THE OPTIMAL CONTENT OF FATTY ACIDS FOR HEALTHY NUTRITION

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Abstract. *Diabetes and obesity are pathologies that have a worldwide spread. The fact that food has become very easily accessible, and the physical effort we do every day is less and less, can be an explanation for the increased rate of obesity nowadays. Starting from the traditional Mediterranean diet, which is characterized by a high intake of monounsaturated fats (eg olive oil, nuts), a low intake of saturated fats (eg red meat) and a moderate intake of polyunsaturated fats and long-chain omega-3 fatty acids (from fish and seafood), a solution could be found to ensure the optimal intake of fatty acids. The present study reviews the fatty acid profile of olive oil and walnut oil samples, both major components of the Mediterranean diet, as well as their mixtures in different proportions, proposing to identify the proportion that ensures the optimal ratio of monounsaturated fatty acids/polyunsaturated, respectively omega-6/omega-3 fatty acids. Gas chromatography-mass spectrometry (GC-MS) analysis showed that there is no significant difference between the fatty acid content of extra virgin olive oil (EVOO) and BIO olive oil, and the same is true for BIO walnut oil and walnut. In the case of the oil mixtures used in the experiment, the fatty acid profile is close to optimal for olive oil/walnut oil 1:2. The following conclusions were drawn: the ratio of mono and polyunsaturated fatty acids in the human diet should be 1:2, and that of omega-6 (linoleic acid) and omega-3 (linolenic acid) fatty acids would ideally be 1:1. In the case of saturated fatty acids, their weight should not exceed 15% of a healthy diet.*

Keywords: *healthy diet, fatty acids, optimal ratio, biology*

INTRODUCTION

Type 2 diabetes mellitus (DM) and cardiovascular disease are the two major causes of mortality nowadays (GIL et al., 2015). Diabetes is strongly connected with obesity and other complications. The fact that food has become very easily accessible, and the physical effort we do on a daily basis is becoming less and less, can be an explanation for the increased rate of obesity nowadays (SAAD et al., 2017). Obesity is also associated with the ingestion of trans fatty acids and industrially produced saturated fatty acids (ALCOCK and LIN, 2015).

Today's Western diets deviate from Paleolithic diets and are linked to high incidence of cardiovascular disease, cancer, obesity and diabetes. Nutrition is one of the vital environmental elements, as individual and population health is the outcome of the interplay between genetic profile and environment (SIMOPOULOS, 2016).

The calories obtained from eaten or stored carbohydrates are consumed by the body during physical activites. But after about twenty minutes, fat-derived calories provide the energy needed to keep on exercising. Food fats provide the body with essential fatty acids (SANCHEZ-VILLAGES and SANCHEZ-TAINTA, 2018). The quality and quantity of fatty acid intake has great influence on our health (GIL et al., 2015).

It has long been recognized that fat is a great source of energy, and research conducted in the first part of the 20th century showed that the lipoids found in dietary fat were essential for optimal physiological function and growth. However, specialists did not believe that fatty acids were essential nutrients (SPECTOR and KIM, 2015).

George Oswald Burr, based on observations made on rats that's diet didn't contain fat, revealed in 1929 that fat was an essential dietary component (BURR and BURR, 1929). Burr then proved that a modest amount of linoleic acid healed the deficiency disease and was thus worthy of being considered a necessary fatty acid (BURR and BURR, 1930).

HOLMAN, JOHNSON, and HATCH (1982) stated that the essentiality of linolenic acid is most likely given by the polyunsaturated fatty acids generated from it. They believed that this acid is a necessary component of the human diet, indispensable for appropriate nerve function.

One of the most significant advances in the research of lipids has been the discovery of the existence of essential fatty acids. It disproved the widely held assumption that dietary fat was just a source of energy and facilitator of fat-soluble vitamin's absorption (SPECTOR and KIM, 2015; GIL et al., 2015).

There is strong evidence that linolenic (omega-3) and alpha-linoleic acids (omega-6) are essential fatty acids because our bodies cannot synthesize them (GIL et al., 2015). Linolenic acid is metabolized to arachidonic acid and alpha-linoleic acid (ALA) to eicosapentaenoic acid and docosahexaenoic acid (SIMOPOULOS, 2016).

Mononunsaturated and polyunsaturated fatty acids (MUFA and PUFA) are examples of healthy fats, while trans fatty acids (industrial-made) are considered to be bad fats. In between these two categories are situated the saturated fatty acids (SFA) (SANCHEZ-VILLAGES and SANCHEZ-TAINTA, 2018).

It has been demonstrated that foods with high content of MUFA and PUFA positively affect blood lipid concentrations, lowering the risk of developing cardiovascular disease (QIAN et al., 2016). This has also been specifically demonstrated for diets high in olive oil and nuts (ESTRUCH et al., 2013).

There is clear evidence that consumption of MUFA instead of SFA lowers the concentration of low- and high-density lipoprotein cholesterols (GIL et al., 2015). Fatty acids, especially arachidonic acid, which is an omega-6 PUFA, also play role in promoting or inhibiting inflammatory processes (chemical mediators like prostaglandines and leukotrienes) (INNES and CALDER, 2018). The consumption of omega-3 PUFAs has been found to be inversely associated with the development of CVD (COELHO et al., 2016).

According to the American Diabetes Association, a diet with reduced content of SFA is proposed for the management of type II diabetes (QIAN et al., 2016).

Starting from the traditional Mediterranean diet, which is characterized by a high intake of monounsaturated fats (eg olive oil, nuts), a low intake of saturated fats (eg red meat) and a moderate intake of polyunsaturated fats and long-chain omega-3 fatty acids (from fish and seafood), a solution could be found to ensure the optimal intake of fatty acids (SANCHEZ-VILLAGES and SANCHEZ-TAINTA, 2018).

The present study reviews the fatty acid profile of olive oil and walnut oil samples, both major components of the Mediterranean diet, as well as their mixtures in different proportions, proposing to identify the proportion that ensures the optimal ratio of monounsaturated/polyunsaturated fatty acids, respectively omega-6/omega-3 fatty acids.

Epidemiological research and clinical trials have shown that a variety of dietary components commonly found in the Mediterranean diet, particularly extra-virgin olive oil (EVOO), improve longevity while decreasing overall mortality. Other advantages included a lower risk of cancer, a lower risk of cardiovascular disease, and better control of type-2 DM (ROMÁN et al., 2019; DINU et al., 2018), as well as limitation of cholesterol levels (ROMÁN et al., 2019). According to observational research, better adherence to the Mediterranean diet is related with a decrease in neurodegenerative illnesses (SOFI et al., 2010).

Regarding walnuts, it should be noted that they have the greatest ALA content of any edible plant (ROS, 2020).

As specified by ROS (2020), the lipid profile of nuts, and walnuts particularly, is expected to play an essential role in the health benefits of persistent nut consumption. Increased nut consumption does not stimulate obesity, owing to a strong satiating effect.

MATERIAL AND METHODS

The profile of fatty acids as methyl esters was determined for organic and conventional extra-virgin olive oil, organic and conventional walnut oil, respectively for mixtures obtained from organic extra-virgin olive oil and organic walnut oil in a ratio of 1:1, 2:1, 1:2, 4:1. In order to identify the fatty acid methyl esters (FAMEs), a Shimadzu GC-MS-QP2010 PLUS (Shimadzu Corporation, Kyoto, Japan) with RT2560 column (100 m × 0.25 mm × 0.20 μm), from the Interdisciplinary Research Platform of University of Life Sciences "King Michael I" from Timisoara was used.

The oil samples were derivatization with 20% BF3 methanolic solution (Merck KgaA, Darmstadt, Germany), by maintaining for 60 minutes at 80°C (FALC Instruments, Treviglio, Italy). FAMEs from the hexane fraction separated by centrifugation (1 mL) were used for GC-MS analysis.

Parameters of GC-MS analysis was:

- flow rate of the carrier gas (Helium) 1 $mL \cdot min^{-1}$,
- splitting ratio 1:50
- oven temperature program start at 100°C maintained for 5 min, and then a gradient at 3°C/min until 250°C was maintained for 10 min.
- injection port temperature 250°C, and the ion source temperature 210°C and the GC-MS interface temperature 255°C.

Fatty acids methyl esters were identified based on the NIST 05 spectrum library. The fatty acid composition was expressed using the peak area normalization method. All the analyses were conducted in triplicates.

RESULTS AND DISCUSSION

The aim of the study was the identification of the ideal proportion in which foods high in monounsaturated fatty acids and those high in polyunsaturated fatty acids should be consumed.

Gas chromatography-mass spectrometry (GC-MS) analysis showed that there is no significant difference between the fatty acid content of extra-virgin olive oil (EVOO) and BIO olive oil, and the same is true for BIO walnut oil and walnut.

In the case of the oil mixtures used in the experiment, the fatty acid profile is close to optimal for olive oil/walnut oil 1:2.

The results of *Table 1* also show that the major component of olive oil is the 9-Octadecenoic acid (Z)-, methyl ester (also known as oleic acid), which is a monounsaturated fatty acid, and the walnut oil contains high amounts of linoleic acid (omega-6) and linolenic acid (omega-3), both of them being polyunsaturated fatty acids.

Table 1

Fatty acid composition of different variations of olive oil and walnut oil samples, as well as mixtures of the two (%)

Fatty acid composition	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8
	EVOO	OO BIO	WO BIO	WO MIX	OO BIO WO BIO 1:1	OO BIO WO BIO 2:1	OO BIO WO BIO 1:2	OO BIO WO BIO 4:1
Hexadecanoic acid, methyl ester	14.64	15.77	9	10.06	11.94	12.48	9.97	13.57
9-Hexadecenoic acid, methyl ester, (Z)-	1.01	1.31	1.65	2.59	3.22	2.68	2.47	2.73
Octadecanoic acid, methyl ester	4.57	5.07	3.12	3.73	3.19	3.85	3.49	3.89
9-Octadecenoic acid (Z)-, methyl ester	68.26	63.36	24.48	20.48	42.42	44.98	38.05	50.8
9,12-Octadecadienoic acid (Z,Z)-, methyl ester	9.46	12.76	47.67	48.15	31.51	29.28	36.39	24.2
Eicosanoic acid, methyl ester	0.8	0.55	0.13	0.17	0.43	0.41	0.42	0.65
9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-	1.26	1.17	13.95	14.81	7.3	6.31	9.19	4.15
SFA	20.01	21.39	12.25	13.96	15.56	16.74	13.88	18.11
MUFA	69.27	64.67	26.13	23.07	45.64	47.67	40.52	53.53
PUFA	10.72	13.93	61.62	62.96	38.81	35.59	45.58	28.35
n-6/n-3	7.51	10.9	3.41	3.25	4.31	4.64	3.95	5.83

SFA- saturated fatty acids, MUFA – monounsaturated fatty acids, PUFA-polyunsaturated fatty acids

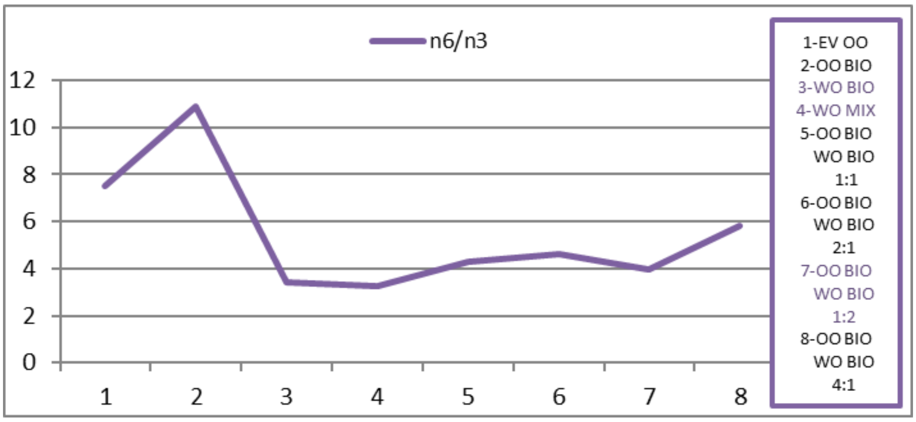

Figure 1. Quantitative ratio of linoleic acid (n-6) and linolenic acid (n-3) in oil samples

Regarding the omega-6/omega-3 ratio in humans diets, according to SIMOPOULOS (2016) it should be as close as possible to 1:1. Results obtained from the present analysis reveal that out of the 8 samples, Sample 3 (WO BIO), Sample 4 (WO MIX) and Sample 7 (OO BIO/WO BIO 1:2) have the closest values to 1.

In fact, Sample 7 with a 1:2 ratio of bio olive oil and bio walnut oil, has shown the best results concerning SFA content, MUFA/PUFA content and n-6/n-3 proportion.

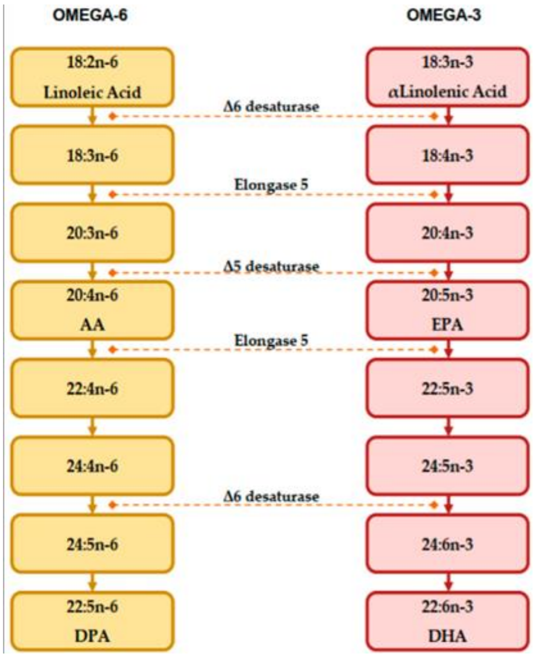

Figure 2. The metabolic pathway of long-chain PUFAs, adapted from PATTERSON et al. (2012) (CAPRA et al., 2023)

As shown in Figure 2, omega-6 and omega-3 have the same methabolic pathway. Eicosanoids, that's precursors are n-6 PUFAs and n-3 PUFAs, have major roles in inflammation regulation. Eicosanoids formed from n-6 PUFA are often proinflammatory, whereas n-3 PUFA-originated eicosanoids are anti-inflammatory. Dietary variations in the consumption of n-6 and n-3 PUFA during the last few decades indicate dramatic increases in the n-6 to n-3 ratio (15: 1), which is associated with higher metabolism of n-6 PUFA than of n-3 PUFA. Increases in chronic inflammatory disorders coincide with this increase of this ratio. Reduced incidence of these chronic disorders may be accomplished by increasing the n-3: n-6 PUFA ratio in Western diets (PATTERSON et al., 2012).

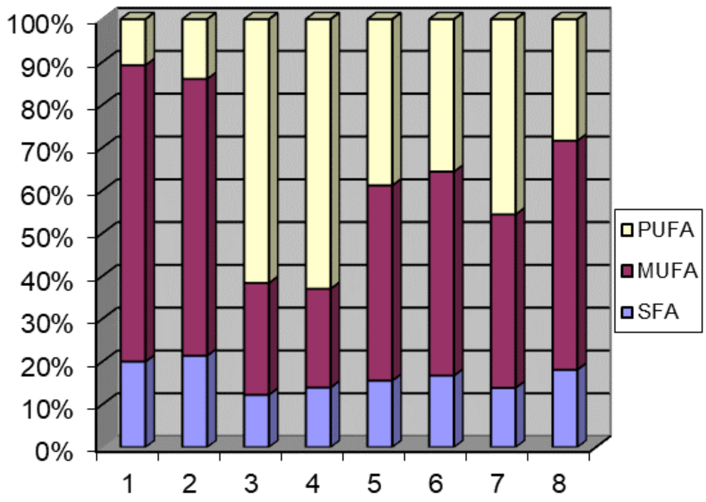

Figure 3. Graphical representation of the ratio of mono-and polyunsaturated and saturated fatty acids

CONCLUSIONS

The high n-6/n-3 ratio of the existing Western diets, linoleic acid being the main PUFA in most of them (INNES and CALDER, 2018), increases the risk of numerous chronic diseases the population, due to the lack of congruence between the environment and people's genes. The optimum ratio for health should be 1:1 n-6 to n-3 fatty acids. This balance is best achieved by reducing consumption of oils with high n-6 fatty acid content (corn, soybean, sunflower oils etc.) and increasing consumption of canola oil, flaxseed oil etc., rich in n-3s. Olive oil is especially low in n-6 FA, but high in MUFA (SIMOPOULOS, 2016).

We suggest that SIMOPOULOS' statement regarding the importance of food labels that differentiate n-3 and n-6 fatty acids, instead of distinguishing only SFAs, MUFAs and PUFAs (SIMOPOULOS, 2016), should be taken into consideration.

The following conclusions were drawn: the ratio of mono- and polyunsaturated fatty acids in the human diet should be 1:2, and that of omega-6 and omega-3 fatty acids would ideally be 1:1. The weight of saturated fatty acids should not exceed 15% of a healthy diet. We recommend the balanced consumption of foods that contain considerable amounts of omega-6 (peanut butter, almonds, avocado oil, cashews, sunflower seeds) and omega-3 (salmon, flax seeds, chia seeds, oysters, mackerel). Walnuts, hemp seeds and soy beans are rich in both of these healthy fatty acids.

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