

The effect of fatty acids on athletes' health

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Abstract. *The development of products with resource-saving technologies, increased nutritional value, expanded range and balanced composition remains relevant. In this research, the chemical composition of red sauce with rapeseed cake of different weights was studied for the presence of fatty acids and the energy value of the product. The effectiveness of a herbal supplement as a source of saturated and unsaturated fatty acids, body energy, and bone density was estimated. The research was conducted in accordance with Regulation (EU) 1169/2011. Fatty acids were detected in different samples - control, with 2.5% (P1), 5% (P2), 7% (P3) of rapeseed cake. It was found that 5% of rapeseed cake in the red sauce provided an optimal increase in unsaturated fatty acids. Such composition helps to reduce the deficiency of unsaturated fatty acids, supply the body with energy, and increase bone density. According to the results obtained, when adding rapeseed cake in a volume of 5%, the energy value decreases, which allows to include the red sauce in a daily diet without threatening to increase the daily energy consumption of adolescents. Data on the chemical composition of rapeseed meal provide an opportunity for its further use in the production of healthy foods.*

Keywords: *rapeseed cake, saturated and unsaturated fatty acids, red sauce*

I. INTRODUCTION

A promising direction in the food industry is the development of products with the use of resource-saving technologies, with increased nutritional value, expanded range and balanced composition. To date, it has been established that in a moderate amount of about 15 grams per day, fatty acids do not pose a threat to health, but rather positively affect internal organs: they participate in the body's thermoregulation, improve skin and hair [2].

There are three main categories of fatty acids:

- Saturated Fatty Acids
- Monounsaturated fatty acids (olive oil).
- Polyunsaturated fatty acids: this group includes omega-6 (borage oil or evening primrose oil), omega-3 (fish oil), and conjugated linoleic acid is likely to be added to this group [1, 4].

The third group of fatty acids is considered vital for health, because the human body does not produce them. Therefore, they are called essential [1,4] Saturated fatty acids are fatty acids whose molecules are saturated with hydrogen. They enter the body with dairy and meat products, butter, eggs. Saturated fats have a solid consistency due to elongated chains along a straight line and tight fit to each other. Because of this structure, the melting point of triglycerides rises. Saturated fats participate in the building of cells and supply the body with energy. Saturated fats in a small

amount (15 grams per day) are needed by the body. If a person ceases to consume them, the cells begin to synthesize them from other foods, but this is an extra load on the internal organs [4].

Unsaturated fatty acids are essential fats that enter the human body with plant foods (nuts, corn, olive, sunflower, linseed oil). These include oleic, arachidonic, linoleic and linolenic acid. Unlike saturated triglycerides, unsaturated ones have a "liquid" consistency and do not freeze in the refrigerator. Monounsaturated (Omega-9) and polyunsaturated compounds (Omega-3, Omega-6) are distinguished depending on the number of bonds between carbohydrate atoms. This category of triglycerides improves protein synthesis, cell membranes, and insulin sensitivity. Moreover, it removes bad cholesterol, protects the heart and blood vessels from fatty plaques, and increases the number of good lipids. The human body does not produce unsaturated fats, so they should be regularly supplied with food [4].

Properties of saturated fatty acids:

- supply the body with energy;
- participate in tissue regulation, hormone synthesis, testosterone production in men;
- form cell membranes;
- provide absorption of microelements and vitamins A, D, E, K;
- normalize the menstrual cycle in women;
- improve reproductive function;
- create a fat layer that protects the internal organs;
- regulate processes in the nervous system;
- participate in the production of estrogen in women;
- protect the body from hypothermia [1].

The purpose of this study is to determine nutrition data per 100 g in accordance with Regulation (EU) 1169/2011, by examining the chemical composition of red sauce with rapeseed cake of different weights for the presence of fatty acids. The study is also aimed at evaluating the effectiveness of herbal supplements as a source of saturated and unsaturated fatty acids, body energy, and bone density [6, 7].

II. MATERIALS AND METHODS

Research was conducted at the University of Chemistry and Technology in Prague.

Fat was first converted to volatile methyl esters by transesterification. The samples thus obtained were analyzed by gas chromatography. The fatty acid content was estimated as a percentage of the peak area of the fatty acid methyl ester in the chromatogram to the total area of all methyl esters. The measurement accuracy for individual fatty acids was

determined as an estimate of the relative standard deviation of the analysis results (RSD = 0.2-5.0%) [8, 9, 10].

The study involved 95 athletes aged from 12 to 15 years, male and female, involved in athletics and characterized by a lack of body energy, unsaturated fatty acids, and bone density.

III. RESULTS AND DISCUSSION

To maintain good health, nutritionists recommend including foods containing saturated fats in the daily menu. They should account for up to 10% of calories from the total daily consumption, which is equal 15 - 20 grams per day [12].

Insufficient intake of saturated fatty acids is manifested by the following symptoms:

- reduced body weight;
- disturbance of the nervous system;
- decreased labor productivity;
- hormonal imbalance;
- deteriorated condition of nails, hair, skin;
- infertility [12].

For fast digestion, it is recommended to use fats with herbs and vegetables [1].

In the food industry, fats are used as food additives under the E570 index. Saturated fatty acids act as a glazing agent, defoamer, emulsifier, foam stabilizer [3].

Lauric and myristic acids exhibit fungicidal, virucidal, and bactericidal activity, inhibiting the growth of yeast and pathogenic microflora. Fatty acids can enhance the antibacterial effect of antibiotics in the intestine, which increases the effectiveness of the treatment of viral and bacterial acute intestinal infections. Presumably, caprylic acid maintains a normal microorganism balance in the genitourinary system. However, these properties are not used in drugs. When lauric and myristic acids interact with bacterial and viral antigens, fatty acids act as immunological stimulants, helping to increase the body's immune response to the intestinal pathogen. Despite this, fatty acids are part of drugs [3, 13].

Fatty acids have many useful properties: they contribute to cell development and the formation of healthy cell membranes [16].

It is proved that fatty acids prevent the development of tumors in animals, and can also block the growth of breast cancer cells, help in the development and functioning of the brain and nervous system, regulate the thyroid gland and adrenal glands, play an important role in blood thinning, and prevent blood clots, which lead to heart attacks and strokes [18].

Fatty acids have anti-inflammatory properties, and can alleviate the symptoms of arthritis, regulate blood pressure, liver functions, the immune system, and help break down cholesterol [19].

There are many sources of essential fatty acids that can be added to a diet to get the right nutrients [3].

The essential omega-3 acids can be found in:

- nuts;
- soy;
- walnut oil;
- rapeseed oil;
- linseed oil;
- oily fish: salmon, herring, cod, flounder, tuna, shrimp [10].

Omega-6 should be consumed 2-4 times more than omega-3. The diet of the average person in this regard is not

quite balanced, the consumption of omega-6 is 14-25 times higher than the consumption of omega-3 due to the large amount of meat in the diet [10].

Omega-3 is extremely important for the development and balanced growth of children and adolescents. Omega-3 is essential for strengthening immunity; reducing the risk of allergies; mental development; anti-inflammatory activity; improving eye function; preventing dry skin; cleansing blood from harmful fats; normalization of the heart and blood vessels; improvement of the mental state (aggression and excessive excitability are eliminated; increased attention span); tooth development; preventing acne and other skin diseases in adolescents [11].

In adults, Omega-3 is involved in the production of eicosanoids - biologically important substances that take part in many processes in the body. If their number decreases, a disease can develop. Omega-3 reduces the risk of cancer, improves memory, increases concentration and bone density, prevents osteoporosis, eliminates chronic fatigue and emotional disorders, reduces the risk of blood clots, prevents diseases of the cardiovascular system. Possessing antioxidant properties, Omega-3 inhibits skin aging and maintains its elasticity, strengthens nails and hair, improves the stamina of the body [17].

For athletes, Omega-3 is an effective source of energy and good mood. When eating foods that contain Omega-3, the recovery time after training is shortened, and pain is reduced. Omega-3 reduces appetite, quickly eliminates the symptoms of chronic fatigue, and increases the production of testosterone, which is especially important for athletes [5, 12].

In sports, Omega-3 is needed, since the main purpose of polyunsaturated fatty acids is to accelerate the metabolism. Omega-3 acids are involved in the formation of cell membranes. Thanks to Omega-3, an uninterrupted supply of nutrients to the tissue occurs. The growth and speed of cell division are significantly increased, which are the main factors in the renewal of bone, muscle, and joint structures. With intense physical exertion, the optimization of metabolism helps to avoid injuries from falls or strong shocks and promotes rapid regeneration. Omega-3 acids are responsible for the transfer of cholesterol to target organs being the part of low-density lipoprotein complexes. Such conglomerates do not stay in the blood vessels and are quickly excreted from the body. This allows minimizing the content of high density lipids in the veins, arteries and capillaries, to dissolve and remove cholesterol blocks from them. At the same time, according to the principle of substitution in the large and small vessels, the concentration of useful triglycerides significantly increases. Triglycerides are essential for people with serious physical exertion as they are responsible for the following: expansion of arteries and veins, normalization of blood circulation; prevention of a sharp rise in blood pressure; provision of cells and tissues with molecular oxygen. To achieve good results, athletes must additionally receive Omega-6 and Omega-3 [5, 10].

If a sufficient amount of Omega-3 enters the body along with food, the absorption of carbohydrates gradually slows down. This feature of the absorption of substances helps to reduce weight and appetite. Polyunsaturated fatty acids are involved in the synthesis of hormone-like compounds - prostaglandins. Prostaglandins regulate human life processes: they support optimal blood coagulation, prevent

the excessive formation of blood clots in small and large blood vessels; provide innervation; transmit impulses from skeletal muscles to the central nervous system; increase the functional activity of liver cells (hepatocytes); restore the urinary system; contribute to proper digestion and peristalsis [5, 14].

The purpose of this study is to enrich the sauce by adding a dietary supplement of plant origin, which increases the nutritional value of the product, affects the structure of cells, supplies the body with energy, and increases the density of bone tissue. The food supplement is rapeseed cake.

In this work, the rape variety Olga was used to obtain rape cake.

TABLE I ORGANOLEPTIC, PHYSICAL AND CHEMICAL PROPERTIES OF RAPE CAKE

Parameter	Description	Test methods
Color	Gray to light brown	GOST 13979.4
Smell	Characteristic of rape cake without foreign smell	GOST 13979.4
Metal foreign matter, mg per 1 kg	None	GOST 13979.5
Other foreign matters	None	GOST 10854-2015

TABLE II ORGANOLEPTIC PROPERTIES OF MODEL SAMPLES OF SAUCES WITH FOOD ADDITIVE OF VEGETABLE ORIGIN

Parameter	Description of sauce	
	Control sample	Sample P2 (5%)
<i>Shelf life at 5 ° C for 48 hours</i>		
Color	Homogeneous, caramel	Homogeneous, light brown
Flavor	Balanced, rich, pleasant	Balanced, pleasant
Smell	Balanced, vegetable, with a plant component	Balanced, vegetable
Consistency	Homogeneous, moderately thick, fluid	

Using degustation, it was found that the red sauce obtained in sample P2 (5%) is more pleasant in terms of flavor and smell and practically does not differ from the control sample [15].

Table 3 shows the chemical composition of rape cake.

TABLE III CHEMICAL COMPOSITION OF RAPE CAKE

Parameter	Weight, g per 100 g of edible portion
Humidity	8.83±2.5
Protein	38.87±0.2
Fat	7.45±0.03
Hemicellulose	12.6±0.1
Cellulose	13.7±0.1
Starch	1.65±0.3
Ash	6.6±0.10.2

It was found that with rape cake in a volume of 5%, an increase in unsaturated fatty acids occurs. This helps to reduce the deficiency of unsaturated fatty acids [15].

The research was conducted in accordance with Regulation (EU) 1169/2011. Fatty acids were detected in different samples (Tables 4-7).

TABLE IV FATTY ACIDS IN THE CONTROL SAMPLE (%) PER 100 G.

	Saturated FA	Parameter	(%)
1	Caprylic acid	C 10:0	0.07
2	Lauric acid	C 12:0	0.08
3	Myristic acid	C 14:0	0.71
4	Pentadecyl acid	C 15:0	0.06
5	Palmitic acid	C 16:0	25.95
6	Margaric acid	C 17:0	0.13
7	Stearic acid	C 18:0	7.74
8	Arachic acid	C 20:0	0.63
9	Behenic Acid	C 22:0	1.63
	Unsaturated FA		
10	Hexadecanoic acid	C 16:1 Δ7c	0.05
11	Palmitoleic acid	C 16:1 Δ9c	0.31
12	Octadecanoic acid	C 18:1 Trans fats	0.05
13	Oleic acid	C 18:1 Δ9c	32.36
14	Octadecanoic acid	C 18:2 Cis-trans isomers	0.48
15	Linoleic acid	C 18:2 Δ9c,12c (n-6)	28.39
16	Octadecatrienic Acid	C 18:3 Cis-trans isomers	0.00
17	Alpha linolenic acid	C 18:3 Δ9c,12c,15c (n-3)	0.10
18	Eicosenoic acid	C 20:1 Δ11c	0.19

TABLE V FATTY ACIDS IN P1 SAMPLE (%) PER 100 G.

	Saturated FA	Parameter	(%)
1	Caprylic acid	C 10:0	0.05
2	Lauric acid	C 12:0	0.04
3	Myristic acid	C 14:0	0.44
4	Pentadecyl acid	C 15:0	0.04
5	Palmitic acid	C 16:0	18.63
6	Margaric acid	C 17:0	0.09
7	Stearic acid	C 18:0	6.23
8	Arachic acid	C 20:0	0.53
9	Behenic Acid	C 22:0	1.35
	Unsaturated FA		
10	Hexadecanoic acid	C 16:1 Δ7c	0.05
11	Palmitoleic acid	C 16:1 Δ9c	0.27
12	Octadecanoic acid	C 18:1 Trans fats	0.09
13	Oleic acid	C 18:1 Δ9c	34.93
14	Octadecanoic acid	C 18:2 Cis-trans isomers	0.34
15	Linoleic acid	C 18:2 Δ9c,12c (n-6)	35.98
16	Octadecatrienic Acid	C 18:3 Cis-trans isomers	0.00
17	Alpha linolenic acid	C 18:3 Δ9c,12c,15c (n-3)	0.11
18	Eicosenoic acid	C 20:1 Δ11c	0.21

TABLE VI FATTY ACIDS IN P2 SAMPLE (%) PER 100 G.

	Saturated FA	Parameter	(%)
1	Caprylic acid	C 10:0	0.07
2	Lauric acid	C 12:0	0.06
3	Myristic acid	C 14:0	0.73
4	Pentadecyl acid	C 15:0	0.06
5	Palmitic acid	C 16:0	16.37
6	Margaric acid	C 17:0	0.11
7	Stearic acid	C 18:0	6.36
8	Arachic acid	C 20:0	0.51
9	Behenic Acid	C 22:0	1.42
	Unsaturated FA		
10	Hexadecanoic acid	C 16:1 Δ7c	0.06
11	Palmitoleic acid	C 16:1 Δ9c	0.25
12	Octadecanoic acid	C 18:1 Trans fats	0.07
13	Oleic acid	C 18:1 Δ9c	32.58
14	Octadecanoic acid	C 18:2 Cis-trans isomers	0.46
15	Linoleic acid	C 18:2 Δ9c,12c (n-6)	39.77

16	Octadecatrienic Acid	C 18:3 Cis-trans isomers	0.00
17	Alpha linolenic acid	C 18:3 Δ9c,12c,15c (n-3)	0.11
18	Eicosenoic acid	C 20:1 Δ11c	0.20

TABLE VII FATTY ACIDS IN P3 SAMPLE (%) PER 100 G.

	Saturated FA	Parameter	(%)
1	Caprylic acid	C 10:0	0.03
2	Lauric acid	C 12:0	0.03
3	Myristic acid	C 14:0	0.48
4	Pentadecyl acid	C 15:0	0.04
5	Palmitic acid	C 16:0	14.98
6	Margaric acid	C 17:0	0.09
7	Stearic acid	C 18:0	6.83
8	Arachic acid	C 20:0	0.57
9	Behenic Acid	C 22:0	1.61
	Unsaturated FA		
10	Hexadecanoic acid	C 16:1 Δ7c	0.04
11	Palmitoleic acid	C 16:1 Δ9c	0.20
12	Octadecanoic acid	C 18:1 Trans fats	0.08
13	Oleic acid	C 18:1 Δ9c	37.24
14	Octadecanoic acid	C 18:2 Cis-trans isomers	0.33
15	Linoleic acid	C 18:2 Δ9c,12c (n-6)	36.36
16	Octadecatrienic Acid	C 18:3 Cis-trans isomers	0.00
17	Alpha linolenic acid	C 18:3 Δ9c,12c,15c (n-3)	0.13
18	Eicosenoic acid	C 20:1 Δ11c	0.29

TABLE VIII FATTY ACIDS IN DIFFERENT SAMPLES (CONTROL, P1, P2) (%) PER 100 G.

	Fatty acids	Parameter (%)	Parameter (%)		
			C	P1	P2
1	Saturated FA	Σ saturated fatty acids	37.01	27.41	25.70
2	Monoene FA	Σ monounsaturated fatty acids	34.02	36.07	33.89
3	Polyene FA	Σ polyunsaturated fatty acids	28.49	36.09	39.88
4	FA transisomers	Σ trans isomers	0.53	0.43	0.53
5	Omega-6 FA	Σ Omega-6	28.39	35.98	39.77
6	Omega-3 FA	Σ Omega-3	0.10	0.11	0.11

Table 8 shows that the indicators of saturated fatty acids, in the sample with rape cake in the amount of 5% (P2), increase compared to the control sample, which indicates the necessity of using this additive as an optimal supplement [15].

TABLE XI FAT CONTENT IN THE SAMPLES PER 100 G.

	Sample	Fat (g/100 g)
1	Control	1.4
2	P1(2.5%)	0.6
3	P2(5%)	1.1
4	P3(7%)	2.0

Table 9 shows that the fat content is different in the samples. The optimal amount of rape cake in the sample is 5%.

TABLE X ENERGY VALUE OF THE SAMPLES PER 100 G.

	Sample	Energy value (kcal/100 g)
1	Control	60
2	P1(2.5%)	69
3	P2(5%)	54
4	P3(7%)	55

The data in Table 10 show that when adding rape cake in a volume of 5%, the energy value decreases, which allows to use red sauce as an additive to the daily diet without threatening to increase the daily consumption of adolescents.

When organizing the nutrition of young athletes, the main attention should be paid to the following:

- Daily calorie consumption should correspond to the energy consumption of the child;
- Daily requirement for nutrients of athletes (gymnastics, figure skating, fencing, table tennis, sledding, ski jumping, shooting, acrobatics, equestrian sports, synchronized swimming, freestyle): (Table XI) [5].

TABLE XI DAILY NEED FOR NUTRIENTS IN TEENAGERS INVOLVED IN SPORTS, 100 GR

Age, years	Gender	Energy value, kcal	Fats, g.	
			animal	general
12-13	M	3100	65	90
	F	2700	60	80
14-16	M	3650	80	105
	F	3100	65	90

Daily requirement for nutrients of adolescents involved in volleyball, basketball, hockey, football, tennis, boxing, swimming, skiing, athletics, wrestling, taekwondo, weightlifting: (Table XII) [5].

TABLE XII DAILY NEED FOR NUTRIENTS IN TEENAGERS INVOLVED IN CERTAIN SPORTS, 100 GR

Age, years	Gender	Energy value, kcal	Fats, g.	
			animal	general
12-13	M	3610	80	110
	F	3350	75	100
14-16	M	3930	85	126
	F	3310	69	110

The low fat content in the diet will lead to fatigue in training.

The data show that when rape cake is added to the red sauce, the content of saturated and unsaturated fatty acids increases. The use of red sauce helps to reduce the deficiency of unsaturated fatty acids [5].

CONCLUSION

Data on the chemical composition of rape cake make it possible to use it in food for athletes. Fatty acids have many useful properties: they contribute to cell development and the formation of healthy cell membranes [16].

When lauric and myristic acids interact with bacterial and viral antigens, fatty acids act as immunological stimulants, helping to increase the body's immune response to the intestinal pathogen.

Fatty acids have anti-inflammatory properties, and can alleviate the symptoms of arthritis, regulate blood pressure, liver functions, the immune system, and help break down cholesterol [19].

A series of quality assessments of red sauce with a herbal supplement were carried out.

Using degustation, it was found that the red sauce obtained in sample P2 (5%) is more pleasant in flavour and smell and practically does not differ from the control sample. It was also found that 5% of rape cake in the red sauce contributed to an increase in unsaturated fatty acids and helped to reduce the deficiency of unsaturated fatty acids.

Fatty acids were detected in different samples. The data obtained show that the indicators of saturated fatty acids in P2 sample increase compared to the control sample, which indicates the necessity to use this additive as an optimal supplement. The data also show that the fat content is different in the samples and the optimum rape cake content is 5%. When adding 5% of rape cake, the energy value decreases, which allows using the red sauce as an additive to the daily diet without threatening to increase the daily consumption of adolescents.

A significant indicator is that the use of red basic sauce helps to reduce the deficiency of unsaturated fatty acids [5].

CONFLICT OF INTERESTS: authors declare no conflict of interest.

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