UDC 612.197.23: 587.11: 616.03
DOI: https://doi.org/

A. Levitsky[1], Dr of Biological Sciences, Professor, E-mail: flavan@mail.ru
Scopus ID 7004258441, ORCID 0000-0002-1966-542X, Researcher ID: B-2672-2016
A. Lapinska[1], PhD. Sc., Associate Professor, E-mail: alocnka.onaft@gmail.com
ORCID 0000-0003-4217-2516, Researcher ID: B-6483-2016
Department of technology Feed and Biofuel Technologies, Tel. +38048 7124013
[1]*Odessa National Academy of Food Technologies, 112, Kanatna Str., Odessa, 65039, Ukraine*
I. Selivanskaya[2], PhD. Sc., Associate Professor, E-mail: irina_selivansky@mail.ru
[2]*Odessa National Medical University, Odessa, Ukraine*
I. Khodakov[3], research officer
[3]*State Establishment "The Institute of Stomatology and Maxillo - facial Surgery NAMS"*

DEVELOPMENT OF AN EXPERIMENTAL MODEL OF AVITAMINOSIS F

Abstract

The article analyzes the role of essential polyunsaturated fatty acids (PUFA), especially omega-3 series in humans and animals. The biosynthesis of essential PUFA in humans and animals is very limited, so they must be consumed with food (feed). The ratio of omega-3 and omega-6 PUFA is very important. Biomembranes of animal cells contain about 30% PUFA with a ratio of ω-6/ ω-3 1-2. As this ratio increases, the physicochemical properties of biomembranes and the functional activity of their receptors change. The regulatory function of essential PUFA is that in the body under the action of oxygenase enzymes (cyclooxygenase, lipoxygenase) are formed extremely active hormone-like substances (eicosanoids and docosanoids), which affect a number of physiological processes: inflammation, immunity, metabolism. Moreover, ω-6 PUFA form eicosanoids, which have pro-inflammatory, immunosuppressive properties, and ω-3 PUFAs form eicosanoids and docosanoids, which have anti-inflammatory and immunostimulatory properties. Deficiency of essential PUFA, and especially ω-3 PUFA, leads to impaired development of the body and its state of health, which are manifestations of avitaminosis F. Prevention and treatment of avitaminosis F is carried out with drugs that contain PUFA.

To create new, more effective vitamin F preparations, it is necessary to reproduce the model of vitamin F deficiency.

An experimental model of vitamin F deficiency in white rats kept on a fat –free diet with the addition of coconut oil, which is almost completely free of unsaturated fatty acids, and saturated fatty acids make up almost 99 % of all fatty acids was developed.

The total content of ω-6 PUFA (sum of linoleic and arachidonic acids), the content of ω-3 PUFA (α-linolenic, eicosapentaenoic and docosahexaenoic acids) in neutral lipids (triglycerides and cholesterol esters) defined. The content of ω-6 PUFA under the influence of coconut oil decreased by 3.3 times, and the content of ω-3 PUFA - by 7.5 times.

The influence of coconut oil, the content of ω-6 PUFA decreased by 2.1 times, and the content of ω-3 PUFA - by 2.8 times. The most strongly reduces the content of ω-3 PUFA, namely eicosapentaenoic, coconut oil, starting from 5 %. Consumption of FFD with a content of 15 % coconut oil reduces the content of eicosapentaenoic acid to zero, ie we have an absolute deficiency of one of the most important essential PUFAs, which determined the presence of vitamin F deficiency.

Key words: *essential fatty acids, coconut oil, vitamin F deficiency, ω-6 PUFA, ω-3 PUFA, fatty nutrition.*

Introduction

Avitaminosis F – is a deficiency of essential polyunsaturated fatty acids (PUFA), especially omega-3 series [1].It is known that the composition of PUFA includes fatty acids, the radical of which is two, three, four, five or six double bonds and which are divided depending on the location of the double bond in the third from the terminal methyl group of the carbon atom or in the sixth from the terminal methyl group of the carbon atom. Omega-3 PUFA include α-linolenic acid ($C_{18:3}$, ω-3), eicosapetaenoic ($C_{20:5}$, ω-3) and docosahexaenoic ($C_{22:6}$, ω-3). Omega-6 PUFA include linoleic ($C_{18:2}$, ω-6), γ-linolenic ($C_{18:3}$, ω-6), arachidonic ($C_{20:4}$, ω-6).

The biosynthesis of essential PUFA in humans and animals is very limited, so they must be consumed with food (feed).

Essential PUFA have two main functions: structural and regulatory. The structural function of PUFA is that they are necessary for the construction of biomembranes, without which there is no cell of the body. Moreover, the ratio of omega-3 and omega-6 PUFA is very important [2]. Biomembranes of animal cells contain about 30 % PUFA with a ratio of ω-6 / ω-3 1-2 [1]. As this ratio increases, the physicochemical properties of biomembranes and the functional activity of their receptors change.

The regulatory function of essential PUFA is that in the body under the action of oxygenase enzymes (cyclooxygenase, lipoxygenase) are formed extremely active hormone-like substances (eicosanoids and docosanoids), which affect a number of physiological processes: inflammation, immunity, metabolism [3].

Moreover, ω-6 PUFA form eicosanoids, which have pro-inflammatory, immunosuppressive properties, and ω-3 PUFAs form eicosanoids and docosanoids, which have anti-inflammatory and immunostimulatory properties.

Deficiency of essential PUFA, and especially ω-3 PUFA, leads to impaired development of the body and its state of health, which are manifestations of avitaminosis F. Prevention and treatment of avitaminosis F is carried out with drugs that contain PUFA.

To create new, more effective vitamin F preparations, it is necessary to reproduce the model of vitamin F deficiency.

The aim of our work was to develop an experi-

mental model of vitamin F deficiency in white rats kept on a fat –free diet with the addition of coconut oil, which is almost completely free of unsaturated fatty acids, and saturated fatty acids make up almost 99 % of all fatty acids [4].

Materials and methods of research

White Wistar rats were used. Rats were fed a 30-day fat-free diet (FFD) supplemented with 5, 10, or 15% coconut oil. The content of ω-6 PUFA (linoleic and arachidonic) and ω-3 PUFA (eicosapentaenoic and docosahexaenoic) in gas and liquid chromatography was determined in neutral lipids of the liver and blood serum.

The experiments were performed on 24 Wistar rats (males, 3 months), which received a fat-free diet (FFD) [5], the composition of which is presented in table 1. All rats were divided into 4 equal groups:

Table 1 - The composition of the fat-free diet for rats [5]

№	Component	Content, g / kg
1	Maizestarch	660
2	Soybeanmealisdefatted	150
3	Ovalbumin	50
4	Sugar	90
5	Mineralmixture	40
6	Vitaminmixture	10

1st - control, which received FFD, 2nd received FFD with the addition of 5% coconut oil (instead of starch), 3rd received FFD with the addition of 10 % coconut oil and 4th - with the addition of 15 % coconut oil. The duration of the experiment was 30 days.After euthanasia, the animals were isolated liver and received serum. In the neutral lipids of all tissues, the content of PUFA was determined by gas chromatographic method [6].

Results and discussion

Consumption of coconut oil dose-dependently reduces the total amount of PUFA in neutral lipids of liver and serum. The content of ω-6 PUFA is reduced in the liver by 3.3 times and in the serum by 2.1 times when consuming a diet of 15 % coconut oil. The content of ω-3 PUFA is reduced in the liver by 7.5 times, in the serum by 2.8 times.

Under these conditions, the content of eicosapentaenoic acid decreased to zero.

The total content of ω-6 PUFA (sum of linoleic and arachidonic acids), the content of ω-3 PUFA (α-linolenic, eicosapentaenoic and docosahexaenoic acids) in neutral lipids (triglycerides and cholesterol esters) of rat liver is shown in the table 2, what does the content of ω-6 PUFA under the influence of coconut oil decreased by 3.3 times, and the content of ω-3 PUFA - by 7.5 times.

The ratio of ω-6 / ω-3 increases by 1.3 - 2.3 times and for the group with the addition of 15 % coconut oil is 43,0.

Similar figures, but for neutral serum lipids, are presented in table 3, which shows that under the influ ence of coconut oil, the content of ω-6 PUFA decreased by 2.1 times, and the content of ω-3 PUFA - by 2.8 times.

Table 2 - The total content of PUFA in neutral lipids of rat liver, whoreceived FFD with the addition of coconut oil (%)

№	Group	Σ ω-6 PUFA	Σ ω-3 PUFA	ω-6/ω-3
1	FFD	14,3±1,8	0,75±0,24	19,1
2	FFD + 5 % coconut oil	5,9±1,0	0,25±0,19	23,6
3	FFD + 10 % coconut oil	4,5±0,9	0,17±0,08	26,5
4	FFD + 15 % coconut oil	4,3±1,1	0,10±0,06	43,0

Table 3 - The total content of PUFA in neutral serum lipids of rats,who received FFD with the addition of coconut oil (%

№	Group	Σ ω-6 PUFA	Σ ω-3 PUFA	ω-6/ω-3
1	FFD	14,6±2,0	0,78±0,23	18,7
2	FFD + 5 % coconut oil	10,2±1,4	0,72±0,24	14,2
3	FFD + 10 % coconut oil	7,6±1,1	0,40±0,19	19,0
4	FFD + 15 % coconut oil	6,9±0,9	0,28±0,14	24,6

The ratio of ω-6 / ω-3 increases by 1.32 times and for the group with the addition of 15 % coconut oil is 24,6.

The most strongly reduces the content of ω-3 PUFA, namely eicosapentaenoic, coconut oil, starting from 5 % (Fig. 1).

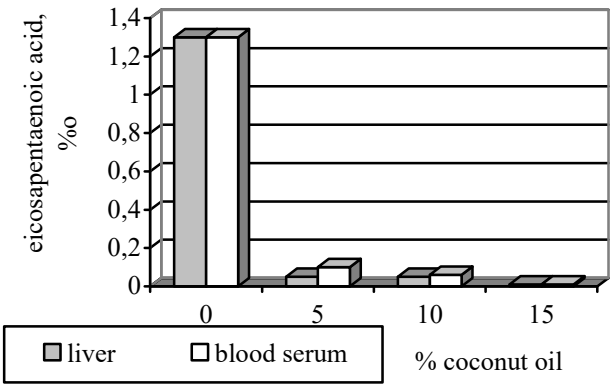

Fig. 1 - The effect of coconut oil on the content of eicosahentaenoic acid inneutral lipids

Consumption of FFD with a content of 15 % coconut oil reduces the content of eicosapentaenoic acid to zero, ie we have an absolute deficiency of one of the most important essential PUFAs, which determined the presence of vitamin F deficiency.

Conclusions

An experimental model of vitamin deficiency F (PUFA deficiency) was developed, which consists in feeding rats FFD with the addition of 15 % coconut oil for least 30 days. Fat-free diet does not eliminate the presence of PUFA in the body.

The consumption of coconut oil (in an amount of 15 %) in a fat-free diet causes the development of experimental deficiency of vitamin F.

REFERENCES

1. *Levitsky A.P., Khodakov I.V., Lapinskaia A.P. [and others]. Vitamin F (essential polyunsaturated fatty acids ω-6 and ω-3 PUFA. Odessa, FLP Tashchenko S. Iu., 2020: 65.*
2. *Levitsky A.P. The role of polyunsaturated fatty acids (pufa) in the formation of the structure and functions of biomembranes // Journal Education, Health and Sport. – 2020. – v. 10, № 6. – P. 101-107.*
3. *Shih E.V., Mahova A.A. Long-chain polyunsaturated fatty acids of the ω-3 family in the prevention of diseases in adults and children: a view of a clinical pharmacologist. Nutritionissues. 2019; v 88(2): P. 91-100.*
4. *Levitsky AP, Khodakov IV.Influence of coconut oil on the content of essential fatty acids in rats fed with a fat-free diet. Bulletin of Marine Medicine. 2016; v 1(70): P. 95-99.*
5. *LevitskyA.P., Makarenko O.A., Demyanenko S.A. Methods of experimental dentistry. Simferopol, Tarpan, 2018: P 78.*
6. *Levitsky A.P., Makarenko O.A., Khodakov I.V. Methods to investigate fats and oils. Odessa: KP OGT, 2016. – 32 p.*

А. Левицький, д-р біол. наук, професор E-mail: flavan@mail.ru
Scopus ID 7004258441, ORCID 0000-0002-1966-542X, Researcher ID: B-2672-2016
А. Лапінська, канд. техн. наук, доцент E-mail: alocnka.onaft@gmail.com
ORCID 0000-0003-4217-2516, Researcher ID: B-6483-2016
Одеська національна академія харчових технологій, вул. Канатна, 112, м. Одеса, 65039, Україна
І. Селіванська, канд. техн. наук, E-mail: irina_selivansky@mail.ru
Одеський національний медичний університет, Одеса, Україна
І. Ходаков, науковий співробітник
Державна установа "Інститут стоматології та щелепно-лицьової хірургії", Одеса, Україна

РОЗРОБКА ЕКСПЕРИМЕНТАЛЬНОЇ МОДЕЛІ АВІТАМІНОЗУ F

Анотація

У статті проаналізовано роль незамінних поліненасичених жирних кислот (ПНЖК), особливо групи омега-3 для людей та тварин. Біосинтез незамінних ПНЖК у людини і тварин дуже обмежений, тому їх необхідно вживати разом з їжею (кормом). Співвідношення омега-3 та омега-6 ПНЖК є дуже важливим. Біомембрани клітин тварин містять близько 30 % ПНЖК у співвідношенні ω-6 / ω-3 1-2. Зі збільшенням цього співвідношення фізико-хімічні властивості біомембран та функціональна активність їх рецепторів змінюються. Регулююча функція ПНЖК полягає в тому, що в організмі під дією ферментів оксигенази (циклооксигенази, ліпоксигенази) утворюються надзвичайно активні гормоноподібні речовини (ейкозаноїди та докозаноїди), які впливають на низку фізіологічних процесів: запалення, імунітет, обмін речовин. Більше того, ω-6 PUFA утворюють ейкозаноїди, які мають прозапальні, імуносупресивні властивості, а ω-3 PUFA утворюють ейкозаноїди та докозаноїди, які мають протизапальні та імуностимулюючі властивості. Дефіцит найважливішої ПНЖК, а особливо ω-3 ПНЖК, призводить до порушення розвитку організму та його самопочуття, що є проявами авітамінозу F. Профілактика та лікування авітамінозу F здійснюється препаратами, що містять ПНЖК.

Для створення нових, більш ефективних препаратів вітаміну F необхідно відтворити модель дефіциту вітаміну F.

В роботі було розроблено експериментальну модель дефіциту вітаміну F у білих щурів, що знаходились на жировій дієті з додаванням кокосової олії, яка майже повністю не містить ненасичених жирних кислот, а насичених жирних кислот становить майже 99 % усіх жирних кислот.

Визначено загальний вміст ω-6 ПНЖК (сума лінолевої та арахідонової кислот), вміст ω-3 ПНЖК (α-ліноленова, ейкозапентаенова та докозагексаєнова кислоти) в нейтральних ліпідах (тригліцериди та складні ефіри холестерину). Вміст ω-6 PUFA під впливом кокосової олії зменшився в 3,3 рази, а вміст ω-3 PUFA - у 7,5 раза.

Вплив кокосової олії, вміст ω-6 ПНЖК зменшився в 2,1 рази, а вміст ω-3 ПНЖК - у 2,8 рази. Найбільш сильно знижується вміст ω-3 PUFA, а саме ейкозапентаенової, починаючи з 5 % кокосової олії, Споживання корму з вмістом кокосової олії 15 % зменшує вміст ейкозапентаєнової кислоти до нуля, тобто ми маємо абсолютний дефіцит однієї з найважливіших незамінних ПНЖК, яка визначала наявність дефіциту вітаміну F.

Ключові слова: *незамінні жирні кислоти, кокосова олія, дефіцит вітаміну F, ω-6 ПНЖК, ω-3 ПНЖК, жирове харчування.*

ЛІТЕРАТУРА

1. *Левицкий А.П. Витамин F (эссенциальные полиненасыщенные жирные кислоты ω-6 та ω-3 ПНЖК / Левицкий А.П., Ходаков И.В., Лапинская А. П. [и др]. Одесса, ФЛП Таценко С.Ю., 2020. – 65 с.*
2. *Levitsky A.P. The role of polyunsaturated fatty acids (pufa) in the formation of the structure and functions of biomembranes // Journal Education, Health and Sport. – 2020. – v. 10, № 6. – P. 101-107.*
3. *Shih E.V., Mahova A.A. Long-chain polyunsaturated fatty acids of the ω-3 family in the prevention of diseases in adults and children: a view of a clinical pharmacologist. Nutritionissues. 2019; v 88(2): P. 91-100.*
4. *Левицкий А.П., Ходаков И.В. Влияние кокосового масла на содержание эссенциальных жирных кислот у крыс, получавших безжировой рацион // Вісник морської медицини. – 2016. – №. 1. – С. 95-99.*
5. *Левицький А.П., Макаренко О.А., Дем'яненко С.А. Методи експериментальної стоматології. Сімферополь, Тарпан, 2018. –78 с.*
6. *Левицкий А.П., Макаренко О.А., Ходаков И.В. Методы исследования жиров и масел: методические рекомендации // Одесса: КП ОГТ. – 2016. - 32 с.*

Received 12.01.2020 **Revised 25.05.2020**
Reviewed 19.03.2020 **Approved 10.06.2020**

Cite as Vancouver Citation Style
Levitsky A., Lapinska A., Selivanskaya I., Khodakov I. Development of an experimental model of avitaminosis F. Grain Products and Mixed Fodder's, 2020; 20 (2, 78): 38-40. DOI: https://doi.org/
Cite as State Standard of Ukraine 8302:2015
Development of an experimental model of avitaminosis F. / Levitsky A. et al. // Grain Products and Mixed Fodder's. 2020. Vol. 20, Issue 2 (78). P. 38-40. DOI: https://doi.org/