PharmacologyOnLine

Archives • 2021 • vol.2 • 361-365

INFLUENCE OF FAT-FREE, FAT AND SUCROSE DIETS ON THE INDICATORS OF LIPID METABOLISM IN RATS

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Abstract

The aim. To determine the effect on lipid metabolism in the serum of rats of diets: fat-free, fat and sucrose.

Materials and methods. Feeding experiments were carried out on rats divided into 3 groups: the first received a fat-free diet (FFD), the second received a diet with 5 % sunflower oil and the third received a diet with 50 % sucrose. The condition of lipid metabolism was assessed according to the following indicators of blood serum: the content of triglycerides (TG), cholesterol, MDA, fatty acid composition of neutral lipids (TG + cholesterol esters) and phospholipids. The duration of feeding was 30 days.

Results. An increase in TG levels in rats fed with oil or sucrose and a decrease in MDA levels in rats fed a sucrose diet was found. The greatest gain in live weight was found in rats fed a fat diet. The presence of all essential fatty acids in the blood serum lipids of rats receiving FFD and a sucrose diet was found, and the content of ω-3 PUFAs was the highest in rats treated with FFD.

Conclusions. Rats have endogenous sources of PUFA, including the ω-3 series. Consumption of sunflower oil inhibits the formation of ω-3 PUFAs and increases the ω-6/ω-3 PUFA ratio by 2.5-4 times. Consumption of sucrose increases the formation of oleic acid and decreases lipid peroxidation.

Keywords: *lipid metabolism, ω-6 and ω-3 PUFA, fat nutrition, sucrose, blood serum*

Introduction

Disorders of lipid metabolism underlie the pathogenesis of a significant number of human diseases [1, 2]. The most important cause of these disorders is inadequate fat nutrition [3]. However, there is an idea of a role in the violation of lipid metabolism of excessive sugar consumption [1].

The aim of this work was to determine the impact on the condition of lipid metabolism of diets with different fat and sugar content, namely fat-free diet, fat diet and diet high in sugar

Methods

The experiments were performed on 18 white Wistar rats (males, 5 months, live weight 223-238 g), divided into 3 groups: 1st received a fat-free diet (FFD), the composition of which is presented in table 1, 2nd group received fatty diet containing 5 % sunflower oil and the 3rd group received a diet containing 50% sucrose.

The duration of feeding was 30 days, after which the rats were euthanized under thiopental anesthesia (20 mg/kg) by total bleeding from the heart and received blood serum, which was determined by enzymatic methods of triglycerides [5] and total cholesterol [5], as well as the content the final product of lipid peroxidation of malonic dialdehyde (MDA) [4].

Lipids were extracted from the combined blood sera of rats of each group [6] and divided into two fractions: neutral lipids (triglycerides + cholesterol esters) and the phospholipid fraction [7]. The fatty acid composition of these fractions was determined by gas chromatographic method [8, 9].

The ratio of ω-6/ω-3 PUFA was calculated by the ratio of ω-6 PUFA (linoleic + arachidonic acid) and ω-3 PUFA (α-linolenic + eicosapentaenoic + docosapentaenoic + docosahexaenoic acid).

Results

Table 2 presents the results of determining the content in the serum of rats of triglycerides, cholesterol and MDA. It is seen that rats fed a fatty or sucrose diet have a significant increase in triglycerides, but cholesterol remains stable. Consumption of sucrose diet significantly reduces the content of MDA in the serum, which indicates the inhibition of the process of lipid peroxidation.

However, the increase in live weight of rats is significantly greater in those animals that received a fat diet.

Table 3 presents the results of determining the fatty acid composition of neutral serum lipids. It is seen that even on FFD in rats all PUFAs are present.

Consumption of sunflower oil reduces the content of palmitic, palmitoleic and oleic acids, but significantly increases the content of linoleic acid (due to the high content of this acid in sunflower oil).

In rats fed a sucrose diet, neutral lipids contained the most oleic acid and very little linoleic acid.

Table 4 presents the results of determining the fatty acid composition of serum phospholipids. It is seen that this fraction of lipids contains a lot of stearic acid (almost 10 times more than the fraction of neutral lipids), as well as much more (3 times) arachidonic acid and docosahexaenoic (3-4 times). But most of all in the serum phospholipids of rats that received FFD, contains eicosapentaenoic acid (50 times more than in rats that received a fatty diet).

Table 5 presents the results of determining the content of ω-6 and ω-3 PUFA in both fractions of serum lipids. As can be seen from these data, phospholipids contain more PUFA (due to long-chain fatty acids) than the fraction of neutral lipids. The phospholipid fraction is 3.7 times more than ω-3 PUFA, so the ratio of ω-6/ω-3 PUFA is 2.7 times less.

In rats fed a fat diet, the content of PUFA was significantly increased due to ω-6 acids in both lipid fractions.

Consumption of sucrose diet increases the content of PUFA in phospholipids, but reduces their content in neutral lipids.

The ratio of ω-6/ω-3 PUFA was the same in both fractions of serum lipids of rats receiving a sucrose diet.

Thus, our studies have shown that rats have endogenous sources of essential fatty acids, because the complete absence of fats in the diet not only does not reduce their content, but, conversely, significantly increases. Possible sources of PUFA may be recycling of PUFA and biosynthesis by endogenous microbiota.

It was found that the largest amount of ω-3 PUFA is in phospholipids and their endogenous synthesis is inhibited by fat intake.

Conclusions

1. In rats, there are endogenous sources of essential PUFA.
2. The largest amount of ω-3 PUFA is found in phospholipids.
3. Consumption of sunflower oil inhibits the endogenous formation of ω-3 PUFA.
4. Consumption of sucrose stimulates the formation of oleic acid and reduces the level of lipid peroxidation.

Acknowledgments

The authors declare that there are no conflicts of interest.

References

1. Tutelian, V.A., Nikitiuk, D.B., Baturin, A.K. (et al.). Nutriom as the direction of the "main blow": determination of physiological needs for macro- and micronutrients, minor biologically active substances of food. Nutrition issues. 2020; vol. 89, № 4; 24-34 (in Russian) DOI: https://doi.org/10.24411/0042-8833-2020-10039
2. Sharafetdinov, Kh.Kh., Plotnikova, O.A. Obesity as a Global Challenge of the 21st Century: Nutritional Care, Prevention and Therapy. Nutrition issues. 2020; vol. 89, № 4; 161-171 (in Russian) DOI: https://doi.org/10.24411/0042-8833-2020-10050
3. Levitsky, A.P., Egorov, B.V., Lapinskaya, A.P. (et al.). Inadequate fat diet. Journal of Education, Health and Sport. 2020; vol.10, № 7; 248-255. DOI http://dx.doi.org/10.12775/JEHS.2020.10.07.029
4. Levitsky, A.P., Makarenko, O.A., Demyanenko, S.A. Methods of experimental dentistry (teaching aid). Simferopol: Tarpan, 2018; 78 (in Russian)
5. Tets, N.U. The encyclopedia of clinical laboratory tests. Moskva: Labinform, 1997: 128, 459-460 (in Russian)
6. Keyts, M. Metods of lipidology. Recciving, analise and identification of lipids. Moskva: Mir, 1975: 334 (in Russian)
7. Khodakov, I.V., Tkachuk, V.V., Velichko, V.I. (et al.). The fatty acids composition of liver lipids of rats which received the palm oil and lincomycin. Marine Medicine Bulletin. 2017; vol. 1, № 74: 145-152 (in Russian)
8. Levitsky, A.P., Makarenko, O.A., Khodakov, I.V. Methods to investigate fats and oils. Odessa: KP OGT; 2015; 32 (in Russian)
9. Levitsky A. P., Egorov B. V., Gozhenko A. I., Badiuk N.S., Selivanskaya I. A., Lapinskaya A. P. Influence of high-fat nutrition with different fat-acid composition of fats on lipid peroxidation processes in rat's organs and tissues / PharmacologyOnLine; Archives - 2021 - vol.1 - 37-46.

Table 1. The composition of rations for rats (%) [4]

Components	FFD	Fat diet	Sucrose diet
Maize starch	65	60	19
Soybean meal is defatted	20	20	20
Ovalbumin	6	6	6
Sucrose	4	4	50
Sunflower oil	0	5	0
Mineral mixture	4	4	4
Vitamin mixture	1	1	1

Note: FFD is a fat-free diet

Table 2. Indicators of lipid metabolism in the serum of rats receiving fatty and sucrose diets

Indicators	FFD	Fat diet	Sucrose diet
Triglycerides, mmol/l	1,03±0,08	1,44±0,12 p<0,05	1,43±0,15 p<0,05 p_1>0,9
Cholesterol, mmol/l	1,59±0,10	1,56±0,11 p>0,8	1,59±0,08 p=1,0 p_1>0,5
MDA, mmol/l	0,89±0,05	0,88±0,04 p>0,8	0,77±0,02 p<0,05 p_1<0,05
Live weight gain, %	33,9±1,5	43,0±0,7 p<0,01	32,1±2,8 p>0,3 p_1<0,01

Note: p – in comparison with the group "FFD"; p1 - in comparison with the group "Fat diet"

Table 3. Fatty acid composition of neutral lipids (triglycerides + cholesterol esters) in the serum of rats treated with fatty or sucrose diets (%)

Fatty acids	FFD	Fat diet	Sucrose diet
Myristic $C_{14:0}$)	1,44	1,15	1,29
Palmitic ($C_{16:0}$)	26,13	19,30	25,39
Palmitoleic ($C_{16:1}$)	10,81	7,03	10,88
Stearic ($C_{18:0}$)	1,97	1,56	1,94
Oleic ($C_{18:1}$)	37,93	31,76	45,20
Linoleic ($C_{18:2}$)	12,84	27,25	7,43
α-linolenic ($C_{18:3}$)	0,36	0,26	0,11
Arachidonic ($C_{20:4}$)	2,36	4,65	2,03
Eicosapentaenoic ($C_{20:5}$)	0,10	0,02	0,10
Docosapentanoic ($C_{22:5}$)	0,10	0,25	0,13
Docosahexaenoic ($C_{22:6}$)	0,22	0,15	0,30

Table 4. Fatty acid composition of serum phospholipids of rats receiving fatty or sucrose diets (%)

Fatty acids	FFD	Fat diet	Sucrose diet
Lauric ($C_{12:0}$)	0,14	0,32	0,11
Myristic $C_{14:0}$)	0,72	0,53	0,72
Palmitic ($C_{16:0}$)	20,02	25,87	22,84
Palmitoleic ($C_{16:1}$)	3,41	2,16	3,33
Stearic ($C_{18:0}$)	21,19	18,99	17,90
Oleic ($C_{18:1}$)	18,04	17,28	23,16
Linoleic ($C_{18:2}$)	12,72	20,05	17,35
α-linolenic ($C_{18:3}$)	0,22	0,53	0,10
Arachidonic ($C_{20:4}$)	8,04	7,28	6,14
Eicosapentaenoic ($C_{20:5}$)	1,03	0,02	0,07
Docosapentanoic ($C_{22:5}$)	0,25	0,09	0,24
Docosahexaenoic ($C_{22:6}$)	1,61	0,36	1,18

Table 5. Indicators of PUFA content in the serum lipids of rats receiving fatty or sucrose diets

Indicators	FFD	Fat diet	Sucrose diet
Neutral lipids			
PUFA content, %	15,28	32,58	10,10
including ω-6 PUFA, %	15,20	31,90	9,46
including ω-3 PUFA, %	0,78	0,68	0,64
ω-6/ω-3 PUFA	19,48	46,91	14,78
Long-chain PUFA (C_{20}+C_{22}), %	2,78	5,07	2,56
Phospholipids			
The content of PUFA, %	23,67	28,33	21,18
including ω-6 PUFA, %	20,76	27,33	23,49
including ω-3 PUFA, %	2,91	1,00	1,59
ω-6/ω-3 PUFA	7,13	27,33	14,77
Long-chain PUFA (C_{20}+C_{22}), %	10,93	7,75	7,63