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COMPOSITION OF FATTY ACIDS IN SELECTED VEGETABLE OILS

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ABSTRACT

Plant oils and fats are important and necessary components of the human nutrition. They are energy source and also contain fatty acids – compounds essential for human health. The aim of this study was to evaluate nutritional quality of selected plant oil – olive, rapeseed, pumpkin, flax and sesame; based on fatty acid composition in these oils. Fatty acids (MUFA, PUFA, SFA) were analyzed chromatography using system Agilent 6890 GC, injector multimode, detector FID. The highest content of saturated fatty acids was observed in pumpkinseed oil (19.07%), the lowest content was found in rapeseed oil (7.03%), with low level of palmitic and stearic acids and high level of behenic acid (0.32%) among the evaluated oils. The highest content of linoleic acid was determined in pumpkinseed (46.40%) and sesame oil (40.49%); in these samples was also found lowest content of *α*-linolenic acid. These oils have important antioxidant properties and are not subject to oxidation. The richest source of linolenic acid was flaxseed oil which, which is therefore more difficult to preserve and process in food industry. In olive oil was confirmed that belongs to the group of oils with a predominantly monosaturated oleic acid (more than 70%) and a small amount of polysaturated fatty acid. The most commonly used rapeseed oil belongs to the group of oils with the medium content of linolenic acid (8.76%); this oil also showed a high content of linoleic acid (20.24%). The group of these essentially fatty acids showed a suitable ratio ∑n3/n6 in the rapessed oil (0.44).

Keywords: plant oil; fat; nutritional quality; fatty acid; SFA; PUFA; MUFA

INTRODUCTION

According to statistical data, the proportion of fat content in total energy intake of an adult man is in developed countries even 42%. Nutrition experts agree that fats in food should be no more than 30 – 35% of total energy daily intake, while one third should be in the form of animal fat and two thirds should constitute a high-quality vegetable fats and oils. The development of new kinds vegetable oils with functional properties use a components of oil seeds with health benefits to human body **(Augustín, 2010)**.

Edible fats and oils are carriers of the importatnt biological factors which relate to the presence of essential fatty acids. Vegetable oils are the primary source of essential fatty acids. Although the fats can be described as one of the basic nutirtional components and they perform specific functions in the human body, currently they are perceived as a component associated with increased risk of disease. The problem is not in fats, but their over-consumption, especially in the unbalanced intake of fatty acids **(Babinská and Bederová, 2012)**. The human body is capable of producing all the fatty acids which it needs except for two: linoleic acid (LA) (omega-6 fatty acid) and alpha-linolenic acid (ALA) (omega-3 fatty acid). These we should be adopt in the diet. Both of these fatty acids are necessary for growth and development, but they are used in the creation of other fatty acids (e.g. arachidonic acid (AA) is formed from LA). Gived that the conversion to the omega-3 fatty acids - eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) is limited, it is recomended that a diet should contain their source. ALA and LA are found in oils from the various kinds of seeds **(Lunn and Theobald, 2006)**. Essential fatty acids are able to absorb sun light. With absorption is improving their ability to react with oxygen, for this reason they are chemically very active. The biggest enemy of essential fatty acids is light. It causes bitterness of oil. The light causes the destruction of vital biological properties of these acids **(Komprda, 2007)**. Fats accepted by food should contain saturated, monounsaturated and polyunsaturated fatty acids. Satured acid sould cover <10% of the available energy from food, polyunsaturated acids n-6, 4 – 8% on average, about 5% **(Velíšek and Hajšlová, 2009)**. Omega-3 fats belong to the group called essential fatty acids. They are highly specific, unsaturated with three double bonds. These includes mainly the alpha-linolenic acid (ALA) and gama-linolenic acid (GLA), but perhaps more important are eicosapentaenoic acid (EPA), which has five double bonds and is made of ALA and docosahexaenoic acid (DHA) which has six double bonds. Conjugated linoleic acid (CLA) belongs to the omega-3 fatty acids and it has exceptional effect, because it moderates the devastating effect of physical overload and stress. It is also involved in the development of obesity prevention. DHA has beneficial effect on vision and contribute to the brain development in children. The alpha-linolenic acid (ALA) is a part of the linseed oil. This oil also contains significant amounts of linoleic acid, which is one of the omega-6 acids group **(Fořt, 2011)**. **Komínková (2012)** report, that the omega-3 acids are necessary for the production of prostaglandins. The beneficial effect of omega-3 fatty acids for our bodies is to have a preventive effect on the many diseases caused by modern lifestyles. It reduce the risk of cardiovascular disease, modify of the blood pressure, improve the elasticity of blood vessels and reduce the level of cholesterol and blood coagulation. Different countries recommend varying amounts of omega-3 fatty acids from 0.5% to 2% of energy intake. The recommended intake of ALA is about 0.6 – 1.2% of daily energy intake or 1 – 2 g per day. It can be achieved by consuming fatty species of fish once or twice a week with occasional substitution sunflower oil by rapeseed oil **(Frej, 2014; Nitrayová et al., 2014)**. Omega-3 and omega-6 fatty acids are important components of cell membranes and they are precursors of several substances in the body, which are involved in a blood pressure regulation and an inflammatory process. Omega-3 fatty acids are promoted to prevent the heart disease. Nowadays, interest about the role of omega-3 fatty acids is increase especially in relation to prevention of the diabetes and some types of cancer (**Lunn and Theobald, 2006)**. Many studies about fatty acids have shown the exceptional importance of correct ratio of omega-6 and omega-3 fatty acids. Estimated long-term ratio of LA : ALA in human food is about 3 : 1 to 2 : 1. Most experts agree that this ratio is ideal for human body and its functions. In the human body, LA and ALA compete for metabolism by the enzyme Δ6-desaturase. It has been suggested that this is important to health, as too high an intake of LA would reduce the amount of Δ6-desaturase available for the metabolism of ALA, which may increase the risk of heart disease. This was supported by data showing that over the last 150 years, intakes of omega-6 have increased and intakes of omega-3 have decreased in parallel with the increase in heart disease. Thus, the concept of an "ideal" ratio of omega-6 to omega-3 fatty acids in the diet was developed **(Simopoulos, 2008)**. However, the ratio that is associated with a reduced risk of heart disease has not yet been identified and some experts now suggest that the ratio is less important – what we should be more concerned with is the absolute levels of intake **(Stanley et al., 2007)**.

The aim of our work was to analyze selected vegetable oils in terms of fatty acids representation and on the basis of obtained results evaluate their nutritional quality.

MATERIAL AND METHODOLOGY

Biological material

Vegetable oils were purchased from specialty store in the Slovak Republic (Olive oil, Olive oil Minerva, Rapeseed oil, Flaxseed oil, Pumpkinseed oil, Sesame oil).

Fatty acids analysis

Fatty acids of oils were analyzed chromatographically by Agilent 6890 GC system, multi Mode injector, FID detector, Agilent Technologies, USA). Lipid fraction was hydrolyzed (saponified) by hydroxide into glycerol and free fatty acids (FFAs). FFAs were esterified with methanol (methylation) to the corresponding fatty acid methyl esters (FAMEs). FAMEs were analyzed, i.e. separated and identified using gas chromatography-flame ionization detector (GC-FID).

Chemicals

All chemicals were analytical grade. We used 10 $mg.mL^{-1}$ of 37-component FAME standard mixture in methylene chloride containing C4 to C24 FAMEs (2 to 4% of relative concentration). Producer Supelco, catalog number 47885-U.

Fatty acid methyl esters (FAMEs) preparation method

Weigh 200 $mg.mL^{-1}$ fat sample into test tube (with ground joint neck). Using a pipette, add 5 mL of *n*-hexane to the test tube. The sample is subsequently dissolved by mixing. Add 1 mL of 2N potassium hydroxide in methanol. Test tube is shaken intensively and then put in water bath heated for 60ºC for 30 s. After shaking the tubes, leave them rest for 1 min. Add 2 mL of hydrogen chloride and gently shake the content. After reaching the equilibrium state and layer separation, the upper layer containing FAMEs is pipetted carefully, filtered through anhydrous Na_2SO_4 and used for GC FID analysis. Before the analysis, 50 μL of FAME solution is diluted with 950 μL of n-hexane. Elution time of separated analytes is the quality indicator. Chromatograms of samples are compared to the standard chromatogram. On the contrary, the area under the peak of monitored analyte is the indicator of quantity. For quantitative evaluation is usually being used the method of internal standardization which assumes that all of the sample components are recorded on chromatogram what covers the total surface of peaks (100%). Areas under the unitary peaks (of individual FAMEs) represent the mass percentage of specific fatty acid from the total fatty acids content of sample.

RESULTS AND DISCUSSION

Lipids are known as important food elements which play an important role in human nutrition, e.g. for the overall health and organism development. According to **Venclová, (2010)** fatty acids are nutritionally the most significant lipid component. Vegetable fats and oils are common and essential constituents of human food where they act like a substantial part of energy source and they also contain essential fatty acids which are necessary for proper functioning of human body **(Gustone, 2011)**. According to the literature reports, palmitic and stearic acid are the most important and widespread saturated fatty acids (SFA) present in animal fats. On the other hand, lauric and myristic acid are the main ingredients of palm fruits and seeds fat. We recorded the highest amount of SFA (19.07%) in pumpkin seed oil (Table 2). In comparison with other samples, the highest content of stearic acid (6.62%) was measured in this oil (Table 1). Equally high was also the palmitic acid content (11.61%) and this oil was the only one where we observed the presence of myristic acid (0.11%). On the contrary, the rapeseed oil showed the lowest content (7.33%) of saturated fatty acids, with low values of palmitic and stearic acid (Table 2). However, behenic and lignoceric acid are in this oil presented in the highest amount. **Velíšek and Hajšlová, (2009)** also report the presence of behenic acid in rapeseed oil up to 2%.

The total saturated fatty acid content ranged in our evaluated oils from 7.33% to 19.07%. SFA are chemically very stable and change either by prolonged heating or at high temperatures. The human body uses SFA to the length of 12 carbon atoms, mainly for the energy production.

They are recommended to people with digestive problems or liver disorders, because they are not stored in body as fat and also due to their easy digestibility. According to **Keresteš et al., (2011)**, SFA with longer chain (above 14 carbons) have a tendency to agglomerate with negative effect to the cardiovascular disease occurrence. SFA are present especially in animal fats. Pursuant to the above mentioned author, SFA plug our tissues by sticking the red blood cells which causes their mobility deterioration and therefore disruption of their ability to supply oxygen to the cells and tissues (hypoxia). The length of SFA carbon chain sets their melting point and stiffness. The longer is fatty part of the molecule, the greater is their tendency to agglomerate. On the basis of the recommended daily amount, the SFA income should not exceed 10% **(Kissová, 2009; Bowden, 2011)**. In animal fats and vegetable oils, most frequent are unsaturated fatty acids (UFA) with straight chain formed by 10 – 36 carbon atoms. Very common are monounsaturated and polyunsaturated fatty acids (MUFA and PUFA) with 16 – 18 carbons. Unsaturated fatty acid content varies in a very wide range, from more than 90% of all fatty acids in rapeseed oil to less than 10% in coconut oil. In comparison with animals, there is far greater variety in plants UFA composition. Like the other animals and plants, human being does not only receive fatty acids through food, but is also able to synthesize the SFA and certain UFA. However, contrary to the plants, he cannot synthesize the n-6 (linoleic) and n-3 (linolenic) PUFA therefore we have to receive them through food. In terms of use and composition, vegetable fats and oils are most often divided into groups with similar content of fatty acids. Olive oil belongs to the group of oils with predominant oleic acid and small amount of PUFA. As the table 1 shows, the oleic acid content was in both analyzed samples above 70% (73.61% and 74.79%) which is the highest% from all of the assessed oils. Olives contain around 50% of oil. The content of other fatty acids there is significantly lower what guarantees longer shelf life and limpidity of olive oil at low temperatures. It is used in food industry as a traditional salad oil with excellent oxidative stability. The research of **Blahová, (2011)** suggests its great antioxidant effects as it prevents cholesterol oxidation to harmful form. Rapeseed oil belongs to the group of oils with medium linolenic acid content. Our sample reached the value around 8% (8.76) which is rather high number. **Dejong and Lanari, (2009)** state linolenic acid content may vary in the range of 6-14%. In the sample of rapeseed oil we also measured a relatively high percentage of another essential fatty acid - linoleic acid (20.24%). However, the most represented PUFA in our sample is oleic acid (58.8%) what coincides with the data of several authors **(Šmidrkal et al., 2008; Velíšek and Hajšlová, 2009)**. From the content of ω-3 and ω-6 fatty acids is also apparent ideal ∑ n3/n6 ratio in the rapeseed oil (0.44 - tab. 2). Thanks to high acid content, rapeseed oil is used as liquid component of fat blends for the production of emulsified fats and shortenings. Fat content in the oilseed rape ranges from 40 to 44%. Oilseed rape is alongside with sunflower our most widespread oil crop, while cultivated are only varieties with reduced erucic acid content (up to max. 2%). According to the mentioned classification, sesame oil belongs to the group of oils without linolenic acid and with high essential linoleic acid content. This also implies a significantly high ∑ n6/n3 fatty acid ratio (136.2). Linoleic acid in our sesame oil sample reached value 40.94% from all of the fatty acids. Oleic acid achieved similarly high amount in the sesame oil (40.75%) and arachidonic acid reached the highest percentage from all of the evaluated oils. **Blahová, (2011)** points out to strong antioxidant effect of sesamol which may be found in Indian sesame seeds. Sesame oil has a soft taste and does not subject to oxidation.

Pumpkin seed oil belongs to the same group as sesame oil, while we measured there the highest essential linoleic (46.4%) and lowest linolenic acid content (0.17%). ∑ n6/n3 fatty acid ratio is much higher (275.68) than in sesame oil.

Table 1 Fatty acids composition in selected vegetable oils [%].

Fatty acids [%]	Evaluated oils					
	Sesame oil	**Flaxseed oil**	**Olive oil**	**Olive oil Minerva**	**Rapeseed oil**	**Pumpkin seed oil**
Myristic acid	0	0	0	0	0	**0.11**
palmitic acid	9.56	5.38	11.01	**11.91**	4.68	11.61
palmitoleic acid	0.14	0.07	0.59	**0.79**	0.14	0.11
heptadecenoic acid	0	0	0	0	0	**0.07**
cis-10-heptadecenoic acid	0	0	0	0	**0.11**	0
stearic acid	5.85	4.29	2.62	2.85	1.60	**6.62**
oleic acid	40.75	17.51	**74.79**	73.61	58.81	32.68
linoleic acid	40.94	15.11	7.01	6.51	20.24	**46.40**
α-linolenic acid	0.30	**56.02**	0.69	0.68	8.76	0.17
Arachidonic acid	**0.62**	0.14	0.45	0.48	0.55	0.46
cis-11-eicosenoic acid	0.16	0.11	0.33	0.28	**1.11**	0.08
cis-11,14-eicosenoic acid	0	0	0	0	**0.08**	0
behenic acid	0.11	0.11	0.13	0.15	**0.32**	0.12
lignocericacid	0.09	0	0	0	**0.17**	0.07
cis-4,7,10,13,16,19-docosahexaenoic acid	0	0	0	0	**0.15**	0

Table 2 Oil assessment from the viewpoint of the fatty acids summary composition.

Summary composition of FA [%]	Evaluated oils					
	Sesame oil	Flaxseed oil	Olive oil	Olive oil Minerva	Rapeseed oil	Pumpkin seed oil
PUFA	41.24	**71.13**	7.69	7.19	29.23	46.57
MUFA	41.05	17.69	**75.72**	74.69	60.16	32.87
SFA	16.24	9.92	14.22	15.40	7.33	**19.07**
∑ n3/n6 ratio	0.01	**3.71**	0.10	0.10	0.44	0.003
∑ n6/n3 ratio	136.20	0.27	10.19	9.58	2.28	**275.68**

Harperová, (2004) refers to extraordinary positive effects of pumpkin seed oil to digestive tract. Traditional flaxseed oil is one of the oils with high α-linolenic acid content. This acid is the main component of leaves, especially of algae and higher plants photosynthetic apparatus. In flaxseed oil is commonly in a quantity up to 65% and our sample showed amount of 56.02% what only confirms very high presence of α-linolenic acid in this oil. **Brát, (2014**) also points out to high α-linolenic acid content, which may in terms of flaxseed oil shelf life cause some problems during food processing. If the oil is not stored cool resp. without light and oxygen access, this will result in fatty acids change to undesirable trans-isomers. Flaxseed oil is primarily the richest omega-3 fatty acids source, which mainly serve as immunity and endocrine glands support and they also ease the water excretion via kidneys. High ∑ n3/n6 ratio (56.02/15.25) was confirmed in our sample too. The presence of oleic acid in flaxseed oil sample represented the lowest number (17.51%) from all of the evaluated oils and so did palmitoleic acid (0.07%).

CONCLUSION

Plants oils are important energy source and their composition is necessary for the human body. They are a source of unsaturated fatty acids, phytosterols, vitamin E. Each type of oil is specific in composition. Their common features normally associated with a high percentage of unsaturated fatty acids, and the absence of cholesterol.

From the evaluation of plant oils, the highest content of saturated fatty acids was measured in pumpkinseed oil (19.7%). The relatively low proportion of saturated fatty acids was reflected in rapeseed oil (7.3%). This oil was represented the broadest range of saturated fatty acids.

From the unsaturated fatty acid had a high presence of oleic acid, olive oil (more than 70%) and rapeseed oil (more than 50%), reflected on the values of MUFA (75.7% in olive oil) and 60.2% rapeseed oil. These oils also had the lowest content of polyunsaturated fatty acid of 7.7% PUFA in olive oil and 29.2% rapeseed oil. From the results it can be confirmed that the pumpkin and sesame oil are classified in the group of oils rich for linolenic acid. This indicated also a high ratio Σn6 / n3 fatty acids (275.7 to 136.2 pumpkinseed oil and sesame oil). PUFA highest proportion (71.13%) was shown in flaxseed oil, in which the ALA content was found at 56%, but this can cause problems during processing and storage of flaxseed oil. From this reason is necessary storage this oil in the dark place, which decrease change for trans-isomers.

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