fats practically corresponds to the formula of a balanced diet. The authors found that the factors shaping the quality of the apiproduct include raw materials and production technology. The author's technology for the production of the apiproduct “Bilar” includes the following stages: cultivation, reception and grinding of larvae to biomass, sublimation vacuum drying of the biomass and obtaining a powder with a mass fraction of moisture of 2%. It has been established that drying preserves biologically active substances ( $\beta$ -carotene and  $\alpha$ -tocopherol) and biopolymers (proteins, lipids and sugars) by 98.8 ... 99.5%. The factors that preserve the quality of the apiproduct include packaging and storage.



## 1. Introduction

In the world, there is an acute problem of the production of protein-containing food products, especially from natural raw materials. In modern environmental conditions, there is a significant decrease of the immunity, which is manifested in an increase in the number of cases of dangerous diseases, for example, tuberculosis, allergy, etc. Nutrition is playing the main role in the correction of immunity. One of the ways to solve these problems is a significant increase of the proportion of foods in the diet with a high content of natural protein and biologically active substances (BAS) with immune-modulating action in the form of powders, pastes, etc.

Sources of BAS, along with vegetables, fruits, berries, medicinal and spicy-aromatic plant raw materials, are api-technology products produced by the honey bee (*Apis mellifera*), such as propolis, royal jelly, pollen and others that have medicinal properties and differ significantly from natural products of the plant origin. The uniqueness of apiproductions is in the fact that specific polyunsaturated decenoic fatty acids, which are produced by the bee's organism and do not occur naturally in pure form, are added to the vegetable BAS (phenolic compounds, carotenoids, vitamins, etc.).

At the end of the 20th century, api-technologists and beekeepers from different countries of the world (Japan, China, Romania, Ukraine, Russia, etc.) began to study the homogeneous biomass of the drone larvae (HBL). It was found that it is a new biologically active api-technology product and has many common properties with royal jelly, although it differs significantly in genesis and biomass yield from one bee family [1], [2], and [3].

In a very short period of ontogeny (5-6 days), larvae of the open bee brood accumulate a significant balanced supply of nutrients that makes it possible to form imago from the egg. As a result, a complex of substances of the plant and animal origin - apiproductions, possessing unique food and immune-modulating properties, allowing them to be considered as the most important components of apilararvetrophy, a new direction of functional nutrition, - is naturally created [4].

It was proved that HBL, like royal jelly, possesses therapeutic and prophylactic properties, especially antioxidant, immune-modulating, anti-tumor, etc., ones. This is due to the fact that HBL contains unsaturated substances, such as decenoic acids and sulfhydryl compounds that are capable of binding the active forms of oxygen and oxidative free radicals, and create insoluble complexes with heavy metal ions. The high therapeutic activity of the use of the drone larvae was established. This nontraditional apiproduction was recognized to be more effective, in comparison with the synthesized preparations of traditional medicine [4].

The quality of the apiproduction from the drone larvae was not studied, and the factors that form and preserve the quality of this product and the use of the drone larvae in the apilararvetrophy were not researched. There are no systematized data on the apiproduction production technology, biochemical and microbiological processes in their storage were not analyzed, technological characteristics were not given to them, and their use was not studied for obtaining protein-enriched food products with immune-modulating properties. It is important to manage the quality of the innovative apiproduction and to develop new directions for using the non-traditional product in the technological production of food, pharmaceutical and cosmetic products that would guarantee the preservation of the native properties of raw materials and improve the quality of the finished products.

The paper is devoted to the solution of an actual scientific problem, namely, the apiproduction from the drone larvae quality management and the study of the factors that form and preserve its quality.

We have developed a process for managing the quality of the innovative apiproduction, showed the process of organizing its production and outlined the factors that form and retain the native properties of a highly biologically active product from the drone larvae. The possibility of the apiproduction production at the small innovative enterprise "Apiproduction" (SIE "Apiproduction" Ltd.) has been demonstrated. This is the first Russian enterprise that manages the quality of innovative apiproduction from the drone larvae and its introduction into the food industry for enriching the products of mass consumption with a high-grade protein, biologically active high-functional substances and complexes.

## 2. Problem Statement

Quality management of the apiprodukt from the drone larvae is an action aimed at establishing, ensuring and maintaining the optimal level of quality at all stages of the life cycle of production. The quality of the apiprodukt is influenced by the forming and preserving factors. The forming qualities of the product include raw materials and production technology. Packaging and storage are to be referred to the preserving factors.

In modern literature sources, many scientists showed that bee products such as royal jelly, honey, flower pollen, propolis, etc. had therapeutic and prophylactic, and nutritional properties, especially antioxidant, immune-modulating, antitumor, etc. This is due to the fact that their composition includes high-grade proteins, phenolic compounds and biopolymers, unsaturated substances, such as decenoic acids and sulfhydryl compounds that are capable of binding reactive oxygen species and the oxidative free radicals, and create insoluble complexes with heavy metal ions.

However, there is no systematic scientific information on the functional properties of the unconventional product of beekeeping of the larval origin – the drone larvae. Moreover, larvae are not a traditional product of the Russian cuisine and their use in the food industry is also difficult because of emotional discomfort when used. We have previously established a high therapeutic activity of the drone larvae use: this nontraditional apiprodukt is recognized to be more effective, in comparison with the synthesized preparations of traditional medicine [1], [2], [3], and [4].

However, our studies allow us stating that:

2.1. To date, the scientific idea of using high-functional apiprodukts of the larval origin in the food production has not been formed. In the Russian Federation, products of the larval origin cause emotional discomfort when consumed and are not used for food. However, in many countries of the world, larvae are utilized as a food product, since they contain a rich full-fledged protein. Therefore, the solution of the problem of searching for alternative raw materials from natural food ingredients is very relevant and timely.

2.2. Quality is a set of characteristics of raw materials that determine its properties. It is known that the quality of products is formed by the qualitative indicators, which are a criterion for assessing the level of quality. It is necessary to study the basic qualitative indicators of the apiprodukt and its amino acid and fatty acid composition, the content of vitamins and minerals and other biologically valuable components and substances that determine the quality of the apiprodukt.

2.3. The factors forming the quality of the apiprodukt from the drone larvae have not been yet studied. They include raw materials and production technology. It is known that larval raw material has a very limited shelf life, since it contains a large amount of water, a high-nutrient environment for the growth of microorganisms, including pathogens that lead to its rapid deterioration and the impossibility of further use. Therefore, the development of technology for the production of the apiprodukt from the drone larvae and the formation of a convenient form for the production is a scientific and technological problem. It is very important in the manufacturing processes to preserve the natural native properties of raw materials, thanks to which the apiprodukt is useful and highly functional.

2.4. The factors preserving the quality of the apiprodukt from the drone larvae have not been studied. These include the development of the storage regimes. Changes of the quality indicators due to the impact of damaging factors are important in the management of the apiprodukt quality. The damaging factors include the influence of storage temperature and the effect of illumination on the preservation of useful properties. Besides, the storage time also negatively affects the safety of the apiprodukt, creating a problem in the management of the apiprodukt quality.

This work is devoted to the solution of the acute scientific problem – the substantiation and development of technology for the production of a new non-traditional apiprodukt of the larval origin, and the management of the apiprodukt quality through the formation and preservation of its properties.

### 3. Research Questions

3.1. The analysis of literature and generalization of research in the field of useful properties of non-traditional products of beekeeping in general and, in particular, the apiproduct from the drone larvae.

3.2. The study of the basic qualitative indicators of the apiproduct, its amino acid and fatty acid composition, the content of vitamins and minerals and other biologically valuable components that determine the quality of the apiproduct.

3.3. The study of the factors that form the quality of the apiproduct from the drone larvae.

3.4. The study of the factors that preserve the quality of apiproduct from the drone larvae.

### 4. Purpose of the Study

The purpose of the study is a scientific justification of the following:

- a. The possibility of using a highly functional apiproduct of the larval origin in the food production;
- b. The main qualitative indicators of the apiproduct, its amino acid and fatty acid composition, the content of vitamins and minerals and other biologically valuable components that determine the quality of the apiproduct;
- c. The factors that form and preserve the quality of the apiproduct from the drone larvae.

### 5. Research Methods

Theoretical basis of this study is the scientific literature on the topic of research, and publications of domestic and foreign scientists. Also, in the process of writing the paper, the material-technical and laboratory base of the SIE "Apiproduct" and the materials of the Internet network have been used.

Methodology of this study includes the system and process approaches.

The object of research is the quality of the apiproduct from the drone larvae and the processes of its formation, maintenance and conservation.

The subject of research is the quality management of the apiproducts from drone larvae, the development of technology for its production, the study of factors that form and preserve quality, and the conduct of an experiment.

To manage the quality of the apiproduct, generic economic methods of research, such as the experimental method and the method of analogues, as well as biological methods have been used.

### 6. Findings

6.1. A study of modern literature showed that at present a new approach to the solution of the problem of stabilization of immunity acquired a special popularity, that is, the use of natural non-traditional raw materials with a high content of BAS for everyday food consumption. Bee products, along with other products, are a source of BAS, and contain a perfectly balanced complex of biologically active compounds, are easily absorbed by the organism and are indispensable additives to various foodstuffs. Royal jelly, flower pollen, propolis, perga and products of the larval origin, which refer to gerontological agents that promote the prolongation of human life, occupy a special place among the products of beekeeping. Not without reason, the World Congress on Beekeeping was held under the motto: "The products of bees are food, health, and beauty".

Royal jelly is the secret of the glands of young worker bees, by which they feed the queens. This substance, complex in its chemical structure, has more than 100 different biologically active compounds and minerals in its composition, and their natural ratio gives the royal jelly a special biological value. It contains sex natural hormones, 21 amino acids (including all essential), fat (A and D) and water-soluble (group B and C) vitamins, macro- and microelements, unsaturated fatty acids, biopolymers, organic acids, etc. Royal jelly has amazing therapeutic and prophylactic properties: antioxidant, anabolic, anti-anemic, heteroprotective, anti-inflammatory, anti-inflammatory, anti-inflammatory, anti-inflammatory, antitoxic, etc. It stabilizes the immune system and cardiovascular system, positively acts on the liver, stomach, intestines, improving metabolism, memory, eyesight,

increases mental and physical performance, exhibits a rejuvenating effect, contributes to longevity and normalizes hormones. It is consumed on 50-100 mg under the tongue twice a day before meals [4] and [5].

Flower pollen (bee pollen) is a unique natural concentrate of all biologically active substances necessary for a full-fledged human organism, a polyvitamin-protein product of beekeeping, which is especially recommended to children to support and strengthen the growing organism. Bee pollen is flower pollen, which bees enriched with nectar, enzymes, and specific decenoic acids, knocked “in lumps” and brought to the beehives on the legs. That is where its name comes from. Bee pollen contains more than 240 different substances and complexes, such phytohormones, amino acids (including all essential), all known vitamins (especially many vitamins C, biotin, group B, carotene of all kinds, PP, etc.), 28 macro- and microelements, essential fatty acids, phenolic compounds with P-vitamin activity, 80 enzymes, which play a decisive role in metabolic processes, biopolymers, and growth factor. According to clinical trials, bee pollen improves metabolic processes of the body, regulates the functions of the immune, hematopoietic and endocrine systems, restores intestinal microflora, mental and physical activity, positively influences the development of the fetus and the child's body, prevents aging processes, stimulates sexual functions, removes radionuclides from the body, improves memory and eyesight, and mental and physical activity. It should be taken for 2 months without interruption in the quantity of 2 teaspoons twice a day before meals and chewed well in the mouth [5].

Propolis, or the bee glue, is a unique bactericidal natural product of beekeeping, developed and used by bees to disinfect their nest and construction works. Organic and inorganic substances collected by bees, under the influence of the bee body's physiological processes become a biologically active complex of compounds of a certain chemical composition and biological action. Propolis contains more than 50 different substances and complexes that consist of vegetable tars by 30-60%, of balms by 2-30%, essential oils by 2-15% (aromatic and tannin substances), and of waxes by 7-36%. This complex of BAS is represented by phytohormones, 17 amino acids, vitamins, 20 macro- and microelements, unsaturated fatty acids, phenolic compounds, umbelliferone, glycosides, bioflavonoids, polysaccharides, and enzymes that play a decisive role in metabolic processes. According to clinical trials, propolis improves metabolic processes in the body, is an effective antibacterial and fungicidal drug, regulates the influences on the immune, hematopoietic and endocrine systems, restores the intestinal microflora, has high anti-tuberculosis and anti-inflammatory properties, and removes radionuclides from the body and has many other properties. Most often it is used in the form of alcoholic tincture of different concentrations. Propolis oil is very effective for the prevention of influenza and other respiratory diseases [4].

Products of the larval origin are the drone and breeding products, and larvae of worker bees, grown by special technology, ground to homogeneous mass and dried to a powdery state. All kinds of larvae have been studied. However, it has been identified that it is expedient to industrially produce an apiproduct of the drone larvae, which has the author's name “Bilar” (bi-bee, lar-larvae) [6], [7], and [8].

According to clinical trials, the apiproduct has multifaceted biological effects: - it is recommended using it for stabilization of the immune and nervous system (in case of vegetative-vascular dystonia, cerebral blood flow disorders, etc.), the hematopoietic system for children with anemia; it normalizes appetite, increases the body's resistance to infections, and is the source of indispensable amino acids, vitamins, macro- and microelements and other essential biologically active complexes. Apiproduct promotes increased growth, normalization of the hormonal background, especially during puberty and the adverse effects of menopause, and in the treatment of sexual infertility. It is recommended for physical exhaustion and during the convalescence of patients, for improving memory and eyesight, mental and physical performance, and for rejuvenating the body.

In 2013, together with pharmacists, physicians and technologists, the technical specifications TU 9882-001-30327738-2013 “Powders from open bee brood “Bilar”” was developed and entered into operation on the SIE “Apiproduct” [9].

6.2. The study of the main qualitative indices of the apiproduct, its amino acid and fatty acid composition, the content of vitamins and minerals and other biologically valuable components was carried out on the basis of the SIE “Apiproduct” using modern methods and technologies. The experimental batch of the apiproduct was produced in accordance with the technological specification.

According to the organoleptic tests, paste and powder are pasty and powdery substances, of light yellow color with a pleasant bread taste, without any foreign tastes and smells; they completely dissolve in water, their pH is 5.8 ... 7.0, and they do not contain mechanical impurities.

The results of the quality parameters study of the paste and powder are presented in the Table 1.

**Table 1.** Comparative characteristics of the apiproduct from drone larvae quality in the form of paste and powder.

Indicator	Paste	Powder
Mass fraction, %:		
- dry substances	23.2±1.0	95.0±4.1
- titrated acids	0.2±0.01	0.8±0.03
- proteins	13.2±0.5	51.2±2.1
- reducing sugars	9.5±0.4	30.0±1.5
- fat	1.2±0.02	4.8±0.5
Mass fraction, mcg per 100 g:		
- carotene	255±10.7	940±40.4
- $\alpha$ -tocopherol	390±16.7	1590±68.2
- Vitamin B1	580±24.3	2320±99.5
- Vitamin B2	956±41.1	3824±64.3
- Vitamin B3	64±2.7	256±11.0
- Vitamin B5	3349±55.6	13396±65.4
- Vitamin B6	55±2.3	220±9.3
Mass fraction of mineral substances, mg in 100 gKa		
Ca	139.5±8.9	556.0±15.2
Mg	31.6±3.7	126.4±12.1
Na	106.0±12.9	424.0±18.0
Zn	225.2±10.1	900.4±20.2
Cu	1.3±0.1	15.2±0.1
Mn	0.6±0.1	2.4±0.1
	0.1±0.02	0.4±0.1

It is also shown that the paste, with a solids content of 23.2%, contains 13.2% of proteins, up to 9.5% of sugars and 1.2% of fats. It is established that the powder is characterized by a significant content of proteins (51.2%), vitamins and minerals, the content of which is 4 times higher than in the paste.

We studied the amino acid composition of the protein fraction of the apiproduct from the drone larvae. Protein refers to full-fledged ones and contains all the essential amino acids that are necessary for the normal development of a living organism. It is known that the most important and deficient in the daily diet are such essential amino acids as lysine, tryptophan, and valine. They reduce the accumulation of radionuclides of cesium and strontium in the human body, improve blood indicators, increase the body's resistance to adverse factors, etc. It is by these amino acids that the powder exceeds the ideal protein level on the FAO/WHO scale by several times.

The apiproduct contains a small amount of fat, which is characterized by a qualitative composition of fatty acids. A total of 28 higher fatty acids were found. Of them, the greatest amount belongs to oleic (28.2%), palmitic (27.5%), and stearic (16.7%) acids. Of polyunsaturated fatty acids, there are linoleic (1.5%), linolenic (8.0%) and arachidonic (1%) acids. Polyunsaturated fatty acids make up 10% of all fatty acids, which are part of fat, saturated - 45%, monounsaturated - 28%. In nutrition, not quantitative, but qualitative composition matters, especially the content of polyunsaturated acids. They

are called “essential”. These structural components take part in the construction of cell membranes in the synthesis of prostaglandins (complex organic substances that regulate metabolic processes in the cell and blood pressure). It is known that the formula for a rational and balanced diet of fatty acids in fat should be as follows: 10% of polyunsaturated, 30% of saturated and 60% of monounsaturated acids. Thus, fats practically meet these requirements.

6.3. The factors that determine the quality of the apiprodukt include raw materials and production technology. As a raw material for the production of apiprodukt, 7... 9-day old larvae were used, of which a paste was made by grinding. The paste was stored at minus 2°C. The paste contains a large amount of water and refers to a rapidly deteriorating product, so the powder form is convenient for future use. Further, the powder was obtained from the paste using a special technology with the help of freeze-drying vacuum by drying in SU-5 unit, and stored at a temperature of plus 5°C without access to light [10].

We conducted research of the effect of drying on the quality of the powder compared with the paste. Using a spectroscopic method for studying the absorption of  $\beta$ -carotene in ethanol, it was proved that the sublimation vacuum drying allowed preserving the biologically active substances ( $\beta$ -carotene,  $\alpha$ -tocopherol) and biopolymers (proteins, lipids, sugars) by 98.8 ... 99.5%.

The obtained research results were used in the development of technical specifications TU 9882-001-30327738-2013 “Powders from the open bee brood “Bilar” [9].

6.4. The factors that preserve the quality of the product include packaging and storage.

Packaging of the powder apiprodukt was made in an inert environment of gaseous nitrogen in a hermetic three-layer film material based on aluminum foil, or in the glass containers.

As a result of the studies, it was found that the powder can be stored without changing the quality for 6 months at a temperature of 20 to 25°C in a sealed package in a place protected from direct sunlight. Changes in the quality indicators of the powder with various preservatives in a hermetic glass package stored at room temperature from 20 to 25°C were studied during the storage for 11 months.

It is established that natural powder apiprodukt from the drone larvae can be kept without changing its quality for 3 months. The possibility of increasing periods of its storage to 6 months (that is 2 times more) with preservatives was also analyzed: additives of propolis, pollen (0.06% on dry matter) in comparison with  $\alpha$ -tocopherol equivalent dose, and also with ascorbic acid.

So, after 6 months of storage of the powder with propolis, the mass fraction of peroxides and hydroperoxides increased by 14.2%, free fatty acids - by 13.5%, organic acids - by 11% that is significantly less than in the control native powder. A similar effect was observed with the addition of a mixture of ascorbic acid and quercetin.

The obtained research results have been used in the development and approval of technical documentation for powders from the open bee brood “Bilar” [9] and [11].

## 7. Conclusion

7.1. Study of modern literature has shown that bee products, along with other products, are a source of BAS, and contain a perfectly balanced complex of biologically active compounds. They are easily absorbed by the organism and are indispensable additives to various foods. Royal jelly, flower pollen, propolis, perga and products of larval origin, which refer to gerontological agents that promote the prolongation of human life, occupy a special place among the products of beekeeping.

7.2. In the paper, the main qualitative indices of apiprodukt, amino acid and fatty acid composition, the content of vitamins and minerals and other biologically valuable components are referred. The experimental batch of the apiprodukt was produced in accordance with the technological specification. The apiprodukt was studied in two forms – as pasty and powdery ones.

So, according to the organoleptic studies, paste and powder are pasty and powdery substances, of light yellow with a pleasant bread taste, without any foreign tastes and smells, and they completely dissolve in water. Their pH is 5.8 ... 7.0, and they do not contain any mechanical impurities.



It is also shown that the paste, with a solids content of 23.2%, contains 13.2% of proteins, up to 9.5% of sugars and 1.2% of fats. It is established that the powder is characterized by a significant content of proteins (51.2%), vitamins and minerals, the content of which is 4 times higher than in the paste.

We studied the amino acid composition of the protein fraction of the apiproduct from the drone larvae. Protein refers to full-fledged ones and contains all essential amino acids that are necessary for the normal development of a living organism. On lysine, tryptophan and histidine, the powder exceeds the ideal protein level on the FAO/WHO scale by several times.

The apiproduct contains up to 5% of fats, which differ in the qualitative composition of fatty acids. A total of 28 higher fatty acids were found. The quantitative composition of fats practically corresponds to the formula of a balanced diet.

7.3. The factors that determine the quality of the apiproduct include raw materials and production technology. As a raw material, 7 ... 9-day old larvae were used for the production of the apiproduct, of which a paste was made by grinding. Further, the powder was obtained from the paste and stored at a temperature of plus 5°C without access to light.

It was found that drying preserves biologically active substances ( $\beta$ -carotene,  $\alpha$ -tocopherol) and biopolymers (proteins, lipids, and sugars) by 98.8...99.5% [12].

7.4. Packaging and storage belong to the factors that preserve the quality of the apiproduct.

Packaging of the apiproduct powder was made in an inert environment of gaseous nitrogen in a hermetic three-layer film material based on aluminum foil, or in the glass containers.

As a result of the conducted studies, it was found that the powder can be stored for 6 months without changing the quality parameters at a temperature of plus 20°C.

The obtained research results were used for the development and approval of technical documentation for the powders from the open bee brood "Bilar" [9].

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