Development of scientifically-based recipe and technology for the production of natural honey-based muesli bar

K Laricheva and O Mikhailova
Yaroslav-the-Wise Novgorod State University, 41, ul. B. St. Petersburgskaya, Veliky Novgorod, Russian Federation
E-mail: Kristina_plus@mail.ru

Abstract. The dynamic pace of life of a modern consumer necessitates nutritious, healthy and portable snacks. Based on the analysis of the component composition of muesli bars on the market, the authors propose the development of a science-based recipe of a muesli bar, in which natural honey is used as the determining structure and binder component. The developed food product is an alternative healthy snack, in the recipe of which there are no white sugar, “harmful” fats, synthetic additives. As part of the study, the optimal formulation was calculated and the technology for the production of a new product was developed; normative and technical documentation was developed; nutritional, energy value, warranty periods of storage of the product were calculated. The results of the study indicate that the developed product in terms of quality and safety meets the requirements of regulatory and technical documentation and can be recommended as dietary and sports nutrition.

1. Introduction
The fashion for proper nutrition and the dynamic rhythm of life of the modern consumer justifies the demand for muesli bars.

Muesli has become popular in Western countries since the mid-60s, when interest in good nutrition was growing. Muesli bars appeared much later, but they are highly recognized, and this is no accident, because they have many advantages: it is a suitable product for the road; it is very easy to store; it takes up little space; it has high nutritional value, making it suitable for snacking “on the run”; muesli bars are a harmless alternative to modern confectionery.

Unfortunately, this product has its drawbacks too: as a rule, high calorie content, which makes the product not suitable for everyone (and the excess of energy value is provided by various sweeteners, sugar, glaze and chocolate); high sugar content, which is why the product is not suitable for diabetics; the use of palm oil and dried fruits in the production, which were processed with sulfur, which increases the amount of harmful substances in this product; the nuts and seeds that make up the bars contain a considerable amount of oil, which gives an extra load on the liver. Therefore, to people who suffer from diseases of this organ, such a product is contraindicated [1].

An analysis of the component composition of muesli bars on the market marked “fitness” showed that most of them do not meet their intended purpose, as they contain a large amount of sugar or sweeteners, fat, chemical dyes, flavorings, wheat flour [1, 2]. Muesli bars on the market by 35-40% consist of binder component, and as a binder component manufacturers use glucose syrup, fats, molasses, which too increase the calorie content of the product, and also raises blood sugar and enhances appetite.
The average calorific value of such muesli bars is about 450 kcal per 100 g of product. A study of research and development in the field of modeling cereal bar recipes showed that such products are not only not useful, but also have adverse effects on the body.

The worldwide pandemic of obesity and metabolic diseases has caused concern among many researchers in the development of healthy snacks. Researchers from the Institute of Nutrition, the Higher School of Applied Sciences and the University Medical Center of Slovenia studied the adverse health effects of excessive sugar intake. The study by Zupanic N, Miklavec K, Kusar A, Zmitek K, Mis NF, Pravst I aimed at assessing the content of “added” sugar in 10 674 pre-packaged foods.

52.6% of all analyzed products contained “added” sugar, which averaged 57.5% of the total sugar content. Studies have shown that cereal bars fell into the category of products with the highest content of “added” sugar (23.8 g/100 g) [3]. Italian market research has also confirmed the high content of added sugar and salt in muesli [4].

Recently, the attitude of many consumers to sugar has changed. A growing number of consumers are initiating a reduction in the consumption of white sugar in their diet, however, it is extremely difficult to do because of the lack of available information about the amount of added or natural sugar in the product [3]. Reducing sugar in packaged foods and drinks can help protect human health. “For this, clear methods are needed to develop feasible, but effective goals for the program to reduce added sugar,” researchers from New Zealand deem [5]. As part of their study, Eyles H, Trieu K, Jiang YN, Mhurchu CN studied the factors that influence the choice of cereal bars in various consumer groups. Analysis of the results of the study showed that consumers pay particular attention to convenience of packaging. People who are into sports pay more attention to the nutritional and energy value of the product. All consumer groups showed great interest in the calorie content and sugar content of the product [5].

The results of various studies provide interesting data on the behavior of certain segments of consumers when choosing cereal bars, in particular, engaged in physical exercises and people engaged in fitness and maintaining a healthy lifestyle [4, 6, 7].

A study of the market and the experience of foreign countries in the development of low-calorie muesli bars showed that the assortment of such “sugar-free” products is clearly insufficient, and therefore development of a new recipe of a muesli bar is very relevant.

We also draw attention to the fact that a modern consumer prefers snacks and bites, not only in order to satisfy their hunger, but also in order to provide the body with the necessary nutrients. In this regard, the developers set a goal of developing recipes of cereal bars using various highly nutritious ingredients. Thus, Malaysian scientists have developed a cereal bar, the main components of which are popped rice, dates, raisins, figs, glucose syrup and honey [8]. Researchers at Harrisburg University have developed an energy bar using cornmeal, legumes, and soy protein [9]. Scientists of the United States of America Coleman E.K., Schmid E., Miklus M. developed a nutritious bar which has less than 110 kcal per 28 gram serving [1]. Spanish researchers from the Department of Food Engineering, together with scientists at Columbia University, have developed an organic cereal bar with an exotic Andean quinoa grain crop [10]. A snack bar based on tapioca flour has been developed at the Federal University of Pará [11]. Around the world, research is actively being conducted in the field of developing formulations with a high protein content [12, 13]; gluten-free cereal bars [14]; cereal bars enriched with dietary fiber [15]. More and more developments have become associated with the therapeutic and prophylactic orientation of food products. Scientists at San Diego State University have developed a nutritious bar for women at risk for osteoporosis [16].

The basis for most Russian-made cereal bars is oatmeal, which has great nutritional value for human body. Also rice, wheat, corn flakes can be used as main raw materials. In addition, other ingredients, such as dried fruits, nuts, dried berries, glucose, fructose, citric acid, and identical natural flavors, are used in the process of making muesli bars. Glucose syrup, vegetable fats, starch syrup, invert sugar syrups are used as structure forming components. For glazing, chocolate (made of milk, dark and white chocolate) icing and yogurt are used.

An analysis of the assortment of muesli bars presented on the Russian market revealed that most often glucose-fruit syrup (binder component) occupies the first place in the list of ingredients, which
means that there is most of this raw material in the product. Next come oatmeal flakes, popped rice and corn, dried fruits, nuts and dried berries. And also very often in the lists of ingredients of glazed bars chocolate and yogurt glaze can be found.

We draw attention to the fact that glucose syrup, which is part of most muesli bars, increases the calorie content of the product too, and it also increases appetite. In this regard, the problem of creating products with reduced energy value, with the exception of white sugar and fats from the recipe, but with the addition of functional components, is very relevant.

All over the world, scientists are puzzled by the creation of not only tasty, but also healthy snacks. A component analysis of the compositions of muesli bars on the market, presented in research projects, showed that honey is used in many recipes. However, in all cases, it was proposed to introduce honey as a flavoring or as means to impart a certain color characteristic to the product. We propose to develop a new recipe of a muesli bar, in which natural honey will be used as a binder component. While, to date, manufacturers and developers of new recipes use sugar, corn and caramel syrups; agar agar; palm, rapeseed and sunflower oils; unrefined sugar from sugarcane, etc. [1, 8, 9, 10, 16, 17] as binder, “gluing” and thickening components. It is noteworthy that in the recipes of low-calorie bars the same “not healthy” ingredients are stated.

Marketing researches conducted by the authors confirmed the relevance of the study and revealed that when choosing a muesli bar, a consumer mainly prefers natural composition, products “sugar-free”, “salt-free”, without various artificial additives.

2. Results
The aim of the study was to develop a new recipe and technology for the production of fitness muesli bars using natural honey as a binder component. The work consisted of the following stages: marketing research in order to identify consumer preferences; analysis of scientific, technical and patent literature; determination of the object, purpose and objectives of the study; selection and preparation of recipe components; development of component composition; development of methods for the preparation of prototypes; development of prototypes of a muesli bar; selection of research methods; quality assessment of developed products; analysis of the results; calculation of the optimal formulation; development of the technological process of production; development of technical documentation; calculation of economic efficiency of production [12].

As part of the study, trial workings were carried out to ensure the optimal ratio of nutritional values and organoleptic properties. Trial workings made it possible to work out the ranges of contents of each of the main recipe components and to reveal the optimal ratio of the main ingredients in the recipe and honey as a “binder” component. As a result of the experiment, 3 recipes of the muesli bar were selected for further research (table 1).

| Name of raw materials       | Sample 1 | Sample 2 | Sample 3 |
|-----------------------------|----------|----------|----------|
| Rolled oat flakes           | 25       | 25       | 10       |
| Natural honey               | 25       | 22       | 12       |
| Walnut                      | 25       | 14       | 18       |
| Dried cranberry             | 25       | 13       | –        |
| Sunflower seeds             | –        | 3        | –        |
| Peanut butter               | –        | 23       | –        |
| Dates                       | –        | –        | 30       |
| Prunes                      | –        | –        | 30       |

During the development of the methodology for preparing test prototypes, great attention was paid to the stages of preparation of raw materials (selection of the optimal size of oat flakes; the degree of grinding of dried berries, fruits and nuts; a method of providing natural honey with a liquid structure), formation of a confectionery rope and the development of optimal baking parameters.
The technology was worked out, all the necessary equipment was selected and calculated. As a result, a hardware-technological scheme was developed for the production of a fitness muesli bar, shown in figure 1.

A five-point scale was used to control the organoleptic properties of prototypes of fitness bars. The sensor profile of trial prototypes is shown in figure 2.

**Figure 1.** Hardware-technological scheme for the production of muesli bars.
1 — Platform scales MASSA-K 4D-PM; 2 — Production table KAYMAN SP-255/0606; 3 — Trolley TCh-300; 4 — Electric industrial meat grinder МЭП-300; 5 — Mixer A2—ShSP; 6 — Confectionery extruder; 7 — Guillotine confectionery cutter “RoboCut-G”; 8 — Tunnel furnace AK-1171; 9 — Refrigeration tunnel “RoboColol”; 10 — Horizontal packing machine PR-250.

**Figure 2.** Sensor profile of test prototypes.
During organoleptic analysis, sample No. 1 showed too loose consistency that did not form the structure of the bar; in the sample No. 2, peanut butter intercepted the taste of the other components; during organoleptic analysis, sample No. 3 received the maximum average score; in the sample No. 3, the desired organoleptic indicators were achieved (table 2).

**Table 2.** Organoleptic quality indicators of sample No. 3.

| Name of indicator | Characteristics |
|-------------------|-----------------|
| Appearance        | The surface is shiny, uniform color, slightly sticky; rectangular shape resistant to deformation |
| Structure         | Semi-solid, not dense, flexible, non-smearing |
| Flavour           | Corresponds to a bouquet of aroma of the main declared ingredients; odorless |
| Taste             | The pronounced taste of the declared ingredients, saturated, without extraneous off-flavour |
| Colour            | Homogeneous, dark brown |

At the next stage of the experiment, physicochemical parameters of the quality of the samples were determined (table 3).

**Table 3.** The results of the study of the physico-chemical indicators of quality assessment of samples.

| Name of indicator                      | Norm | Sample 1     | Sample 2     | Sample 3     |
|----------------------------------------|------|--------------|--------------|--------------|
| Mass fraction of moisture, %, no more | 8.0  | 5.1±0.9      | 5.9±0.7      | 5.3±0.9      |
| Mass fraction of metallomagnetic impurities, mg/kg, not more than | Not allowed | Non detected | Non detected | Non detected |
| Pest infestation                      | None | None         | None         | None         |

Physico-chemical characteristics of the experimental samples confirmed the high quality indicators of the developed product. Safety indicators were also normal. The study of the samples was carried out in accordance with the developed regulatory and technical documentation.

To establish a guaranteed shelf life, studies were conducted on organoleptic, physico-chemical and safety indicators of muesli bars packed in a biaxially oriented polypropylene film (BOPF) after 2, 4 and 6 months. The experiment was carried out at a relative air humidity of not more than 75%, at three temperature conditions 0°C, 18°C and 25°C. Based on the studies, the shelf life of the muesli bar was set to 6 months.

The results of the experiment allowed one to simulate the optimal formulation and to calculate it. The recipe for a new type of fitness muesli bar is presented in Table 4. The name of the new product “Healthy pocket snack” was also chosen. The chosen name is easy to remember, contributes to the formation of the image of the product, is attractive to consumers aspiring for a healthy lifestyle.

**Table 4.** Recipe for the “Healthy pocket snack” muesli bar.

| Name of raw materials | Dry substance content, % | The ratio of components, % |
|-----------------------|--------------------------|---------------------------|
| Dates                 | 21.5                     | 30                        |
| Prunes                | 18.9                     | 30                        |
| Walnut                | 15.7                     | 18                        |
| Natural honey         | 8.6                      | 12                        |
| Rolled oat flakes     | 7.4                      | 10                        |
The calculation of the nutritional and energy value of the new product showed that replacing the “sugar gluing” components with natural honey made it possible to obtain a “healthy” low-calorie snack. Comparing the “Healthy pocket snack” muesli bar with the counterparts (average calorific value 450 kcal per 100 g) on the market, we noted that the energy value in the new bar is lower by 100 kcal. Given that the bar is proposed to be produced in an individual polymer package with a net weight of 60 g, the calorie content of such a healthy snack will be approximately 200 calories.

An assessment of the economic efficiency of the proposed industry-oriented technology predicts that the proposed development will be successful. The projected price of a muesli bar weighing 60 g is within 62 rubles. This fact suggests that the new product can fully compete with other muesli bars on the market.

3. Conclusion
The studies have shown that consumers demand and want healthy food that is portable, convenient and proportionate. In this regard, muesli bars are an attractive and innovative option for a convenient and healthy snack. As part of the scientific research work, the need for expanding the assortment line of “sugar-free” muesli bars is theoretically substantiated. Based on the study of the component composition of muesli bars on the market, the use of natural honey as a binder of the component structure is justified. The recipe was experimentally selected, the optimal ratio of the main ingredients in the recipe and honey as a “gluing” component was revealed. The recipe has been developed and the technology for the production of a new product has been worked out, all the necessary equipment has been selected, a hardware-technological scheme has been developed.

The use of honey as a binder of the component structure in the production of muesli bars will expand the range of products that are healthy, reduce calories, increase nutritional value, and remove white sugar from the recipe. The developed muesli bar “Healthy pocket snack” meets the expectations of consumers: it does not contain artificial colors and flavors, has physico-chemical and organoleptic characteristics within the normal range for this type of product, and is excellent for a proper snack.

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