

Confectionary products enriched with biologically active food components of aquatic bioresources in the diet of sport youth

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Abstract. This article presents some results of analysis of the biologically active food additives market, dietary supplement consumer groups. It was revealed that the most responsive consumers of new products, including dietary supplements, are young people under the age of 35, primarily students of higher educational institutions. Based on the results of these studies and studies of rheological and organoleptic characteristics of chocolate mass and finished product, the composition of the chocolate truffles enriched with fish oil and dietary fiber was developed and patented. Wild Kamchatka salmon fish oil is used as an enriching component in chocolate truffles, rich in polyunsaturated fatty acids (eicosapentaenoic and docosahexaenoic acids), as well as wheat fiber - a source of dietary fiber. The developed composition was tested in production conditions using the technology described in the article.

1 Introduction

Over the past few years, the principles of a healthy lifestyle have been actively promoted in the Russian Federation. In terms of the epidemiological situation of 2020-2021, and the support of the population by the state in the field of healthcare and sports, most people are aware of the need to pay special attention to their physical health. The percentage of the population leading a healthy lifestyle, choosing a balanced diet and paying special attention to physical activity is increasing. Due to the increasing awareness in matters of nutrition and health, sugar consumption decreases, which affects the supply of confectionery products. Nowadays products with a reduced sugar content and without sugar occupy about 5% of the total turnover in the confectionery market.

In the modern consumer's understanding, taking dietary supplements is an integral part of healthcare. In proportion to the growing awareness of the population about the benefits of biologically active substances, the dietary supplement market is growing, new functional and enriched products appear, including confectionery products of increased biological value.

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As enriching components of such products, raw materials of plant origin are often used, and as a "carrier" of dietary supplements - marmalade sugar products [1,2,3,4]. Enriched confectionery products existing on the Russian market are carriers of polyunsaturated fatty acids of mainly plant origin, for example, flax seeds or linseed oil, which contain only alpha-linolenic acid. However, the benefits of this acid are achieved by converting it into eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) by the human body. Fish oil, in turn, contains a set of eicosapentaenoic and docosahexaenoic acids, the properties of which are of the particular physiological interest to the human body [5].

According to the latest data, chocolate and cacao-based products are among the most popular confectionery products around the world. Considering its high consumption, it seemed as a reasonable option to fortify chocolate with different bioactive compounds as a delivering agent. Over the past few years, several successful attempts have been made to enrich chocolate products with aquaculture products [6].

That is why the enrichment of cocoa-based confectionery products with biologically active food components of aquatic biological resources, and, as a result, the development of a new form of dietary supplement, is relevant and promising nowadays.

2 Materials and methods

2.1 Materials

As research objects we used samples of chocolate mass and chocolate truffles prepared from these samples, enriched with fish oil from wild Kamchatka salmon containing 30% omega-3 fatty acids (20% of eicosapentaenoic acid (EPA) and 10% docosahexaenoic acid (DHA), manufactured by "Tymlat Fish Factory". Confectionery chocolate without sugar was used to prepare chocolate mass for truffles (mass fraction of cocoa - 72%, cocoa butter - 42%). Maltitol and stevia extract were used as sweetener in that chocolate. Wheat fiber with grinding degree of 200 mcm, hydration of not less than 1:6 and fat retention of not less than 1:6 was used as a source of dietary fibre. Whipped cream with a fat content of 33% was also one of the main ingredients of the truffles.

2.2 Methods of research

Marketing studies were conducted by comprehensive analysis and statistical processing of open databases, media and industry publications. The degree of interest of the consumer target group was determined through a sociological survey and online questionnaires.

The viscosity measurements of the chocolate ganache were performed using a Brookfield RVDV-II+ Pro rotary viscometer equipped with a RV 7 spindle at $24 \pm 1^\circ\text{C}$. Six samples of chocolate ganache with different mass fractions of dietary fiber were studied at the following parameters: the mass of the test sample - 400 g, the shear rate - 2.5; 5; 10; 20; 50; 100 s^{-1} . Quantitative recalculation of chocolate mass viscosity index (thixotropic index) was calculated according to the Eq. (1):

$$n = \eta_L / \eta_H \quad (1)$$

where n is a "thixotropic index," dimensionless, η_L - viscosity at low shear rate, cP or $\text{mPa}\cdot\text{s}$, η_H - viscosity at high shear rate, cP or $\text{mPa}\cdot\text{s}$.

The hardness, adhesion and chewability of the finished product were determined using a texture analyzer, TexturePro CT V1.8 Build 31, with a TA5 nozzle and a load of 0.05 N at a speed of 2 m/s and an ambient temperature of 24°C after stabilizing the chocolate ganache samples for 40 minutes.

The calculation of hardness, adhesion and chewability was carried out according to the diagrams obtained during the tests. Hardness was defined as the maximum amount of load in the compression cycle, adhesion as the maximum negative force of the first compression cycle, and the chewability coefficient was calculated as the multiplication of hardness, cohesion and elasticity.

Organoleptic characteristics of the created confectionery products were determined on the basis of a 5-point reference scale for assessing the quality of confectionery products of increased nutritional value.

3 Results and discussion

3.1 Marketing studies

Marketing research conducted in March 2022 showed that the dietary supplement market is, on the one hand, one of the fastest growing segments of the pharmaceutical market, and on the other, a specialized direction of the food market. The turnover of the Russian dietary supplement market in monetary terms was characterized by positive dynamics, which, in our opinion, is primarily due to the desire of the population to increase the body's resistance to infections and reduce anxiety due to the COVID-19 pandemic, as well as the widespread popularization of a healthy lifestyle among Russian citizens [7].

Traditionally, general dietary supplements remain the most popular in the Russian market. Their share at the end of 2021 amounted to 32.2% of the total consumption. It is worth noting that compared to 2020, the sales amount of this dietary supplement segment increased by almost 4%.

The second position in the structure of dietary supplements by purpose is occupied by the segment "acting on the digestive system" (20.5%). The increase was + 19.3%.

Dietary supplements affecting the functions of the central nervous system are on the third place, with a specific proportion of 9.4%. This group also showed positive dynamics in the past year (+ 12.4% compared to the level of 2020) [7].

One of the main trends that appeared in the period of 2017-2020 in the Russian Federation is the trend of Health & Wellness, the main principle of which is to maintain physical health and take care of mental well-being. This trend is due to the fact that millennials are the main driver of demand in Russia in such innovations. There are several reasons for this:

- growing welfare of millennials - the main share of the middle class in the Russian Federation is formed by young people from 25 to 38 years old;
- the lowest unemployment rate among this population in the Russian Federation;
- the greatest exposure to stress and chronic fatigue due to a tight work schedule, high professional workload, which makes to look for a solution to the problems of "habitual poor health".

Moreover, the number of people who follow a healthy lifestyle is growing every year. According to the Federal State Statistics Service, at the beginning of 2021, about 5% of men and 8.1% of women in Russia are adherents of healthy lifestyle. At the same time, in some regions this indicator is much higher. For example, in Sevastopol, 27.96% of men and 27.72% of women prefer sports, proper nutrition and environmental friendliness of life [8, 9].

Industry experts note that the portrait of the consumer is currently changing in the focal market. If in the 2010s dietary supplements were bought mainly by people in the 35-45 age group, now millennials and zoomers are the most active buyers - people from 20 to 38 years old [7]. Figure 1 shows that more than 50% of people actively consuming dietary supplements are classified as young people.

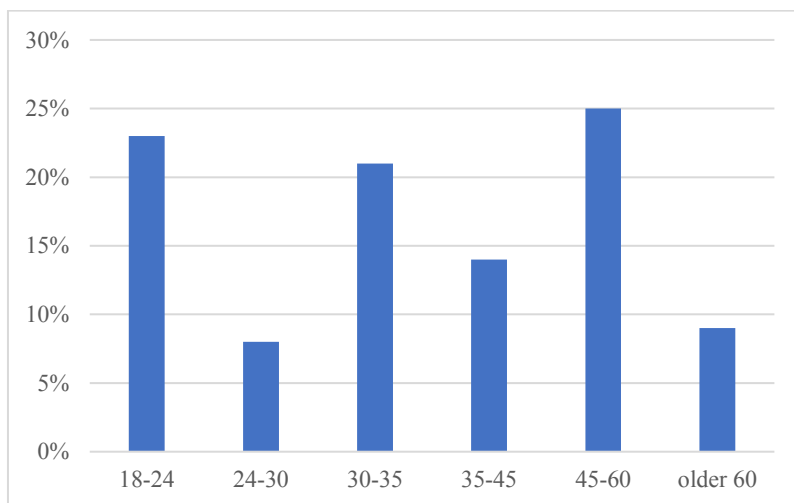


Fig. 1. Dietary supplement consumption structure by age, % [7].

With regard to the distribution of dietary supplement consumption by gender, 77% of consumers are women, 23% are men. It should be noted that men are more often interested, according to the survey results, in sports nutrition and various supplements to maintain body weight. And women, in turn, are more likely to use dietary supplements to maintain beauty (hair, skin, nails). Both men and women prefer dietary supplements designed to maintain health in general (including for the cardiovascular system, immunity, etc.) approximately to the same extent [7].

As was mentioned earlier, the most responsive consumers of new products, including dietary supplements, are young people under the age of 35, primarily students of higher educational institutions.

In October 2021, a survey of 420 students was conducted, which proved the relationship between the deterioration of the psycho-emotional state after physical activity and the lack of necessary macro- and micronutrients, the imbalance of the diet [10].

In November 2022, a second survey of 430 students of Sevastopol State University was conducted. The survey confirmed the fact of increased interest in sports in Sevastopol - 52.9% of respondents regularly go in for sports. This indicator increased by 9.1% compared to 2021, which proves the positive dynamics of youth involvement in sports.

About 60% of young people who took part in the survey believe that they receive the necessary microelements and vitamins with food, correctly composing their diet. However, only 40% really monitor nutrients entering the body, filling the shortage of biologically active substances by using various dietary supplements.

The survey showed that there is a need to develop a new form of dietary supplement that is attractive to young people. Such a new type of dietary supplement can be chocolate truffles enriched with fish oil.

3.2 Rheological and sensory characteristics of chocolate truffles with fish oil

The rheological characteristics are fundamental in selecting right amounts of truffle components. The additional inclusion of fish oil in chocolate ganache, which is a solid emulsion, inevitably liquefies the mass, so soluble and insoluble dietary fibers have been added to increase its stability.

The rheological characteristic of the chocolate mass mainly focuses on viscosity and hardness. Determination of the chocolate ganache viscosity at the manufacturing stage is necessary to adjust the modes of further truffle making and helps predict the consistency of

the final product. The hardness of the chocolate ganache after stabilization also characterizes the consistency of the final product, allowing the chewability factor to be calculated.

The viscosity of the chocolate ganache was determined using a Brookfield RVDV-II+ Pro viscometer. Six samples were prepared for the study, including the control sample. Among the recipe components of these samples were both soluble dietary fiber (polydextrose, pectin substances) and insoluble dietary fiber (wheat fiber). These dietary fibers were used in samples in various combinations of weight ratios. The control sample (No. 6) did not contain any fish oil or fiber.

The results of the quantitative determination of the flow characteristics of the non-Newtonian liquid, which is chocolate ganache, for each sample are presented in Table 1. Chocolate ganache is a thixotropic liquid, that is, it breaks down under prolonged mechanical action, so its viscosity can be characterized by a quantitative value - a thixotropic index, that was calculated according to the Eq. (1).

In addition, hardness, adhesion and chewability are also important rheological characteristics of the truffles. In sensory detection, hardness is characterized as the force required to compress food between teeth, adhesion force is the work required to overcome the forces of attraction between the surface of a food sample and the surface of other materials in contact with the sample (palate, tongue, teeth), and chewability is the energy required to chew a solid food product to a swallable state.

These rheological characteristics of the stabilized chocolate mass were determined using a texture analyzer, TexturePro CT V1.8 Build 31. The results of quantitative indicators calculation of hardness, adhesion and chewability, as well as thixotropic index, product viscosity index, are given in Table 1.

Table 1. The rheological characteristics of chocolate ganache samples as a function of dietary fiber content.

Sample No.	Mass fraction of dietary fiber, %	Mass fraction of omega-3 fatty acids, %	Thixotropic index (viscosity index)	Hardness, N	Adhesion, Pa	Chewability coefficient
1	4,1±0,1	1,4±0,3	47,5	19,60±0,10	8,14±0,12	147,0
2	1,5±0,1	1,4±0,3	6,3	14,47±0,11	5,18±0,10	0,8
3	2,9±0,1	1,4±0,3	37	8,20±0,08	2,57±0,10	1,4
4	3,1±0,1	1,4±0,3	6,8	10,67±0,11	3,4±0,09	4,3
5	2,9±0,1	1,5±0,3	23,8	12,37±0,10	5,00±0,10	57,5
6	1,5±0,1	0,0	14,4	13,52±0,09	5,73±0,11	21,5

Sensory analysis of six samples was performed. The results of organoleptic evaluation of truffles with fish oil are presented in the form of profilograms in Figure 2.

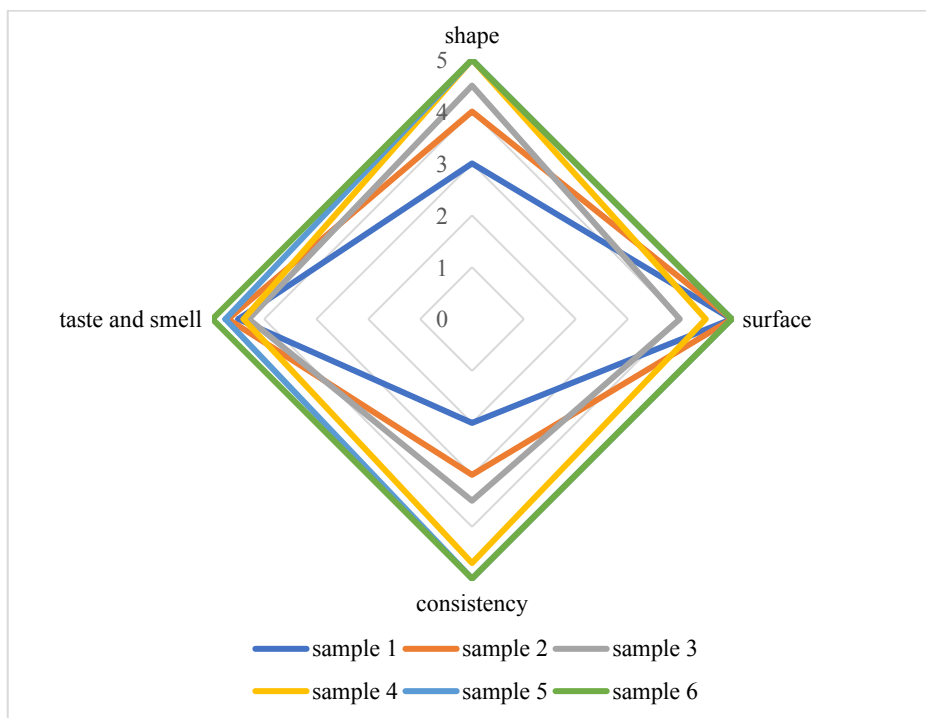


Fig. 2. Organoleptic profiles of fish oil truffle samples.

The results of the studies presented in Table 1, as well as in Figure 2, indicate that the additional inclusion of insoluble dietary fiber in the formulation of fish oil truffles in a certain ratio has a positive effect on the consistency of the final product.

Based on the results of marketing, organoleptic and rheological studies, the composition of chocolate truffles enriched with fish oil and dietary fiber was developed and patented (Table 2) [11]. As an enriching component in these truffles, wild Kamchatka salmon fish oil is used, rich in polyunsaturated fatty acids (eicosapentaenoic and docosahexaenoic acids), as well as wheat fiber - a source of dietary fiber.

Table 2. Fish oil chocolate truffles formulation.

Component	Mass fraction, %
Chocolate	55-61
Cream	27-30
Wheat fiber	5-6
Fish oil	3-4
Sugar	0-6
Cardamom	0,3-2
Cacao powder	0,1-0,3

Introduction of wheat fiber into the chocolate mixture composition allows not only to enrich the final product with food fibres, but also to densify the truffle structure without using artificial stabilisers and bulks. Moreover, the addition of dietary fiber to the truffle composition reduces the time of truffle stabilization from 10-12 hours to 15-20 minutes, which significantly speeds up and simplifies the production process. The synergistic effect of using wheat fiber consists in reducing the smell and taste of fish oil to the threshold level or below [11].

The positive effect of polyunsaturated fatty acids on the condition of athletes at all stages of sports training has been sufficiently studied [12]. In addition, dietary fiber is important for athletes, as it does not only normalize the intestinal microflora, but also stimulates the body's protective functions along with polyunsaturated fatty acids.

Above-mentioned combination of components, in addition to the described preventive action and functional value, gives the truffle a harmonious taste without unpleasant tastes and odors, and also allows to use practically no refined sugar in the composition, since the truffle has sufficient sweetness due to the inclusion of cream lactose. To increase the sweetness of truffles, it is allowed to add a certain amount of sugar or replace chocolate with a cocoa content of 75% with chocolate with 55% cocoa in the composition. Cardamom also hides extraneous possible flavors and give the truffle an interesting taste. Coating of the truffle with an additional layer of chocolate slows down the oxidation processes of the filling deterioration and ensure long-term storage without using artificial preservatives [11]. Above-mentioned composition of chocolate truffles can be implemented according to the following technology, including chocolate tempering with cocoa content 75% or 55%, chocolate mass preparation by mixing chocolate with 40°C-heated cream, as well as fish oil emulsification into chocolate mass at 30-35°C temperature and addition of dietary fibre in the form of wheat fibre. The chocolate mass is squeezed in the form of cone-shaped truffles and left for stabilization at 14-16°C. After stabilization, the truffles are given a round shape, coated with tempered chocolate and rolled in cocoa powder.

4 Conclusion

Thus, the analysis of the current state of the Russian dietary supplement market showed a positive trend in the consumption of biologically active substances over the past few years, primarily associated with increasing awareness of young people in the field of health and sports. According to the results of the Sevastopol students' survey, it was concluded that the popularity of sports among the youth of this region is growing annually, however, nutrition is still neglected. Due to the growing incidence caused by micronutrient insufficiency, the introduction of functional products into the diet of sports students is relevant. It is proposed to use chocolate truffles enriched with fish oil and dietary fibers as such products, the composition of which was scientifically justified in terms of sensory and rheological characteristics and patented. The developed technology for the production of chocolate truffles with fish oil was successfully tested at the confectionery manufacture in Kaliningrad.

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