QUALITY AND SAFETY PROBLEMS OF SPORTS NUTRITION PRODUCTS

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Introduction. Throughout the world, the development of evidence–based food technology and its production is given particular importance. A lot of research is being done in this perspective (Bazarnova et al., 2019; Laukaleja & Kruma, 2019). Separately, the production of the sports nutrition product line is singled out. Sports nutrition is a constantly developing area in which hundreds of scientific papers.

The study of the quality and safety of products for sports nutrition throughout the "product lifecycle" is of high importance. The aim of this paper was to study the most significant safety indicators of polyunsaturated fatty acids and the fat component of some sports nutrition products.

The objects of study were sports nutrition products.

Protein bars of the firms 'ProteinBar' (Russia) and 'Bombbar' (Russia). Technology which involves the preparation of used dry raw materials, its dosing, mixing with sugar invert syrup, fat component, vitamin premix, rolling, calibration, molding, molding and packaging. Capsule forms of dietary supplements ω–3, ω–6, ω–9 by 'Sportline' (Russia), 'Multipower' (Germany) and 'Maxler' (USA). There are a variety of technologies for the production of encapsulated materials: spray drying to obtain capsules, spray freezing, inclusion in matrix, co–extrusion, encapsulation in a gel, encapsulation in a fluidized bed. Vegetable oils for encapsulations are pre–cleaned. The manufacturer as follows indicates the storage conditions of the test products: 'Keep away from direct sunlight, in a dry, cool place, inaccessible to children'. The sell–by–date of the control sample is 12 months. Studies of the fat component were carried out on the 3rd month of product storage. The research took place at a given shelf life for the purpose of modeling assessment of real safety when consuming sports nutrition products. Subsequently, research results in the dynamics of storage of this product line will be reflected.

Research methods. Generally accepted regulated methods that normalize the safety and quality of fats were used. Fat was extracted from the finished product by the extraction–weight method according to GOST R 54053–2010 'Methods for determining the mass fraction of fat'. The following indicators were studied:

concentration of epoxides by reaction with concentrated phosphoric acid (Stopskij et al., 1986);

acid number was determined by standardized methods to GOST R 52110-2003. Vegetable oils. Methods for determination of acid value;

the peroxide number of the fat component of the product was determined by the iodometric method;

content of oxidation products (copolymers) insoluble in petroleum ether (CIPE) according to the method described in the manual of the All–Russian Research Institute of Fats with the following additions.

A mixture of oxidation products insoluble in petroleum ether was dissolved in hot ethyl alcohol, concentrated to a small volume in a water bath, transferred quantitatively to a 50 cm^3 volumetric flask, made up to the mark with ethyl alcohol and mixed well. The resulting solution containing CIPE from 5 g of the fat fraction was divided into 2 equal parts. One part was dried to constant weight, and then calcined to determine the ash, as described in the main method. According to the data obtained, the content of CIPE in oxidized fat was calculated in % of the fat mass, given that the treated solution contains CIPE of 2.5 g of fat. In the second part of the solution, the fatty acid content was determined by titration with a 0.1 mol dm^{-3} alkali solution. According to the obtained results, the content of CIPE in oxidized fat in mmol kg^{-1} of fat was calculated (Rzhehin & Sergeev, 1967).

Statistical processing was carried out in accordance with GOST R (national standard) ISO 5725–2–2002. The arithmetic average of the results of two parallel determinations made under the conditions of repeatability (convergence) is taken as the measurement result. The mathematical processing of the results included the determination of the arithmetic mean *X*, the standard deviation of the individual result (standard deviation) *S* and the standard deviation of the arithmetic mean (standard error) *SX*. The measurement results xi, the absolute deviation of which from the arithmetic mean x exceeded *3S*, were discarded as unreliable. Accuracy of the measurements (absolute error Δx) was determined with reliability $\acute{a} = 0.95$. The correlation dependence was calculated using the Microsoft Excel program.

RESULTS AND DISCUSSION

Results. Table 1 presents the nutritional data of the test samples indicated on the package. The content of the fat component in capsules is 25% of the daily intake for 'Sportline', 20.8% of the daily intake for 'Maxler' and 21.8% of the daily intake for 'Multipower'. The remaining PUFAs come with the main diet of athletes. The content of protein components in the bars is 32.1% of the daily intake for 'ProteinBar', 27.7% of the daily intake for 'Bombbar'.

The qualitative composition of sports nutrition products indicated on the label is shown in Table 2. Based on the labeling data, the analyzed 'ProteinBar' bars contain flavors, soya lecithin, soy protein isolate. These components can have a negative effect on the human body, causing allergic reactions, exacerbation of the course of chronic diseases of the gastrointestinal tract. In addition, soy proteins are characterized by an unbalanced amino acid composition, they are imperfect.

Table 1. Nutritional value of control samples of bars and capsules

Product	Proteins, g	% of the daily intake	Fats, g	% of the daily intake	Carbohydrates, g	Energy value, kcal
Protein bars 'ProteinBar' (per 100 g)	35.0	32.1	20.0		39.0	476.0
Protein bars 'Bombbar' (per 100 g)	30.2	27.7	13.1		8.0	262.0
'Multipower' Capsules (in 3 capsules /	0		3.1	21.8	2.0	15.0
'Sportline' (in 3 capsules / daily rate)	0		3.6	25.0	3.0	39.0
'Maxler' (in 3 capsules / daily rate)	0		3.0	20.8	0.6	10.0

In 'Bombbar' bars, the content of whey protein isolate and milk protein concentrate shows that the product contains complete protein and the product containing it does not cause any concern, except for milk protein intolerance.

The origin of fatty acids in capsules, such as eicosapentaenoic acid, docosahexanoic acid, alpha–linolenic acid, oleic acid, is not indicated.

Table 2. The composition of the objects of study

Product name				
Protein bars		Encapsulated Fats		
'ProteinBar'	'Bombbar'	'Sportline'	'Maxler'	'Multipower'
soy protein isolate, whole–grain cereals that do not need cooking, cocoa butter, fructose, caramel starch syrup, banana, emulsifier, chocolate icing, cocoa powder, soy lecithin, cream flavor.	protein complex (whey protein isolate, milk protein concentrate), sweetener maltitol, inulin, almond flour, cocoa butter substitute, milk fat, water–retaining agent, glycerin, milk powder, dried pear, yogurt powder, cinnamon, pear flavoring, soya lecithin, lemon acid, contains sugars of natural origin.	ω–3 – 340 mg, ω–6 – 42 mg, ω–9 – 271 mg, fish oil, unrefined linseed oil, unrefined olive oil, eicosapentaenoic acid, docosahexanoic acid, alpha–linolenic acid, oleic acid.	ω–3 – 540 mg, ω–6 – 150 mg, ω–9 – 210 mg, organic linseed oil, alpha–linolenic acid, oleic acid, linolenic acid, gelatin, glycerin, locust bean gum, purified water.	ω–3 – 340 mg, ω–6 – 42 mg, ω –9 – 271 mg, fish oil, unrefined linseed oil, unrefined olive oil, eicosapentaenoic acid, docosahexanoic acid, alpha–linolenic acid, oleic acid.

The results of the study of the fat component of protein bars for sports nutrition and ω–3, ω–6, ω–9 capsules are shown in Table 3.

In the study of the fat component, the content of free fatty acids was determined. This indicator in the Russian Federation is controlled by technical regulations in fat products. The content of free fatty acids value, mmol kg^{-1} of oil: the permissible level is 10.7–71.3 (according to the regulatory documentation of the Russian Federation).

Table 3. The results of the study of the fat component of protein bars for sports nutrition and ω–3, ω–6, ω–9 capsules

Sample name	Acid number, mmol kg^{-1}	Peroxide value, mEq0 kg^{-1}	Mass fraction of oxidation products in-	The content of epoxides,
'ProteinBar'	33.9	0.9	0.4	47.6
'Bombbar'	30.3	2.0	0.3	13.6
Capsules ω–3, ω–6, ω–9 'Sportline'	7.1	4.1	1.1	8.5
Capsules ω– 3–6–9 'Maxler'	30.3	4.0	1.0	9.6
'Multipower' Capsules	33.9	4.8	0.7	9.8

The peroxide value in the fat component in the product indicates the presence of peroxides, the primary oxidation products. Peroxides are toxic to the body and therefore are standardized by TR TS 021/2011 and TR TS 024/2011 on safety. Peroxides, when ingested in large quantities, cause necrosis of the cells of the gastrointestinal tract, the development of cancer cells. The peroxide value, mEq0 kg^{-1}: permissible level – no more than 10.0.

The content of copolymers insoluble in petroleum ether (CIPE,%): acceptable level is not more than 1.0 (Onishchenko, 2001). This indicator does not exceed the norm, but these values correspond to frying fats subjected to repeated thermal effects; for native fats, this indicator is not standardized.

The content of epoxides, mmol kg^{-1}: the permissible level is not more than 60–65 mmol kg^{-1} (Rogozin et al., 2018). The amount of epoxides in the fat component of the Bombbar bar is 13.6 mmol kg^{-1}, which corresponds to the acceptable level of food safety. The amount of epoxides in the fat component of the 'ProteinBar' bar is 47.6 mmol kg^{-1}.

Specified parameters for the fat component of ù–3, ù–6, ù–9 capsules for sports nutrition have indicators that do not exceed the regulated norm.

The mass fraction of oxidation products in the fat component 'Maxler' products reached the maximum permissible value, while 'Sportline' products exceeded the indicators by 0.1%. 'Multipower' capsules, all the studied parameters, excluding mass fraction of oxidation products, are normal. Thus, despite the encapsulated form, the fat component is susceptible to oxidation. Given the fact that athletes of many sports (Ronald, 2013; Kashapov & Kashapov, 2019) consume sports nutrition products daily, there is a need for further refinement studies of the safety of the lipid fraction.

Discussion &Conclusion. In scientific periodicals, there are no works describing the study of the safety of the fat component in the composition of products for sports nutrition, but there is a significant number of works concerning the safety of fats in general.

The amount of 'ProteinBar' bar epoxides is 47.6 mmol kg^{-1}. The number of epoxides is not standardized in any of the normative and technical documents, but scientific studies have proved that these products are toxic.

Researchers from different countries have confirmed the toxic effect of epoxides on various body systems. For many of them, toxicological studies have shown cyto– and genotoxicity, carcinogenicity and mutagenicity, this may become a precursor of leukotoxins, which can cause leukocyte degeneration and necrosis, disrupt the endocrine system, block the estrous cycle in rats, and stimulate the proliferation of human breast cancer cells (Greene et al., 2000; Gulyaeva et al., 2000). Epoxidation serves as the activation of many known chemical carcinogens; chemical carcinogenesis is a multi–stage process, which includes initiation, promotion and progression (Makarenko et al., 2018). Epoxides trigger initiation – the first critical and irreversible step in carcinogenesis, requiring covalent binding of the carcinogen to DNA. They are inserted into the nucleotide and change the body's genome, that is, they are mutagenic products (Gulyaeva et al., 2000).

One of the secondary products formed during the oxidation of oils and fats is polyoxyacids. The quantitative content of these compounds is defined as the total content of oxidation products insoluble in petroleum ether. According to literature data, a close correlation between the content of fat breakdown products insoluble in petroleum ether and the effect of oxidized fats on the body is known (Simakova et al, 2015). Negative effects on blood and biochemical parameters of fat metabolism were recorded in experiments on animals (Simakova et al., 2014). Oxidation products insoluble in petroleum ether have a proven toxic effect and have a carcinogenic and carcinogenic effect (Goicoechea &Guillen, 2010). Our experimental data obtained in the study of some indicators of the safety of the fat component of the selected sports nutrition products are highly correlated with the experimental data on the study of fat safety described in the literature.

In our opinion, the studies shave shown the need for further study of the safety indicators of the fat component in sports nutrition products during storage. The data obtained indicate the need for a critical assessment of production technology, products for sports nutrition, as well as the feasibility of amending the regulatory documentation in order to further control the safety of the fat component.