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To cite this article: I A Prokhoda *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **274** 012122

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Management of the life cycle of the innovation apiproduct from drone larvae and its introduction in the food industry

I A Prokhoda^{1,2*}, E V Eliseeva¹, O P Polesskaya¹, E I Potseluev¹ and D V Zabenko¹

¹ Bryansk State University named after Academician I. G. Petrovsky, 14 Bezhitskaya str., Bryansk 241036 Russia

² Small innovative enterprise Apiproduct Ltd., 16a Bezhitskaya str. Bryansk 241036 Russia

E-mail: irina.proxoda@yandex.ru

Abstract. The article summarizes the experience of the small innovative enterprise “Apiproduct” (Open Company SIP “Apiproduct”) – the first Russian enterprise that manages a life cycle of the innovation apiproduct from drone larvae, and its introduction in the food industry for the enrichment of mass consumption products with high-grade protein, biologically active high-functional substances and complexes. The authors analyzed the key stages of the life cycle of the apiproduct that consist of the justification of the idea of utilization of products of the larval origin in the food industry, experimental scientific and practical research, technology of the apiproduct manufacturing in a powder form with the author's name “Bilar”, and production of its pilot batch in the Open Company SIP “Apiproducts”. The authors’ technology of production of the apiproduct “Bilar” includes the following stages: cultivation, reception and grinding of larvae to biomass, sublimation vacuum drying of biomass and production of powder with a mass fraction of 2% moisture. To date, the Russian apiproduct “Bilar” passed the sanitary-hygienic examination and can be used in its pure form as a food processor, containing in addition to protein, vitamins B, β -carotene, α -tocopherol, additionally biotin, vitamins PP, 28 macro- and microelements, unsaturated fatty acids (linoleic and arachidonic), phenolic compounds with p-vitamin activity, 80 enzymes, biopolymers, growth factor, etc., that has a long shelf life due to removal of water from the structure. The practice of the SIP “Apiproduct” work demonstrates that manufacturing and introduction of this innovation product – apiproduct “Bilar” – to the market significantly increases the assortment and competitiveness of the enterprise.

1. Introduction

In today's world, humanity faces a global problem of food shortages, which is largely due to the growth of the population of the Earth and diversion of a large share of the food resources to technical purposes. In addition to the shortage of the food raw materials, modern food industry, performing a role of a supplier of basic nutrient material (proteins, fats, carbohydrates) to the population, proposes to a contemporary man not only refined food, devoid of a number of nutrients, but also containing substances (dyes, preservatives, flavors, etc.), toxic to the human organism, and it is one of the most important problems so far.



The analysis of the actual food of the population in different regions of Russia testifies that it is short of vitamins, dietary fiber (pectin, cellulose), macro- and microelements. Therefore, it is very important to enrich food with biologically active components able to improve many physiological processes in the human body, reducing the risk of alimentary-dependent, that is, dependent on nutrition factors, diseases, such as allergic diseases, anemia, atherosclerosis, diseases of the digestive system, thyroid disease, hypertension, gout, obesity, osteoporosis, diabetes, and certain pathologies of pregnancy, etc.

The involvement of environmentally safe non-traditional raw materials into the economic turnover, the use of which in their pure form and in the production of food will enrich it with vital food substances (nutrients), satisfying energy, regulatory, protective and other needs of the organism to the level corresponding to physiological needs of a man, is seen as one of the ways to solve these issues.

The products of api-technologies produced by the honey bee (*Apis mellifera*), such as propolis, royal jelly, flower pollen and others that have healing properties and differ significantly from natural products of the plant origin, are sources of the biologically active substances (BAS), along with vegetables, fruits, berries, medicinal and spicy-aromatic plant raw materials. The uniqueness of the bee products is that the plant BAS (phenolic compounds, carotenoids, vitamins, etc.) are supplemented with specific polyunsaturated decenoic fatty acids that bees produce and that cannot be found in nature in its pure form.

The unconventional products obtained from the larvae of the open bee brood occupy a unique place among the bee products, which accumulate a significant balanced supply of nutrients. As a result, a complex of substances of the plant and animal origin with unique nutritional and immunomodulating properties is created naturally that allows considering them as important components of the functional nutrition.

All processes in our world, including economic ones, take place in time, that is, have a beginning, develop, and undergo changes and end. People's needs and attitudes to life change over time as they move from one stage of life to another.

Ditto, all goods and services pass through a series of stages that constitute the cycle.

The cycle means a set of interrelated processes, phenomena and works, which form the finalized development round for any period of time.

We have elaborated an innovation life cycle for the apiprodukt and shown the process of the organization of its manufacturing and possibilities of introduction on the basis of the summarized experience of work of the small innovative enterprise "Apiprodukt" (SIP "Apiprodukt"). This is the first Russian enterprise that manages a life cycle of the innovation apiprodukt from the drone larvae, and its introduction in the food industry for the enrichment of mass consumption products with high-grade protein, biologically active high-functional substances and complexes.

2. Problem Statement

Some contemporary researchers have convincingly shown in their works that a number of bee products, such as the apiprodukt from the drone larvae, royal jelly, etc., have therapeutic and prophylactic properties, especially antioxidant, immunomodulatory, antitumor, etc. This is due to the fact that they are composed of the unsaturated substances, such as decenoic acid, sulfhydryl compounds, which are able to bind active forms of oxygen, oxidizing free radicals and create insoluble complexes with ions of heavy metals. In particular, a high therapeutic activity of the use of larvae has been established: this nonconventional apiprodukt has been recognized to be more effective in comparison with synthesized drugs of traditional medicine [1], [2], [3], [4].

However, the results of our research allow concluding that:

2.1. To date, the scientific idea of utilization of the high-functional apiprodukts of the larval origin in food production has not yet been formulated. The products of the larval origin in the Russian Federation are not used in food as they are not components of the traditional Russian cuisine.

However, in many countries, the larvae are utilized as the element of the public food and are considered as the richest source of full-fledged protein. Therefore, the decision of the problem of search for alternative raw materials of the natural food ingredients is very urgent and timely.

2.2. The useful high-functional features of the apiproduct from the drone larvae for their direct use in the food industry have not been studied, and technology of production has not been developed. It is known that the raw materials of the larvae origin have a very limited shelf life since they contain a lot of water, a high-nutrient medium for the growth of microorganisms, including pathogens, which leads to its rapid deterioration and the impossibility of further use. On this reason, developing of the production technology for the apiproducts from the drone larvae is a scientific and technological problem. At the same time, it is very important to preserve the native natural properties of raw materials in the production processes, thanks to which the apiproduct is useful and highly functional.

2.3. The utilization of the drone larvae for protein-enriched foods with immunomodulatory and high-functional properties has not been studied as well. It has been scientifically proven that the apiproducts possess curative properties, especially antioxidative, immunomodulatory, anticancer, etc. This is because they contain unsaturated substances, such as decenoic acid, sulfhydryl compounds that are able to bind reactive oxygen species, oxidative free radicals and to create insoluble complexes with ions of heavy metals. A high therapeutic activity of the drone larvae has been identified, so that this non-conventional apiproduct has been recognized as more effective in comparison with synthetic drugs of the traditional medicine [1], [2], [3], [4].

2.4. There is no scientifically proven information about the drone larvae apiproduct life cycle, from the elaboration of the scientific idea to its massive manufacture and introduction into the food industry.

This work is devoted to the solution of the acute scientific problem - justification and development of production technology of the new nonconventional apiproduct of the larval origin, management of the life cycle of this apiproduct, and its use in the production of high-functional food.

3. Research Questions

3.1. Study and summarizing of literature and making generalization in the sphere of the directed enrichment of the food products of mass consumption by non-traditional products of the larval origin.

3.2. Justification of the scientific idea of the use of "Bilar" apiproduct in the food industry.

3.3. Elaboration of the drone larvae apiproduct life cycle.

3.4. Summarizing the experience of work of the small innovative enterprise "Apiproduct" (SIP "Apiproduct"), managing the life cycle of the apiproducts "Bilar" from the drone larvae and its implementation in the food industry for the enrichment of products of mass consumption with high-grade protein, biologically active high-functional substances and complexes.

3.5. Elaborating on the perspectives of introduction of the apiproduct "Bilar" from the drone larvae on the market, and development of methods of sales promotion.

4. Purpose of the Study

The purpose of this study is a scientific justification of:

- Possibilities to use apiproducts from the drone larvae for the enrichment of mass consumption products with high-grade protein, biologically active high-functional substances and complexes.
- Development of the life cycle of the apiproduct and production of the apiproduct
- "Bilar" on its basis;
- Perspectives of bringing the apiproduct "Bilar" to the market.

5. Research Methods

The theoretical background of this research is relevant scientific literature, and publications of Russian and foreign scientists. In addition to that, normative documents and accounting data of the enterprise SIP "Apiproduct", and information from Internet have been used for writing of this article.

The methodology of this study includes the system and process approaches.

The object of the research is a high-functional apiproduct from the drone larvae.

The subject of the research is a management of the life cycle of the high-functional apiproduct from the drone larvae, development of its production technology, carrying out of the experiment and introduction of the product on the market.

Universal economic methods of research have been used for the implementation of different stages of the apiproduct life cycle, such as experimental method, the method of analogues, as well as biological methods of research.

6. Findings

6.1. The study of modern literature has shown that today, due to popularization of the role of food in the prevention of alimentary diseases among the population, there is a steady trend of the increasing volume and expanding assortment of the food products, enriched with biologically active substances, as one of the tools to improve the competitiveness of products. So far, enriched food products make up no more than 3% of all known foods. However, according to forecasts of the world's leading experts in the field of food and medicine, in the next 15 – 20 years, their share will reach 30% of the total food market.

6.2. The small innovative enterprise "Apiproduct" was established on December 28, 2011 and it is a commercial company.

The purposes of the Company are the following:

- Practical utilization (introduction) of the results of the intellectual activity;
- Introduction of the innovation technologies, including biotechnologies, in different spheres of economy;
- Promotion of the maximal satisfaction of the economic demands and needs of the population in goods (products), works and services. Saturation of market with the goods, works, services and technologies;
- Research and development and educational and innovation work, transfer of technologies, organization of scientific events on the territory of the Russian Federation and other countries (science tourism), organization of visits to exhibitions, production and realization of the high technology products: apiproducts, physiologically active substances, etc.;
- Getting profit and its distribution between the Parties in accordance with applicable law and the company Charter.

Basic activities of the Company are the following:

1. Research and development in the field of natural and technical sciences and humanities.
2. Introduction (transfer) of the innovative technologies into production.
3. Provision of services connected with production of the agricultural products.
4. Quality expertise of conventional and non-conventional food products.

Intellectual property of the Company consists of the Patent for useful model No. 108917 "Device for selection of the drone larvae", and the Patent for the invention № 2473355 "Treatment and prevention drug of the drone larvae, which has immunomodulatory effect" [10], [11].

The stages of the life cycle of the apiproduct "Bilar" have been developed at this enterprise. They consist of the justification of the idea of use of the products of the larvae origin for enrichment of mass food products, technology of production, planning and organization of production, and introduction of

products on the market. A pilot batch of the larvae was produced in the production unit of the enterprise.

6.3. Creative act of the elaboration of the idea is the first step in any innovation. It is difficult to plan or forecast this stage beforehand, since it is based on close interaction of mental processes with intuitive guesses, and is probabilistic.

The idea to use bee larvae for medical and preventive purposes appeared at the end of the 18th century and was justified by I. Mechnikov. The founder of the Russian school of virology connected it with the search of the effective means to combat tuberculosis. In this direction, the best means for dissolving the shell of the cochlea sticks is difficult to imagine, since wax is produced by a young bee, which means that it is able to dissolve the wax "armor" of the tuberculosis shell, making it accessible and vulnerable. Innovation in the form of the idea of using larvae of bees in the production of antituberculosis drugs and immunomodulating medicines have been spread by a group of scientists under the leadership of A. I. Cherkasova. In a very short period of the ontogenesis (5-6 days), the drone larvae accumulate significant and balanced supply of nutrients that helps building imago from the egg. As a result of that, an aggregate of substances of the plant and animal origin is created by a natural way. They have unique nutritional and immunomodulatory properties that allow considering them as the important components of apilarvaetrophy, a new direction of functional food.

We have found out that "Bilar" (a name is formed from the words "a bee" and "a larver") is a nonconventional bee product of the larvae origin, produced from the drone larvae, which has evident therapeutic and prophylactic effect due to the presence of the biologically active and naturally balanced substances and complexes. The powder form is the most appropriate for its utilization. The powder "Bilar", in addition to protein, vitamins, β carotene, α -tocopherol-enriched with Biotin, carotene of all kinds, PP, 28 macro - and microelements, unsaturated fatty acids (linoleic, linolenic and arachidonic), phenolic compounds with P – vitamin activity, 80 enzymes, biopolymers, growth factor, etc., has a long shelf life due to the removal of water from the composition [11].

Our suppositions about possibility to use products of the larvae origin in different spheres of activity have been confirmed by a group of scientists from different countries of the world. Thus, at the end of the 20th century apitechnologists-beekeepers from around the world (Japan, China, Romania, Ukraine, Russia, etc.) began studying the homogeneous biomass of larvae. It was found that it is a new biologically active product of apitechnology and has many common properties with royal jelly, although it differs significantly in genesis and biomass yield from one bee family [5, 6, 7].

However, high therapeutic and prophylactic properties of the apiproduct from drone larvae have not been studied so far with regards to their utilization in the food industry for the directed enrichment of products of mass consumption with the high-grade protein and other biologically active substances.

6.4. Innovation cycle of the high technology apiproduct from the drone larvae includes two interconnected periods – the period of the creation of innovation, and the innovation life cycle. It is connected with the fact that the new idea can be used in different spheres, and not just once.

In the process of its creation, innovation goes through three stages, starting with the awareness of the need for innovation, including the development of ideas, and ending with an experiment. Life cycle of innovation has four stages and includes a set of measures focused at the promotion of a product, its introduction on the market, distribution to other commodity markets, stable implementation of innovations, commercialization and final transformation of the innovation into a conventional product. Thus, once innovation is widely used by other market players, the innovation cycle is complete.

The stages of the life cycle of the apiproduct "Bilar" consist of the technology of manufacture, researching of its food value, planning and organization of production in the SIP "Apiproduct".

The next stage is a development of the material form of the product, or the "look" for the idea. It will end with the documented product that includes the design of the product, technological scheme of the process, etc. In addition to that, at this stage it is necessary to prove scientific and technological feasibility to implement the idea.

At the next stage, the documented idea should be materialized that means introduction of the innovation with its subsequent replication.

At this stage of the transformation of the idea into a specific product, it is very important to have information about analogues products, both domestic and foreign, as well as the information about sales market for the forthcoming products. It is necessary to assess development of the competing directions of research and development. For selection of the most economically profitable solution, it is needed to create a series of samples of the innovation, which would supplement each other but have significant differences. Feasibility of the technological implementation and economic relevance should serve as the selection criteria.

In the process of the innovation development, the laboratory researches are carried out, technological schemes are designed, technological documentation is made (technological conditions, instructions, drawings, etc.). The technology of cultivation, selection and storage of the larvae has been developed and tested at the SIP "Apiproduct". The apiproduct "Bilar" has been produced from 7- to 9-day drone larvae by the method of grinding until smooth mass is received. The paste has been dried using vacuum freeze-drying installation "SU-5" and kept at a temperature of 5°C protected from light.

The next stage is an introduction of the new product or technology to the production. It is often subdivided into a number of step-by-step activities, which include production of prototypes and their test, and preparation of working documentation for the release of the first industrial batch.

A pilot batch of the apiproducts "Bilar" from the drone larvae has been produced in a production conditions of the enterprise. There are the following stages in its production technology: the cultivation, reception and crushing of larvae to biomass, mixing of biomass with api-admixture of propolis, and packing and storage.

Larvae are obtained and inspected in accordance with technological instructions. Grinding is carried out in the laboratory, using grinders (at first, in a meat grinder type of MIM-300, and then in a homogenizer of the type Usefest p/ FW is 0.3, to a particle size of 20-100 µm) and receiving homogenates. After the end of the work, the tank should be washed and dried. The crushed paste from the larvae has been filtered through a metal brass mesh, which had 100 holes per 1 square centimeter.

The powder has been obtained from the paste by using a freeze-vacuum drying. To do this, the paste is poured into special trays with a layer of 2 cm and frozen to a temperature of - 20°C. This temperature is optimal, since it stabilizes the raw material and does not allow spraying on the walls of the sublimation machine in vacuum conditions. Frozen in the trays, the paste was placed in a sublimator.

The process of drying consists of the two stages: stabilization and the drying itself. The process of drying as a whole lasts for 50 hours. The received powder has the author's name "Bilar". The packing of the "Bilar" powder is produced in an inert medium of gaseous nitrogen in a sealed package in three-layer film materials based on aluminum foil or glass. The proposed storage technology at + 20° C allows saving the "Bilar" for 6 months without changing its quality in a place protected from direct sunlight. The working yield of the powder with 1 liter of paste is 220-230 g.

Thus, the period of innovation of the life cycle of the apiproduct has ended with an experiment, which has allowed obtaining the "Bilar" powder from the larvae pasty product in a more convenient form for the market [8], [9].

Apiproduct from the drone larvae corresponds to the requirements of the approved technical conditions TU 9882-001-30327738-13 in compliance with the applicable sanitary norms and rules for formulations and technological instructions approved in the prescribed manner.

Apiproduct marking contains the following information:

- Name of the product;
- Name and the juridical address of the producing company;
- Net weight;
- Technical conditions number;

- Shelf life, the date of manufacture of the product, and conditions of storage;
- Product composition;
- Information on basic consumer properties (nutritional and energy value);
- Batch number.

The final stage in the life cycle of the apiproduct is its aging. It involves activities aimed at finding solutions for the disposal of the product that would become a conventional one. However, it has not happened so far, and it is impossible to say that the apiproduct has passed through the whole management cycle.

6.5. The next stage of the life cycle management of the apiproduct is its promotion and introduction on the market, distribution to other markets, and stable implementation of the innovations, commercialization and final transformation of the innovation into a conventional product.

In arranging sales, the SIP "Apiproduct" aims at the work with households and population that take 40% of the total turnover. The share of the medical and medical-preventive institutions is 30%, 20% and 10% respectively take sport and educational institutions, such as kindergartens and schools.

Along with the traditional scheme of distribution of "Bilar" through the trading network, it is planned to widely use the capabilities of modern Internet technologies: the mechanisms of the online trade will be organized through the Internet-shop "Apiproduct", the options of the internet payments will be used, virtual consultations for customers will also be organized on the enterprise website, a network community of producers and customers of the product through Internet is going to be created.

When promoting products on the market, it is planned to use the following methods to stimulate sales:

1. General stimulus is planned to be applied directly at the field for the overall recovery of trade. The promotion activities would include some options for reducing the price of the products, demonstrative presentation of the advertised goods or services, games, tastings, distribution of colorful ads and billboards, strengthening of the advertising campaign in the media, Internet advertising, development and distribution of leaflets with discount coupons, free gifts, when purchasing products for a certain amount, competitions, etc.
2. Selective stimulation will be used when working with legal entities: the system of discounts for the full payment of the consignment, the acquisition of large wholesale lots, or the full payments of the buyer to the SIP "Apiproduct" within the first month from the date of purchase.
3. Individual stimulation are going to be executed in those places, where general exposition of the products produced by the company is arranged, including virtual exposition in the internet store and on the SIP "Apiproduct" website.

7. Conclusion

7.1. The idea to use bee larvae for medical and preventive purposes appeared at the end of the 18th century and was justified by I. Mechnikov. Today, the innovation in a form of the idea of using larvae of bees in the production of antituberculosis drugs, and immunomodulating medicines have been spread by a group of scientists under the leadership of A. I. Cherkasova. In the process of the experimental work, we have found out that the drone larvae accumulate a significant and balanced supply of nutrients with unique nutritional and immunomodulatory properties that allows using them for the food enrichment.

7.2. Our study of scientific literature and generalization of research in the field of the directed enrichment of the food products of mass consumption by non-traditional products of the larval origin has shown that this direction is very actual and perspective, and it is planned to increase the share of the enriched products from 3% to 30% in the next 10-20 years.

7.3. The article presents the life cycle of the high-functional apiproduct "Bilar" from the drone larvae in a powder form, developed by the authors. This product, besides protein, vitamins of group B, β -carotene, α -tocopherol, is in addition enriched with Biotin, carotene of all types, PP, 28 macro-and

microelements, unsaturated fatty acids (linoleic, linolenic and arachidonic), phenolic compounds with P – vitamin activity, 80 enzymes, biopolymers, growth factor, etc., and has a long shelf life due to removal of water from the composition.

The life cycle of the apiproduct under consideration includes the following stages: cultivation, reception and grinding of larvae to biomass, sublimation vacuum drying of biomass and obtaining a powder with a mass fraction of 2% moisture.

The product "Bilar" from the drone larvae can be used in its pure form and as a food processor, and improve the competitiveness of the enterprise.

7.4. The authors have presented the process of the organization of production of the innovation product "Bilar" on the example of the SIP "Apiproduct", the basic activities of which are: research and development in the field of natural and technical sciences, introduction (transfer) of the innovative technologies into production, and provision of services connected with production and expertise of the food products. On the basis of this enterprise, the production of products of beekeeping from the drone larvae, which possess especially valuable medical and food properties allowing using them as high-functional apiproduct, has been organized for the first time in Russia.

7.5. The analysis of perspectives of promotion of the "Bilar" apiproduct on the market has been carried out, based on the estimated cost of its production and implementation, received in the course of scientific and experimental work.

The planned payback period for the enterprise "Apiproduct", conditioned by a high demand for a new type of production, is calculated as 3 years. Sales volume is expected to increase by 40%, with an overall cost increase by 18%. At the same time, net profit will increase by 66% and profitability by 40%.

Formation and increase of demand for a new kind of apiproducts possessing medical, prophylactic and high-functional properties assumes carrying out consecutive educational work, aimed at raising public awareness about the beneficial and curative properties of the new products, as well as participation in all-Russian and regional programs for the recovery of the population.

8. Acknowledgments

The authors of the article express their gratitude to A. I. Cherkasova, the Director of the P. I. Prokopovich Ukrainian Research Station of Beekeeping, who has been at the origins of the formation of a new direction in using the products of the larval origin for the enrichment of mass consumption products.

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