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FORMULATION OF SUNFLOWER AND FLAXSEED OIL BLENDS RICH IN OMEGA 3 FATTY ACIDS

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Summary

The recommendations of the World Health Organization (WHO) are aimed at increasing the consumption of foods rich in omega 3 fatty acids. The recommended ratio of omega 6 and omega 3 fatty acids in diet is 4-10 : 1, which allows muscle building, hormone production, reduces risk of the cardiovascular diseases, reduces blood pressure, triglyceride concentrations, improves brain functions, mood, intelligence etc. However, just some foods (eg. flaxseed oil, fish oils etc.) are rich in these compounds. The aim of this study was to examine the possibility of enriching refined sunflower oil (RSO) with omega 3 fatty acids by adding cold pressed flaxseed oil (CPFO). Samples: refined sunflower oil, cold pressed flaxseed oil, their blends in the mass ratio 70:30, 50:50 and 30:70 were analised, and the obtained results were compared with the one comertial vegetable oil blend present on the market of R. Serbia. The content of saturated fatty acids in analysed samples ranged from 9.63 to 10.3 2%, monounsaturated from 17.15 to 30.44 % and polyunsaturated from 59.78 to 73.15 %. The ratio of omega 6 : omega 3 fatty acids found in the samples was between 853 : 1 and 0.33 : 1.

Keywords: oil blends, flaxseed oil, omega 6 : omega 3 ratio

Introduction

A large number of health problems are closely related to inadequate composition of fatty acids in the diet. Essential fatty acids are polyunsaturated fatty acids with 18, 20 and 22 carbon atoms and containing 2 to 6 double bonds. All double bonds have *cis* konfiguration. Humans can not synthesize fatty acids which in alkyl chain have double bonds after 10th carbon atom. Deficit of essential fatty acids in human body is clinicaly exposed as disturbance of growth and skin changes. Brain is particulaty sensitive on a lack of essential fatty acids (Dimic, 2005).

Omega 3 fatty acids protect from cardovascular diseases through the modification of cell membrans' phospolipids and helpig the creation of eicosanoids (Nair et al., 1997). Having a diet rich in omega 3 prevents from inflammatory reactions (Serraino and Thompson, 1991), atherosclerosis and high blood pressure (Rotondo, 1995; Harris, 1997), also strengthens immunity, even helps with autoimmune diseases (Parbtani and Clark, 1995).

From the nutritional point of view, the ratio of essential omega 6 and omega 3 fatty acids is very important, and recommended healty ratio ranges from 4 : 1 to 10 : 1 (Lepsanovic and Lepsanovic, 2000). The most represented oil in the Serbian market is sunflower oil because of the availibility of the raw material and its price. Sunflower oil is source of omega 6 fatty acids and it doesn't contain omega 3 fatty acids. On the other hand, flaxseed oil is rich in omega 3 fatty acids and with affordable price. Flaxseed oil differs from other commercial oils due to the very high contribution of ALA (alpha - linolenic fatty acid), which is usually in concetration above 50% (Przybylski, 2005). Due to the high content of this "unique" fatty acid, flaxseed oil is often used as a dietary supplement, in cases where it is necessary to enrich diet with omega-3 fatty acids such as alpha-linoleic fatty acid. Flaxseed oil contains small amounts of saturated fatty acids compared to soy and sunflower oil (Przybylski, 2005; Shukla et al., 2002).

The way to get to the recommended healty ratio of omega 3 and 6 fatty acids is to make blends of oils rich in those acids. Mostafa et al. (2013) investigated seven blends formulated from flaxseed, olive and canola oil. Blends were different in content of omega 3 to 6 and omega 9 to 6 to 3 fatty acids ratio. The aim of this study is to examine the possibility of enriching refined sunflower oil with flaxseed oil. The mathematical model of the dependence of the share of flaxseed oil in the blend and the ratio of omega 6 and omega 3 fatty acids will be formed. In this way, it will be possible to calculate which is the share of flaxseed oil most preferred from the aspect of the ratio of omega 3 and omega 6 fatty acids.

Materials and methods

Materials: For the purposes of this study, six samples were used: two initial sampls: refined sunflower oil (RSO), cold pressed flaxseed oil (CPFO), three blends from this two oils and one commercially available blend from the market, according to the list shown in Table 1. Blended vegetable oils were obtained by blending refined sunflower seed oil (S) and cold

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pressed flaxseed oil (F), in appropriate proportions, bought in the local store. The required mass of the oil is carefully measured into a 1000-ml glass beaker, using a glass stick. The oil which was present in the blend in lower proportion was added into the beaker first, following the oil present in the blend in higher proportion. The oils were blended with a magnetic stirrer and immediately transferred to PET bottles of 500 ml volume which were completely filled with oil (without empty space), sealed with an original seal, and the oil was stored at 4 °C before testing.
The obtained results are compared with the results obtained by the analysis of the sample 6 which represents a commercially available blend of three refined vegetable oils: rapeseed, sunflower and corn oils, in decreasing order. The ratio of these oils in the blend is not known. This oil is the only avaible blended oil rich in omega 3 fatty acids in the Serbian market.

Table 1. Labels and identification of samples

Sample	RSO (%)	CPFO (%)
1	100	0
2	70	30
3	50	50
4	30	70
5	0	100
6	-	-

Methods: The fatty acids composition in oils was determined by the application of gas chromatography - Mass Spectrometry (GC-MS) (according to SRPS EN ISO 12966-2: 2015 and SRPS EN ISO 12966-2: 2017) using the HP 5890 gas chromatograph with HP 5971A mass detector ("Hewlett Packard", USA). All determinations were done in three repetitions. Based on the fatty acids composition, the content of saturated, monounsaturated and polyunsaturated fatty acids and their ratio, as well as the ratio between omega 6: and omega 3 fatty acids and ratio between omega 3 ratio: omega 6: omega 9, were calculated. The results are presented as the mean ± standard deviation, and the differences between the results were tested using the Student t-test with a level of significance of 95%. Statistical analyse of the obtained results and graphical representations were made using Microsoft Excel 2010 (Microsoft, Washington, USA) and Statistica 13.0 (StatSoft, Tulsa, USA).

Results and discussion

Flaxseed oil is rich in alpha linolenic fatty acid and is the source of omega 3 fatty acids, while sunflower oil is rich in linoleic acid and is the source of omega 6 fatty acids. Orsavova et al. (2015) determinated the next fatty acid content in sunflower oil: SFA 9.4%, MUFA 28.3% and PUFA 62.4%. 62.2% of total fatty acid content made omega 6 and 0.16 % made omega 3 fatty acids. Omega 6 and 3 ratio was 311:1. Guimaraes et al. (2013) investigated the nutritional value of flaxseed and sesame oil. The content of SFA, MUFA and PUFA in flaxseed oil was 9.97%, 18.0%, 52.24%, respectively. Founded amount of omega 6 fatty acids was 12.34% while amount of omega 3 fatty acid was 39.90%. Omega 6 and 3 ratio was 0.31:1.
The results of the fatty acids analysis of sunflower and flaxseed oil in this study were in agreement with those stated in literatures, as shown in Tables 2 and 3. Results of analysis obtained of their blends are between the results of individual oils (sample 1 and 5). Among the tested blends the highest content of saturated fatty acids was found in the sample 2, while the smallest content was found in the sample 4. Sunflower oil is rich in monounsaturated linoleic acid, so the highest content of monounsaturated fatty acids was found in the sample 1 and it was in amount of 30.44 ± 0.07 %. With the reduction of RSO content in blends, the content of monounsaturated fatty acids was reduced to 17.15 ± 0.02 % found in initial cold pressed flaxseed oil. The highest content of polyunsaturated fatty acids was found in the sample 5 and in amount of 73.15 ± 0.09 %. Flaxseed oil is rich in polyunsaturated alpha linolenic acid, so with the reduction in the content of flaxseed oil in the blends, the content of polyunsaturated fatty acids was reduced to 59.78 ± 0.02 %, found in initial refined sunflower oil.The content of saturated and monounsaturated fatty acids in the sample 6 was significantly lower compared to the tested blends, with only 6.41 ± 0.04 % (SFA) and 28.48 ± 0.02 % (PUFA), while the content of monounsaturated fatty acids was considerably higher, 65.10 ± 0.02 %.

Table 2. The content of saturated, monounsaturated and polyunsaturated fatty acids in the tested blends and their ratio

Sample	SFA (%)	MUFA (%)	PUFA (%)	SFA:MUFA:PUFA
1	9.78 ± 0.05	30.44± 0.07	59.78 ± 0.02	1 : 3.11 : 6.16
2	10.32 ± 0.04	26.86 ± 0.06	62.82 ± 0.02	1 : 2.60 : 6.09
3	9.88 ± 0.01	23.97 ± 0.02	66.15 ± 0.01	1 : 2.43 : 6.70
4	9.63 ± 0.00	21.31 ± 0.05	69.06 ± 0.05	1 : 2.21 : 7.17
5	9.70 ± 0.07	17.15 ± 0.02	73.15 ± 0.09	1 : 1.77 : 7.54
6	6.41 ± 0.04	65.10 ± 0.02	28.48 ± 0.02	1 : 10.15 : 4.44

Table 3. The content of omega 3, 6 and 9 fatty acids as well as their ratio in the tested blends

Sample	n-3 (%)	n-6 (%)	n-9 (%)	n-3 : n-6 : n-9	n-6 : n-3	n-3 : n-6
1	0.07 ± 0.00	59.71 ± 0.02	30.36 ± 0.07	1 : 853 : 433.71	853 : 1	0.00 : 1
2	14.48 ± 0.03	48.34 ± 0.01	26.75 ± 0.06	1 : 3.34 : 1.85	3.34 : 1	0.30 : 1
3	26.02 ± 0.00	40.13 ± 0.00	23.92 ± 0.02	1.09 : 1.68 : 1	1.54 : 1	0.65 : 1
4	36.93 ± 0.07	32.13 ± 0.02	21.26 ± 0.05	1.74 : 1.51 : 1	0.87 : 1	1.15 : 1
5	54.84 ± 0.12	18.31 ± 0.03	17.11 ± 0.02	3.20 : 1.07 : 1	0.33 : 1	2.99 : 1
6	4.78 ± 0.00	23.70 ± 0.02	65.00 ± 0.02	1 : 4.96 : 13.6085	4.96 : 1	0.20 : 1

The content of omega 3, 6 and 9 fatty acids as well as the ratio of these acids in the blends is shown in Table 3.

The determined content of omega 3 fatty acids was the highest in the initial sample of flaxseed oil and was 54.84 ± 0.12 %, while the expected lowest content was found in the initial sunflower oil as it was expected and was only 0.07 ± 0.00 %. With omega 6 fatty acid content, the situation was reversed. The highest content was found in the sample 1 and was 59.71 ± 0.02 %, while the lowest value was determined in the sample 5 and was 18.31 ± 0.03 %. The highest content of omega 9 fatty acids was found in the sample 1 and amounted to 30.36 ± 0.07 %, while the lowest amount was found in the sample 5 and was 17.11 ± 0.02 %. Blended vegetable oil 6 is significantly different in the content of omega 3, 6 and 9 fatty acids compared to the tested blends and the content of omega 3 and omega 6 fatty acids was significantly lower and amounts 4.78 ± 0.00 % and 23.70 ± 0.02 %, respectively. The content of omega 9 fatty acids in this oil is higher than the content of these acid in the tested blends and amounts to 65.00 ± 0.02 %. The ratio of omega 6 and omega 3 fatty acids is 4.96, which is in line with recommendations (Lepsanovic and Lepsanovic, 2000).

Based on the results determinated with t-test with 95% probability it is concluded that there is no statistically significant difference in the total amount of saturated fatty acids between samples 1 to 5 ($p>0.05$). Also has been established that there is a statistically significant difference in the total amount of monounsaturated fatty acids ($p<0.05$), except between samples 2 and 3 where no statistically significant difference was found ($p=0.012$). Samples 4 and 5 are not significant differnet in content of polyunsaturated fatty acids ($p=0.015$) while all the other samples have significant differece. In the n-3, n-6 and n-9 content was found a statistically significant difference between all samples, except between samples 2 and 3 where in n-9 content wasn't found statistically significant difference ($p=0.013$).

The dependence of flaxseed oil content in blends ($\omega_{\%CPFO}$) and the ratio of omega 6 and omega 3 fatty acids ($\omega_{n\text{-}6/n\text{-}3}$) is described by the logarithmic function:

Eq. 1. Logarithmic dependence of flaxseed oil content in blends ($\omega_{\%CPFO}$) and the ratio of omega 6 and omega 3 fatty acids ($\omega_{n\text{-}6/n\text{-}3}$)

$$\omega_{\%CPFO} = -10.9 \ln(\omega_{n\text{-}6/n\text{-}3}) + 65.689 \quad (R^2 = 0.792) \qquad (1)$$

Based on the recommended ratio of omega 6 and omega 3 fatty acids in the diet of 4-10:1, using the obtained dependence, it has been determined the most optimal ratio of vegetable oils in the blend. The most favorable content of cold pressed flaxseed oil in the blend is from 40.59 to 50.58 %, ie. the share of refined sunflower oil from 59.41 to 49.42 %.

The results of cluster analysis of samples of blended vegetable oils obtained from the calculated values shown in Tables 2 and 3 are shown using the dendrograms in Fig. 1. The results of clustering were obtained by the minimum variance method by the Ward's method, and the clustering is based on Euclidean distances. On the dendrogram two separate subclasses are allocated. In the first subclass, the difference between samples (5, 4 and 3), expressed as Euclidean distance, ranges from 14.4 to 38.1, while the difference between the samples in the second subclass (sample 1 and 2) is 19.3. It is concluded that sample 3 and 4 are the most similar according to data shown in Table 2 and 3, value of Euclidean distance between sample 3 and 4 is the lowest (14.4). Similar to this two samples is sample 5, but values of Euclidean distances between sample 5 and samples 3 and 4 are higher, 38.1 and 23.8, respectively.

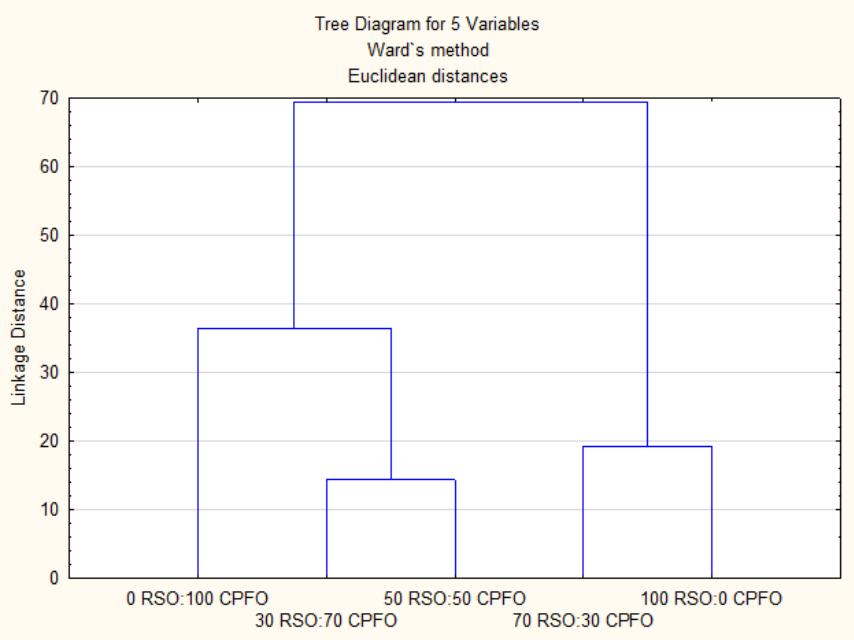

Fig. 1. Dendrogram of the hierarchical cluster analysis of the tested samples based on content of SFA, MUFA, PUFA, n-3, n-6, n-9 and n-3 : n-6 ratio

Conclusions

Blending vegetable oils with certain properties directly affects the improvement of certain oil characteristics. With the addition of cold pressed flaxseed oil in refined sunflower oil, the optimal ratio of omega 6 and omega 3 fatty acids can be achieved. Using the logarithmic function of the dependence between the ratio of omega 6 and omega 3 fatty acids and the share of cold pressed flaxseed oil in blends, it is determined that the preferred blending ratio of these two vegetable oils is one in which the proportion of cold pressed flaxseed oil is between 40.59 and 50.58%.

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