UDC 612.397+577.16+613.2
DOI https://doi.org/10.15673

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HIGH OLEIC SUNFLOWER OIL DECREASES ENDOGENOUS BIOSYNTHESIS OF ENERGY FATTY ACIDS AND INCREASES ENDOGENOUS BIOSYNTHESIS OF ω-3 LONG-CHAIN PUFA

Abstract

The work shows that Fatty acids of dietary fats provide two main functions in the human and animal body: energy and structural-regulatory, Polyunsaturated fatty acids (PUFA) are the basis of membrane lipids of all cells of the body The structure and functional activity of cells, their resistance to pathogenic factors depends on the ratio of ω-6 / ω-3 PUFA. Adherence to recommended metabolic energy reserves in poultry feed is essential to optimize feed costs. The use of oils or fats is a common economic practice in modern poultry production. Energy functions are carried out due to the oxidation of energy fatty acids in mitochondria, which include, first of all, palmitic (C16:0), palmitooleic (C16:0), stearic (C18:1) and oleic (C18:1). In addition to providing energy, edible oil can also enhance dietary palatability, reduce dustiness, and increase lipoprotein hydrolysis to promote the production of essential fatty acids. Adipose tissue should be considered not only as a source of various fatty acids, but also as an important endocrine organ that takes an active part in the activity of the immune system. To determine the effect of a diet with high oleic sunflower oil on the content of energy fatty acids (EFA) and long-chain PUFA (LCPUFA) in rat liver lipids. We used high oleic sunflower oil (HOSO) containing 85.5% oleic acid. The rats were fed a fat-free diet (FFD) and diets with 5 or 15% HOSO for 35 days. Lipids were extracted from the liver and separated into three fractions: neutral lipids (NL), phospholipids (PL) and free fatty acids (FFA). The fatty acid composition of lipid fractions was determined by gas chromatography. FFA are the sum of the following acids:$C_{16:0}$, $C_{16:1}$, $C_{18:0}$, $C_{18:1}$and$C_{18:2}$. LCPUFA are presented $C_{20:4}$ ω-6, $C_{20:5}$ ω-3, $C_{22:5}$ ω-3and $C_{22:6}$ ω-3. Most of all, EFA is contained in the NL fraction (89%), then in the PL fraction (79%), and least of all in the FFA fraction (68%). LCPUFA is found most of all in the FFA fraction (20%), then in the PL fraction (13%), and least of all in the NL fraction (2%). In rats that received fat diets, the content of EFA increased in the NL fraction by 2-3%, in the FFA fraction by 5-8%, and did not change in the PL fraction. The content of LCPUFA ω-6 (arachidonic acid) with fat nutrition dose-dependently decreases in the fraction of NL and FFA and does not change in the fraction of PL. On the contrary, the content of ω-3 LCPUFA increases in rats treated with HOSO in all lipid fractions. Also, the ω-6/ω-3 LCPUFA ratio is significantly reduced in rats treated with HOSO. Consumption of HOSO stimulates endogenous biosynthesis of ω-3 LCPUFA.

Keywords: fat nutrition, oleic acid, liver lipids, long-chain PUFA, ω-6/ω-3 LCPUFA ratio.

Introduction

Fatty malnutrition is one of the most important causes of the development of mass noncommunicable diseases (atherosclerosis, myocardial dystrophy, type 2 diabetes mellitus, obesity). Among these disorders, so much excessive consumption of fat-containing products can have a significant place, but their non-optimal fatty acid composition (due to the large amount of palmitic, linoleic and trans fatty acids) and a significant deficiency of polyunsaturated fatty acids (PUFAs), especially ω-3 series. A deficiency of these PUFAs causes the development of vitamin F deficiency, the manifestations of which are a violation of neuropsychic activity, cardiovascular, immune, digestive and almost all of the body's defense systems [1, 2, 3].

A deficiency of essential PUFAs in human and animal food makes their continuous introduction into the body in the form of PUFA-containing preparations [4, 5].

Fatty acids of dietary fats provide two main functions in the human and animal body: energy and structural-regulatory. Adherence to recommended metabolic energy reserves in poultry feed is essential to optimize feed costs [6].

The use of oils or fats is a common economic practice in modern poultry production [7].

In addition to providing energy, edible oil can also enhance dietary palatability, reduce dustiness, and increase lipoprotein hydrolysis to promote the production of essential fatty acids [8, 9].

Energy functions are carried out due to the oxidation of energy fatty acids in mitochondria, which include, first of all, palmitic ($C_{16:0}$), palmitooleic ($C_{16:0}$), stearic ($C_{18:1}$) and oleic ($C_{18:1}$). The latter is formed most of all in the body and is oxidized in mitochondria more easily than all other fatty acids. In addition, linoleic acid is also referred to EFA. ($C_{18:2}$ ω-6) [8, 9].

The structural and regulatory function of fats is carried out due to long-chain polyunsaturated fatty acids (LCPUFA), which include arachidonic ($C_{20:4}$ ω-6), eicosapentaenoic ($C_{20:5}$ ω-3), docosapentaenoic ($C_{22:5}$ ω-3) and docosahexaenoic ($C_{22:6}$ ω-3). These acids are part of biomembrane phospholipids and are substrates for the formation of physiologically active regulators. The source of LCPUFA in food is milk, meat and, above all, fish from the northern latitudes [10].

Adipose tissue should be considered not only as a source of various fatty acids, but also as an important endocrine organ that takes an active part in the activity of the immune system [11].

Polyunsaturated fatty acids (PUFA) are the basis of membrane lipids of all cells of the body The structure and functional activity of cells, their resistance to pathogenic factors depends on the ratio of ω-6 / ω-3 PUFA [5].

In human and animal nutrition, fats are used that differ in their fatty acid composition. It has been established that olive oil containing up to 75% oleic acid has a positive effect on the body systems [12].

In recent decades, breeders have created high-oleic varieties of sunflower, in which the content of oleic acid exceeds 80%. It is shown that the consumption of high-oleic sunflower oil has a positive effect on the state of the animal organism [13].

The aim of our work was to determine the effect of a diet containing high oleic sunflower oil (HOSO) on the content of EFA and LCPUFA in rat liver lipids.

Materials and research methods

HOSO manufactured by LLC Biokhimtekh (Odessa, Ukraine) containing 85.5% oleic acid was used (Table 1). Cold pressed oil, unrefined.

Table 1 – Fatty acid composition of high oleic sunflower oil (HOSO)

Fatty acid	Short Formula	Content, % of the amount of fatty acids
Myristic	$C_{14:0}$	0,08
Palmitic	$C_{16:0}$	3,86
Palmitoleic	$C_{16:1}$	0,19
Stearic	$C_{18:0}$	2,72
Oleic	$C_{18:1}$	85,51
Linoleic	$C_{18:2}$ ω-6	6,51
Linolenic	$C_{18:3}$ ω-3	0,21
Arachinic	C20:0	0,26

Feeding experiments were carried out on Wistar white rats (males, 5-8 months old, live weight 220-280 g), divided into 3 equal groups of 6 animals each. Group I received a fat-free diet (FFD), the composition of which is shown in Table 2. Group II received a diet with 5% HOSO (instead of 5% starch) and Group III received a diet with 15% HOSO. The duration of feeding was 35 days.

After euthanasia of the animals under thiopental anesthesia, the liver was removed and lipids were extracted from it according to the Dole method [14]. Lipids were divided into 3 fractions: neutral lipids containing triglycerides + cholesterol esters (NL), phospholipids (PL), and free fatty acids (FFA) [15]. The fatty acid

Table 2 – Component composition of diets for rats

Components	FFD	Fat diets, %	
		5 % HOSO	15 % HOSO
Corn starch	64	59	49
Soybean meal defatted	20	20	20
Ovalbumin	6	6	6
Sucrose	5	5	5
Mineral Blend	4	4	4
Vitamin Blend	1	1	1
Oil HOSO	0	5	15

composition of lipid fractions was determined by gas chromatography [16]. The results of the studies are presented as average values for each lipid fraction obtained by combining extracts from each sample.

Results of the study and their discussion

Table 3 presents the results of the determination of EFA in liver lipids of rats treated with FFD and fat diets with 5% or 15% of HOSO. It can be seen that FFAs constitute the bulk of all fatty acids in the liver. In the NL fraction they contain on average 88-92%, in the PL fraction 74-79% and in the EFA fraction 68-76%. Surprisingly, the total content of EFA and the content of linoleic acid does not depend much on the intake with the feed of the HOSO. Rats treated with FFD have a very high content of such EFA as palmitic, palmitooleic, stearic, and oleic, which are synthesized in the liver under the action of the enzyme complex of fatty acid synthase, elongase, and stearyl-CoA desaturase [2].

Table 3 – Influence of consumption of diets with HOSO on the content of energy fatty acids (EFA) in rat liver lipids

№	Lipids fraction	Content of EFA, %		
		FFD	HOSO, 5 %	HOSO, 15 %
1	Neutral lipids (NL)			
	Total	88,19	91,95	91,54
	including $C_{18:1}$	38,17	54,10	61,22
	including$C_{18:2}$	7,31	11,27	8,86
	Other EFA	42,71	26,58	21,86
2	Phospholipids (PL)			
	Total	79,08	73,57	79,27
	including $C_{18:1}$	14,95	19,75	32,37
	including$C_{18:2}$	7,33	10,79	8,22
	Other EFA	56,80	43,03	38,68
3	FFA			
	Total	68,45	73,45	76,17
	including $C_{18:1}$	19,05	31,85	37,90
	including$C_{18:2}$	8,19	11,94	9,40
	Other EFA	41,21	29,66	28,87

Feeding with HOSO increases the content of oleic acid in lipids and reduces the content of such acids as $C_{16:0}$, $C_{16:1}$and $C_{18:0}$.

On fig. 1 shows the content of LCPUFA in the lipid fractions of the liver of rats treated with FFD and diets with HOSO. It can be seen that the greatest amount of these acids is contained in the FFA fraction, somewhat less in the PL fraction, and very little (no more than 2%) in the NL fraction. Fat diets had little effect on the content of LCPUFA in the fractions of NL and PL, however, they showed some tendency to decrease in the FFA fraction after consumption of a diet with 15% of the HOSO.

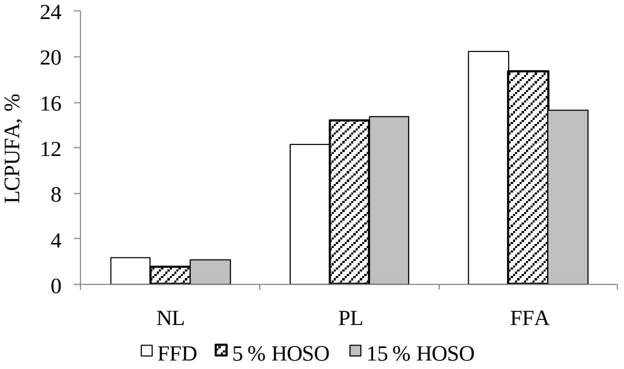

Fig. 1. Influence of consumption of HOSO on the content of LCPUFA in rat liver lipids (FFD – fat-free diet, HOSO – high oleic sunflower oil NL – neutral lipids; PL – phospholipids; FFA – free fatty acids

Table 4 presents the results of determining the level of individual LCPUFA in liver lipids. It can be seen that the content of arachidonic acid in the NL decreases with the consumption of HOSO, while the content of ω-3 LCPUFA, on the contrary, increases.

Table 4 – The content of LCPUFA in neutral lipids of the liver of rats fed diets with high oleic sunflower oil (HOSO)

Fatty acid	FFD	HOSO, 5 %	HOSO, 15 %
Arachidonic $C_{20:4}$ ω-6	1,77	1,32	0,99
Eicosapentaenoic $C_{20:5}$ ω-3	0,08	0,09	0,23
Docosapentaenoic $C_{22:5}$ ω-3	0,11	0,12	0,25
Docosahexaenoic $C_{22:6}$ ω-3	0,20	0,27	0,63

Table 5 presents the results of the determination of LCPUFA in the PL fraction of the liver. The content of arachidonic acid in the composition of liver PL changes little with the consumption of fatty diets, while the content of ω-3 LCPUFA increases significantly ($C_{22:6}$ ω-3).

Table 5 – LCPUFA content in liver phospholipids of rats fed diets with high oleic sunflower oil (HOSO *)*

Fatty acid	FFD	HOSO, 5 %	HOSO, 15 %
Arachidonic $C_{20:4}$ ω-6	10,17	10,48	9,56
Eicosapentaenoic $C_{20:5}$ ω-3	0,23	0,10	0,42
Docosapentaenoic $C_{22:5}$ ω-3	0,21	0,41	0,46
Docosahexaenoic $C_{22:6}$ ω-3	1,66	3,24	3,99

Table 6 presents the results of the determination of LCPUFA in the FFA fraction. It can be seen that high-fat diets cause a reduction in arachidonic acid, however, a diet with 15% HOSO significantly increases the content of ω-3 LCPUFA.

Table 6 – The content of LCPUFA in the fraction of free fatty acids (FFA) of the liver of rats fed diets with high oleic sunflower oil (HOSO)

Fatty	FFD	HOSO, 5 %	HOSO, 15 %
Arachidonic $C_{20:4}$ ω-6	16,47	15,65	9,06
Eicosapentaenoic $C_{20:5}$ ω-3	0,52	0,31	1,17
Docosapentaenoic $C_{22:5}$ ω-3	0,60	0,57	0,84
Docosahexaenoic $C_{22:6}$ ω-3	2,83	2,28	4,03

More clearly, the content of ω-3 LCPUFA is shown in fig. 2, which shows a dose-dependent increase in the content of this group of LCPUFA in all lipid fractions, especially in the FFA fraction.

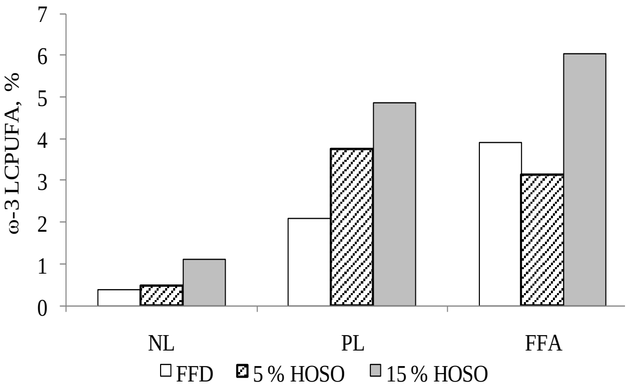

Fig. 2. Influence of the consumption of HOSO on the content of ω-3 LCPUFA in rat liver lipids (FFD, HOSO, NL, PL, FFA – see Fig. 1)

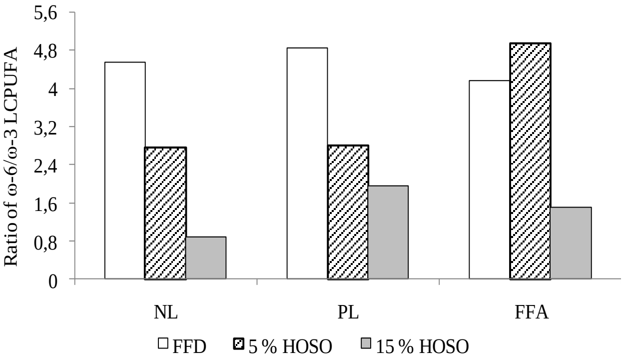

Fig. 3. Influence of consumption of HOSO on the ratio of ω-6/ω-3 LCPUFA in rat liver lipids (FFD, HOSO, NL, PL, FFA – see Fig. 1)

Taking into account the biological role of the ratio ω-6/ω-3 LCPUFA [17], we calculated this ratio for the lipid fractions of the liver of rats fed with FFD and diets with HOSO. It can be seen that the consumption of HOSO dose-dependently reduces this ratio to the level of optimal physiological (1-2) [17].

The presence in the composition of lipids in the liver of rats that did not receive fat with food, almost all fatty acids of both energy and structural-regulatory groups, casts doubt on the concept of essential fatty acids, which include linoleic, linolenic and LCPUFA. Endogenous systems for the biosynthesis of these acids may be associated with the metabolic activity of our microbiota, which is capable of synthesizing any fatty acids [18].

The use of HOSO in nutrition shows that the total content of EFA in liver lipids does not change, since the content of other energy acids, primarily palmitic and palmitooleic acids, decreases with the intake of oleic acid from food. It is possible that oleic acid is an inhibitor of fatty acid synthase.

The most important thing that we have been able to establish is the ability of oleic acid to stimulate the endogenous biosynthesis of ω-3 LCPUFA. Perhaps this stimulation is associated with the ability of oleic acid to stimulate the growth of probiotic bacteria, in particular, lactobacilli and bifidobacteria [18, 19]. It is possible that in this respect it will be possible to consider oleic acid and fats containing it as prebiotics.

Our studies have added to the positive effects that have already been shown for HOSO and olive oil, a new biological effect of stimulating the endogenous biosynthesis of ω-3 LCPUFA, the significance of which for the animal organism is beyond doubt.

Further research is needed in this direction.

Conclusions

In the animal body, endogenous biosynthesis of all classes of fatty acids, including essential ones, which include PUFA, occurs. High oleic sunflower oil inhibits the endogenous biosynthesis of energy fatty acids, oleic precursors, i.e. palmitic and stearic. High-oleic sunflower oil dose-dependently activates the endogenous biosynthesis of ω-3 LCPUFA. If the participation of the endogenous microbiota in the biosynthesis of ω-3 LCPUFA is confirmed, then high-oleic sunflower oil (like olive oil) can be considered as a new type of prebiotic.

Acknowledgments The authors declare that there are no conflicts of interest.

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УДК 612.397+577.16+613.2

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ВИСОКОЛЕЇНОВА СОНЯШНИКОВА ОЛІЯ ЗНИЖУЄ ЕНДОГЕННИЙ БІОСИНТЕЗ ЕНЕРГЕТИЧНИХ ЖИРНИХ КИСЛОТ ТА ПІДВИЩУЄ ЕНДОГЕННИЙ БІОСИНТЕЗ ω-3 ДОВГОЛАНЦЮГОВИХ ПНЖК

Анотація *У роботі показано, що жирні кислоти харчових жирів забезпечують дві основні функції в організмі людини і тварин: енергетичну та структурно-регуляторну. Поліненасичені жирні кислоти (ПНЖК) є основою мембранних ліпідів усіх клітин організму. Структура та функціональна активність клітин, їх стійкість до патогенних факторів залежить від співвідношення ω-6 / ω-3 ПНЖК. Дотримання рекомендованих запасів метаболічної енергії в кормах для птиці є важливим для оптимізації витрат на корм. Використання олії або жиру є звичайною економічною практикою в сучасному птахівництві. Енергетичні функції здійснюються за рахунок окислення в мітохондріях енергетичних жирних кислот, до яких належать, насамперед, пальмітинова (С16:0), пальмітоолеїнова (С16:0), стеаринова (С18:1) та олеїнова (С18:1. Окрім забезпечення енергією, жир раціону також може покращити харчові, смакові якості, зменшити пил і посилити гідроліз ліпопротеїнів для сприяння синтезу незамінних жирних кислот. Жирову тканину слід розглядати не тільки як джерело різноманітних жирних кислот, а й як важливий ендокринний орган, який бере активну участь у діяльності імунної системи. Визначали вплив дієти з високоолеїновою соняшниковою олією на вміст енергетичних жирних кислот (ЕЖК) та довголанцюгових ПНЖК (ДЛПНЖК) у ліпідах печінки щурів. Ми використовували високоолеїнову соняшникову олію (ВОСО), що містить 85,5% олеїнової кислоти. Раціони годівлі щурів безжирова дієта (БЖД) і раціони з 5 або 15% ВОСО протягом 35 днів. Ліпіди екстрагували з печінки і розділяли на три фракції: нейтральні ліпіди (НЛ), фосфоліпіди (ФЛ) і вільні жирні кислоти (ВЖК). Жирнокислотний склад ліпідних фракцій визначали методом газової хроматографії. Сума жирних кислот (СЖК) – це сума С16:0, С16:1, С18:0, С18:1 і С18:2. ДЛПНЖК представлені С20:4 ω-6, С20:5 ω-3, С22:5 ω-3 та С22:6 ω-3. Найбільше ЕЖК міститься у фракції НЛ (89%), потім у фракції ФЛ (79%), а найменше у фракції ВЖК (68%). Найбільше ДЛПНЖК міститься у фракції ВЖК (20%), потім у фракції ФЛ (13%) і найменше у фракції НЛ (2%). У щурів, які отримували жирові дієти, вміст ЕЖК підвищувався у фракції НЛ на 2-3%, у фракції ВЖК на 5-8%, а у фракції ФЛ не змінювався. Вміст ДПНЖК ω-6 (арахідонової кислоти) з жировим харчуванням дозозалежно зменшується у фракції НЖК і ВЖК і не змінюється у фракції ФЛ. Навпаки, у щурів, які отримували ВОСО, вміст ω-3 ДЛПНЖК зростає у всіх ліпідних фракціях. Крім того, співвідношення ω-6/ω-3 ДЛПНЖК значно знижується у щурів, які отримували ВОСО. Споживання ВОСО стимулює ендогенний біосинтез ω-3 ДЛПНЖК.*

Ключові слова: жирове харчування, олеїнова кислота, ліпіди печінки, довголанцюгові ПНЖК, співвідношення ω-6/ω-3 ДПНЖК.

Received 29.10.2022 **Revised 25.11.2022**
Reviewed 08.11.2022 **Approved 20.12.2022**

Cite as Vancouver Citation Style
Levitskiy A., Levitsky Yu., Selivanska I., Lapinska A., Velichko V. High oleic sunflower oil decreases endogenous biosynthesis of energy fatty acids and increases endogenous biosynthesis of ω-3 long-chain PUFA. Grain Products and Mixed Fodder's, 2022; 22 (4, 88): 36-40.
DOI https://doi.org/10.15673/

Cite as State Standard of Ukraine 8302:2015
High oleic sunflower oil decreases endogenous biosynthesis of energy fatty acids and increases endogenous biosynthesis of ω-3 long-chain PUFA. / Levitskiy A. et al. // Grain Products and Mixed Fodder's. 2022. Vol. 22, Issue 4 (88). P. 36-40. DOI https://doi.org/10.15673/

UDC 811.161.2(075)
DOI https://doi.org/10.15673/

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ФАХОВА ТЕРМІНОЛОГІЯ – НЕОБХІДНИЙ ЕЛЕМЕНТ БУДЬ-ЯКОЇ ГАЛУЗІ ВИРОБНИЦТВА

Анотація

У статті обґрунтовано значення фахової термінології у будь-якій галузі науки, культури, техніки. Простудійовано також питання стандартизації термінології, тобто вироблення термінів-еталонів, термінів-зразків, унормування термінології в межах однієї країни (якщо це національний стандарт) або в межах групи країн (якщо це міжнародний стандарт). Безпосередньо здійснено комплексне дослідження шляхів формування та становлення окремих термінів у галузі виробництва й переробки зернової продукції, таких як «зла́ки» [zláky], «зерно́» [zernó], «збіжжя» [zbijjia], «бо́рошно» [bóroshno], «крупа́» [krupá], «су́ржик» [surjyk]. Зроблено зауваги до варіювання терміну «хліб» [hlib] в українській та інших слов'янських мовах. Звернено також увагу на процес детермінологізації деяких слів української мови, зокрема, на термін