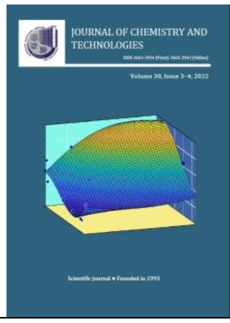
Journal of Chemistry and Technologies

pISSN 2663-2934 (Print), ISSN 2663-2942 (Online).

journal homepage: http://chemistry.dnu.dp.ua



UDC 621.892.31

FORMATION OF PRELIMINARY OIL BLENDS BASED ON FATTY ACID COMPOSITIONS OF OIL-BEARING SOURCES

Jahongir H. Hasanov[1*], Sherzod D. Mirzahmedov[2], Nodir Berdiev[1], Shavkat I. Salikhov[1]

[1]*Laboratory of Chemistry of Proteins and Peptides, Institute of Bioorganic Chemistry, Academy of Sciences of Uzbekistan, Mirzo Ulug'bek 83, 100125, Tashkent, Uzbekistan*

[2]*Department of service technique, Tashkent state technical university named after Islam Karimov, University 2, 100011, Tashkent, Uzbekistan*

Received 1 September 2022; accepted 18 October 2022; available online 26 January 2023

Abstract

Fatty acid profiles of oil-bearing sources have different structures and percentages. No individual oil follows recommendations of ratios of SFA : MFA : PFA (1 : 1.5 : 1). The aim of our study is to create blends of oils from local raw materials with optimal fatty acid composition of polyunsaturated fatty acids (PUFA) omega 6 and omega 3 and SFA ratio: MUFA: PUFA. For the study dog-rose (Rosa Canina) seed, flax (Linum usitatissium), walnut (Juglans nigra), soybean (Glycine max), canola (Brassica napus) and rice (Oryza sativa) bran oils were selected. Flax oil has been mixed with soybean and canola oils in various proportions such as 25 : 75, 35 : 65, 45 : 55 (v/v) respectively. Flax, canola and dog-rose oil's omega 6 : omega 3 fatty acids ratios were 0.28, 1.6 and 1.76 respectively, which are follow omega 6: omega 3 fatty acids optimum ratios. All oil blends followed the recommended diapasons of omega 6: omega 3 fatty acid ratios. However, flax and soybean oil blend's SFA: MUFA: PUFA ratios appeared as 1 : 1.99 : 5.32, 1 : 1.94 : 5.3, 1 : 1.9 : 5.38, flax and canola oil blends demonstrated 1 : 3.98 : 7.22, 1 : 4.74 : 6.43, 1 : 5.03 : 6.11 respectively. These studies show that oil blending is an interesting and economical beneficial method to improve nutritional value of oil species.

Keywords: Essential fatty acids; omega 6: omega 3 ratio; PUFA: MUFA: SUFA ratios; oil blending.

ФОРМУВАННЯ ПОПЕРЕДНІХ ОЛІЙНИХ СУМІШЕЙ НА ОСНОВІ ЖИРНОКИСЛОТНОГО СКЛАДУ ОЛІЙНОЇ СИРОВИНИ

Джахонгир Х. Гасанов[1*], Шерзод Д. Мірзахмедов[2], Нодір Бердієв[1], Шавкат І. Саліхов[1]

[1]*Лабораторія хімії білків і пептидів, Інститут біоорганічної хімії Академії наук Узбекистану, вул. Мірзо Улугбека 83, 100125, Ташкент, Узбекистан*

[2]*Кафедра техніки сервісу, Ташкентський державний технічний університет імені Ісламa Карімова, Університетська 2, 100011, Ташкент, Узбекистан*

Анотація

Композиції рослинних жирних кислот мають різну структуру та склад. Жодна з цих олій не відповідає рекомендаціям щодо співвідношення НЖК : МНЖК : ПНЖК (1 : 1.5 : 1). Метою нашого дослідження є створення купажів олій з місцевої сировини для досягнення оптимального жирнокислотного складу поліненасичених жирних кислот (ПНЖК) омега 6 і омега 3 та співвідношення СЖК : МНЖК : ПНЖК. Для дослідження були обрані олії насіння шипшини (Rosa Canina), льону (Linum usitatissium), волоського горіха (Juglans nigra), сої (Glycine max), ріпаку (Brassica napus) та рисових висівок (Oryza sativa). Лляна олія була змішана з соєвою та ріпаковою оліями в пропорціях 25 : 75, 35 : 65, 45 : 55 (v/v) відповідно. Співвідношення жирних кислот омега 6 : омега 3 в олії льону, ріпаку та шипшини становило 0.28, 1.6 та 1.76 відповідно, що відповідає оптимальному співвідношенню жирних кислот омега 6 до омега 3. Всі олійні суміші відповідали рекомендованим діапазонам співвідношення омега 6 : омега 3 жирних кислот. Однак співвідношення ПНЖК : МНЖК : ПНЖК у суміші льону та соєвої олії становило 1 : 1.99 : 5.32, 1 : 1.94 : 5.3, 1 : 1.9 : 5.38, а у суміші льону та ріпакової олії – 1 : 3.98 : 7.22, 1 : 4.74 : 6.43, 1 : 5.03 : 6.11 відповідно. Ці дослідження показують, що змішування олій є цікавим та економічно вигідним методом покращення поживної цінності різних видів олії.

Ключові слова: незамінні жирні кислоти; співвідношення омега 6 : омега 3, співвідношення ПНЖК : МНЖК : НЖК, купажування олій.

**Corresponding author: e-mail address: hasanovjahongir1980@gmail.com*
© 2022 Oles Honchar Dnipro National University;
doi: 10.15421/jchemtech.v30i4.263838

Introduction

Edible oils mainly serve as an energy source of human body, carrier of fat-soluble vitamins, essential fatty acids (FAs) and include A, D, E, K vitamins [7; 9; 21]. Polyunsaturated fatty acids (PUFAs) omega 3 and omega 6 play the leading part in human nutrition and may help in preventing such diseases as asthma, brain dysfunction, cardiovascular problems and arthritis. The lack of omega 3 FA leads to neurological disbalances, growth problems as well as the lack of the omega 6 FA may cause growing issues and dermatitis [6; 12; 17; 19; 26].

Recently, "essential" fatty acids have been considered as a functional food, and the studies of the biochemistry revealed anti-estrogen, antithrombotic and anti-inflammatory effects decreasing harms of serious illnesses such as diabetics, cancer and the problems of body support systems. Moreover, some studies reveal profits of "essential" fatty acids for cognitive functions, cardiovascular, eye health, as well as childhood and pregnancy [2; 14].

Overcoming health issues depends not only on consumption of the kind of substances but it should be paid more attention on proper intake of them. Omega 3 (α-Linolenic acid) and Omega 6 (Linoleic) are not synthesized by human body, so these fatty acids have to be accepted via food. Omega 3 and omega 6 fatty acids of plant oils can be converted to DHA and EPA [8; 27]. However, omega 6: omega 3 ratio should be regulated to avoid health issues. Higher rates of omega 6: omega 3 ratios promote the pathogenesis of diseases such as cancer, inflammatory and autoimmune diseases. So, recent recommendation for consumption of omega 6: omega 3 ratio is below 4 [3; 23–25]. However, our local diet contains higher ratio of omega 6: omega 3. This may be connected with geographical conditions and traditional eating habits. Therefore, local sources of oily materials can be studied in the direction of mentioned recommendations and it should be avoided the consumption of inadequate ratios of essential fatty acids. Additionally, the World Health Organization (WHO) suggests saturated, mono- and poly-unsaturated fatty acids ratios at 1 : 1.5 : 1 [29], but no individual oil meets these nutritional requirements.

Proper blending of oil and fats can meet nutritional requirements [1]. Blended oils are prepared by mixing two or more oil species in a specific proportion following consumption needs. Blending oils can change the profile of fatty acids for human necessities. Moreover, blending of oil not only supports balanced nutrition intake, but also improves human health as well as reduces suffering certain types of health disorders [16]. According to [11], consumption of blends of flax with canola (high oleic) oils is cardioprotective due to lipid-lowering effect.

In this connection, we aimed to create oil blends of commercial level from local grown oil-bearing materials. Additionally, the fatty acids compositions of waste materials such as dog-rose (Rosa Canina) seed, rice (Oryza sativa) bran oils have been studied; they include valuable oils and were not studied locally.

Materials and methods

Our research design was developed for the goal of studying the fatty acid composition of local oil-bearing materials and their oil blends.

Seeds and extraction process. Dog-rose (Rosa Canina) seed, flax (Linum usitatissium), walnut (Juglans nigra), soybean (Glycine max), canola (Brassica napus) and rice (Oryza sativa) bran were brought from commercial plantations and industries located in Uzbekistan: Namangan (40^0 59′43'' N, 71^0 40′ 21″ E), Kashkadarya (39^0 30′ 0″ N,64^0 34′ 0″ E) and Tashkent (41^0 19′ 0″ N, 69^0 15′ 0″ E) regions. Some materials were cleaned, milled and extracted.

Blending of oils. Oil blends were prepared using local flax oil with soybean and canola oils in the proportions of 25:75, 35:65, 45:55 respectively. The proportion levels were chosen randomly. The methodology used by authors [5] was applied for local oil blending.

Analysis of FAME and preparation. The **f**atty acid composition of oil samples was determined by applying «Agilent Technology» GC 7890B/ MS 7000D, DB-FATWAX UI, capillary column (30 m x 0.25 mm i.d., 0.25 µm film thickness). The carrier gas was helium. The temperature program of the column was started from 170 °C and hold during 2 min, then it was raised with heating rate 4 °C /min till 280 °C and hold during 5 min. Detector and vaporization temperature were 280 °C. Fatty acid methyl esters (FAMEs) were prepared. 0.1 g oil sample was used with nitrogen protection, 1 ml toluol and 1 ml BF_3-MeOH reagent was added in the flask. The solution was heated in water bath and maintained at 60 °C for 10 min; then it was cooled at room temperature. Bidistilled (1 ml) water was added to the resulted solution and mixed during 5 minutes. The injection volume of the sample was 0.1µl.

Statistical analysis. Experiments were repeated twice, and the mean values were reported with ± standard deviations.

Results and discussion

The fatty acid composition of the local oil-bearing materials was analyzed applying GC-MS. Obtained results of fatty acid profile of local oil species are presented in the Table.

Table

Fatty acid composition of local oils

Fatty acids	Oil samples					
	CO	**RBO**	**DGSO**	**WO**	**FO**	**SBO**
Miristic	0.19±0.02	0.33±0.01	0.05±0.00			
Palmitoleic			0.14±0.01	6.72±0.89		
Pentadecanoic			0.03±0.00			
Palmitic	5.24±1.06	22.58±1.83	4.95±0.79		6.95±1.03	9.4±0.97
Margaric			0.05±0.00			
Linoleic	16.1±1.29	24.49±1.38	49.7±2.89	58.67±3.31	15.2±1.23	55.24±4.12
Linolenic	10.02±0.9	1.85±0.32	28.14±0.89	6.03±1.1	52.58±3.36	7.48±0.78
Oleic	65.15±4.49	46.94±2.79	13.44±0.99	25.12±2.03	19.98±1.19	25.33±1.74
Stearic	1.51±0.36	2.48±0.29	1.54±0.12	3.46±0.78	5.2±1.01	2.55±0.29
Behenic acid	0.42±0.03		0.11±0.01		0.07±0.00	
Arachidic	0.48±0.01	0.75±0.05	0.55±0.04		0.02±0.00	
Erucic acid	0.16±0.01					
Lignoceric		0.58±0.03				
SFA	7.84	26.72	7.28	3.46	12.24	11.95
MUFA	65.31	46.94	13.58	31.84	19.98	25.33
PUFA	26.85	26.34	77.84	64.7	67.78	62.72
omega6:omega3	1.6	13.23	1.76	9.72	0.28	7.38
SFA: MUFA: PUFA	1:8.33:3.33	1.01:1.78:1	1:1.86:10.69	1:9.2:18.69	1:1.63:5.53	1:2.11:5.24

Values are means of duplicate ± standard deviation. CO-canola oil, RBO-rice bran oil, DGSO-dog-rose seed oil, WO-walnut oil, FO-flax oil, SBO-soybean oil.

It is well known that geographical region, climate, extraction method and genotype of oil source may influence on oil fatty acid profile. We have selected oily sources with higher unsaturated fatty acids which have been grown in our geographic regions, and some of them were not studied locally. Additionally, we aimed for seeking new blend types for the future even though they are not produced commercially.

It can be seen from the table 1 that canola oil includes the highest percentage of oleic acid 65.15 ± 4.49, followed by linoleic and linolenic ones 16.1 ± 1.29, 10.02 ± 0.9 respectively. The ratio of the omega 6: omega 3 of the canola oil is lower than the recommended value. However, MUFA and PUFA were higher than the SFA. Additionally, SFA: MUFA: PUFA ratio was 1:8.33:3.33, while rice bran oil contains the lowest quantity of linolenic acid (1.85±0.32) among studied oil samples. Content of oleic (46.94±2.79) and linoleic (24.49±1.38) fatty acids was higher than the other fatty acids content in rice bran oil. The omega 6: omega 3 ratio in rice bran oil has the highest level (13.23) and SFA: MUFA: PUFA are accounted for 1.01:1.78:1. The next specie was dog-rose (Rosa canina) seed oil; it was not recommended for eating purposes but some investigation has been done for using it on pharmacy [30] since this oil composition is valuable. The linolenic and linoleic fatty acids contents were 28.14 ± 0.89, 49.7 ± 2.89 respectively. In walnut oil the highest fatty acids were the linoleic (58.67±3.31) and linolenic (6.03 ± 1.1) ones, and omega 6: omega 3 ratio was 9.72. Moreover, the ratios of SFA: MUFA: PUFA were high as 1 : 9.2 : 18.69. Due to significant amount of the linolenic fatty acid (52.58 ± 3.36) as well as the linoleic one (15.2 ± 1.23) the flax oil was found predominated, and as a result omega 6: omega 3 ratio was 0.28. The flax oil contained the highest PUFA amount among the edible local oils, and ratio of the SFA: MUFA: PUFA was 1 : 1.63 : 5.53. Soybean oil fatty acid composition was dominated by the linoleic one (55.24 ± 4.12) and following was the oleic one (25.33 ± 1.74). The ratio of omega 6: omega 3 of soybean oil appeared as 7.38, while SFA: MUFA: PUFA ratios were accounted for 1:2.11:5.24. Studies on fatty acid profiles of selected oil-bearing sources were also carried out by other researchers [4; 11; 15; 18; 28; 31], and our results appeared close to theirs.

The ratios of omega 6: omega3, SFA: MUFA: PUFA influence on nutritional, qualitative, oxidative aspects and stability of the oils. The calculations of omega 6: omega 3, SFA: MUFA: PUFA ratios of oil species revealed that no

Journal of Chemistry and Technologies, 2022, *30*(4), 513-519

individual oil can follow the both recommendations at the same time directly. For instance, flax and canola oils are suitable in term of the essential fatty acid ratios but they do not meet recommendations of SFA: MUFA: PUFA ratios. Additionally, rice bran oil fatty acids content is close to recommendations of SFA: MUFA: PUFA ratios but omega 6: omega 3 ratio was the highest.

In this regard, flax, canola and soybean oils have been selected for blending due to the possibility of producing commercial oils for our local markets. Furthermore, flax oil was chosen to be mixed with soybean and canola oils, because of the lower SFA: MUFA: PUFA and omega 6: omega 3 fatty acid ratios rather than the rest of oil types that were selected for blending. The percentage of the oils that blended for each other's has been selected randomly for these preliminary our studies.

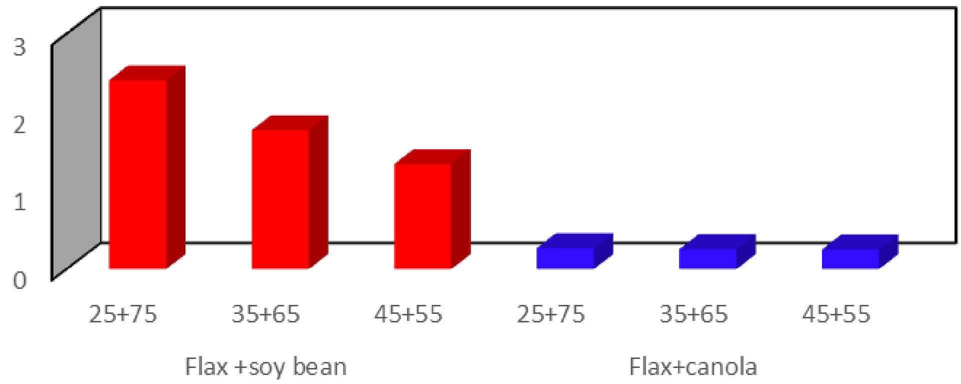
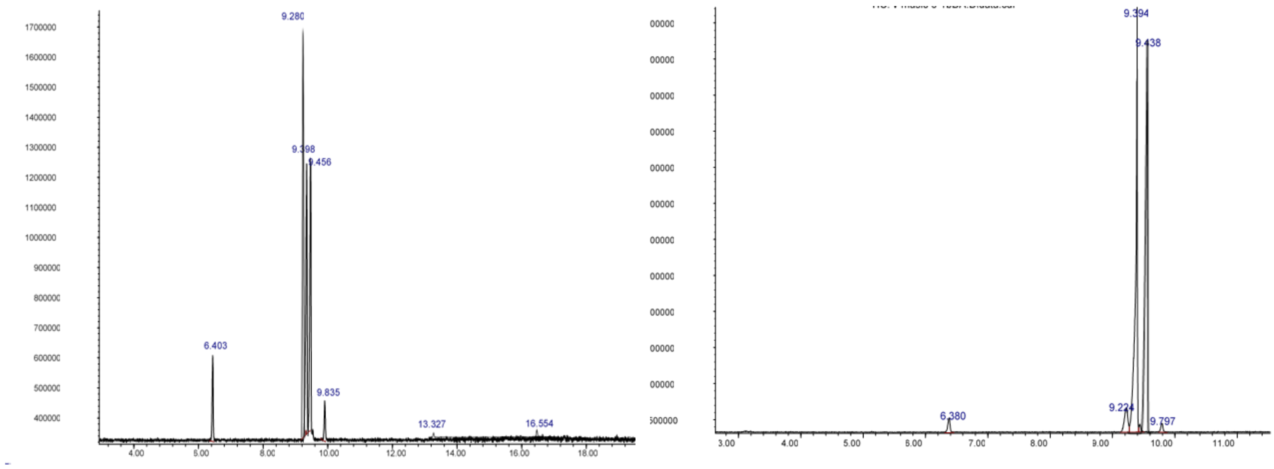


Fig. 1. Omega 6: omega 3 fatty acid ratios of oil blends of flax with soybean and canola

The results of omega 6: omega 3 fatty acids ratios of flax with soybean and canola oil blends were presented in Fig.1. The ratio of omega 6: omega 3 fatty acids of blend of flax with soybean oil decreased sharply from 2.4 to 1.34. Perhaps, this is due to the inverse differences of omega 6 and omega 3 FAs respectively.



a) flax seed oil+ soybean oil, 25+75 (v/v) **b) flax seed oil+canola oil 45+55 (v/v)**

Fig.2. Chromatogram of the oil blends

Contrary to this, omega 6: omega 3 FAs ratio of flax and canola oil blends demonstrated slight change where their numbers were fluctuated. The flax-canola oil blends observed in [20] conform to recommendations of omega 6: omega 3 FA ratios. Examples of the chromatogram of the 25+75 flax +soybean, 45+55 flax+canola oil blends are presented in Fig. 2.

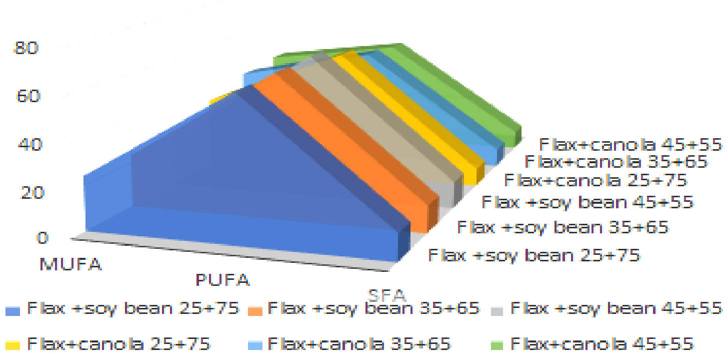


Fig. 3. Percentage of SFA, MUFA and PUFA of oil blends

As it revealed in Fig. 3, in some flax-soybean oil blends the amount of MUFA represented the tendency of decreasing percentage from 23.99 to 22.92 %, and flax-canola oil blends represented rise effects (32.6–41.3 %). Moreover, percentages of PUFA of flax-soybean oil blends demonstrated rise picture with small changes (63.99%, 64.44%, 64.99 %) but flax-canola blends' PUFA content shows decreasing tendency. The SFA of flax-soybean and flax-canola blends were changed scarcely, or some proportions were not changed.

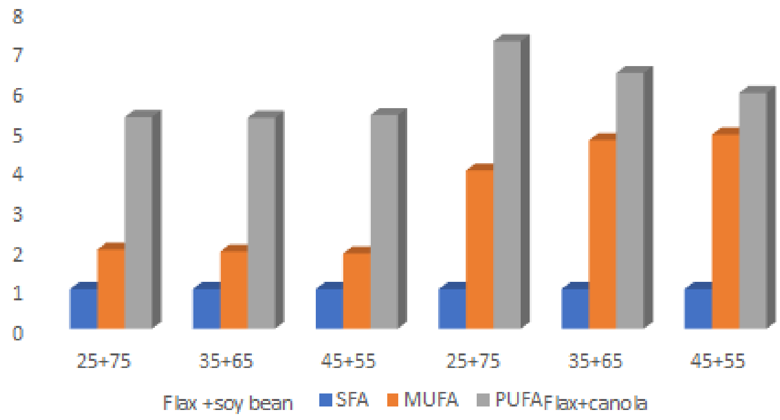


Fig. 4. SFA: MUFA:PUFA ratios of oil blends

In term of SFA: MUFA: PUFA ratios, flax and soybean oil blends demonstrated slow changes when proportion of flax oil increased. The SFA: MUFA: PUFA ratios appeared as 1:1.99:5.32, 1:1.94:5.3, 1:1.9:5.38, when flax oil amount raised (25 %, 35%, 45 %) in soybean oil respectively (Fig.4) but initial ratio of the SFA: MUFA: PUFA of soybean oil was 1:2.11:5.24. The ratios of the SFA: MUFA: PUFA changed considerably when mixing oils of flax and canola at the mentioned proportions as well. The SFA: MUFA: PUFA ratios of flax and canola oil blends changed sharply (1:3.98:7.22, 1:4.74:6.43, 1:4.88:5.93) as it is described in Fig.4. However, at the studied proportions SFA: MUFA: PUFA ratios were not so close to the recommended values. However, in [13] the linseed (flax seed) and soybean oil blend percentage is defined as 20 : 80, where SFA: MUFA: PUFA ratios are 1:1.4:4.6, what is close to the recommendations (1 : 1.5 : 1). Perhaps, this is connected with the geographical region's differences of the oil-bearing sources.

Conclusions

In the present study preleminary researhces have been performed for the goals of determing the fatty acid profiles of local oil-bearing materials and their blends. Six oil-bearing materials have been selected, and some of them were not used before as a source of oil at the local market. The blends of oils from local raw materials with an optimal fatty acid composition have been created, in which the ratio of omega 6: omega 3 is within the recommended values, namely, the blends of flax + soybean oil and flax + canola oil in certain percentages, while SFA: MUFA: PUFA were outside the recommendations, and the blends of linseed and soybean oils in percentage 35:65, while the ratio of PUFA: MUFA: PUFA was 1 : 1.94 : 5.3, which is close to the recommendations (1 : 1.5 : 1).

Acknowledgments

The authors are grateful for the support to the laboratory facilities of the Institute of Bioorganic Chemistry of the Academy of Sciences of Uzbekistan.

References

[1] Akriti., D, Rajni, C., Meenakshi Garg. (2018). A Review on Blending of Oils and Their Functional and Nutritional Benefits. *Chemical Science Review and Letters, 7*(27): 840–847.

[2] Arbex, A. K., Bizarro, V. R., Santos, J. C. S., Araújo, L. M. M., de Jesus, A. L. C., Fernandes, M. S. A., Marcadenti, A. (2015). The Impact of the Essential Fatty Acids (EFA) in Human Health. *Open Journal of Endocrine and Metabolic Diseases*, 5, 98–104. doi:10.4236/ojemd.2015.57013

[3] Artemis, P., Simopoulos, A. (2010). The omega-6/omega-3 fatty acid ratio: health implications. *Nutrition – Sante*, *17*(5): 267–275.

[4] Özcan, M.M., Erman, D., Sabire, D. (2020). Influence of refining stages on the physicochemical properties and phytochemicals of canola oil. *Journal of Food Processing and Preservation. 45*(2), e15164. https://doi.org/10.1111/jfpp.15164

[5] Choudhary M., Grover K., Kaur G. (2015). Development of rice bran oil blends for quality improvement. *Food Chem*, *177*, 770–777. https://doi.org/10.1016/j.foodchem.2014.10.051

[6] Lakdawala, N., Grant-Kels, J. M. (2017). Acrodermatitis caused by nutritional deficiency and metabolic disorders. *Clinics in dermatology*, 35(1), 64–67. https://doi.org/10.1016/j.clindermatol.2016.09.009

[7] Dorni, C., Sharma, P., Saikia, G., Longvah, T. (2018). Fatty acid profile of edible oils and fats consumed in India. *Food Chem*, *237*, 9–15. https://doi.org/10.1016/j.foodchem.2017.05.072

[8] Kshitij, B., Narsingh, V., Trivedi, R.K., Shipra, B., Neha, S. (2016). Significance of Ratio of Omega-3 and Omega-6 in Human Health with Special Reference to Flaxseed Oil. *International Journal of Biological Chemistry*, *10*, 1–6.

[9] El-Hamidi, M., Zaher, F. A. (2018). Production of vegetable oils in the world and in Egypt: an overview. *Bulletin of the National Research Centre*, 42, 19. doi:10.1186/s42269-018-0019-0

[10] Food fats and oils, http://www.iseo.org/foodfats.htm

[11] Matthaus, B., Özcan, M. M., Al Juhaimi, F. (2016). Some rape/canola seed oils: fatty acid composition and tocopherols. *Zeitschrift für Naturforschung C*, *71*(3-4). https://doi.org/10.1515/znc-2016-0003

[12] Grosso, G., Galvano, F., Marventano, S., Malaguarnera, M., Bucolo, C., Drago, F., and Caraci, F. (2014). Omega-3 Fatty Acids and Depression: Scientific Evidence and Biological Mechanisms. *Oxidative Medicine and Cellular Longevity*, 24757497. doi:10.1155/2014/313570

[13] Grover, S., Kumari, P., Kumar, A., Soni, A., Sehgal, S., Sharma, V. (2021). Preparation and Quality Evaluation of Different Oil Blends. *Lett. Appl. Nanob. Bo. Sci.*, *10*: 2126–2137

[14] Jacob, A. H., Charlisa, A. B., Mary, A., Paola, de S., Manuel, V. P. (2021). Improving the Cognitive Development of Children in Rural Areas as Development Tool. *Rural Development*, doi.org/10.5772/intechopen.97476

[15] Jahongir, H., Miansong, Z., Amankeldi, I., Yu, Z., Changheng, L. (2019). The influence of particle size on supercritical extraction of dogrose (Rosa canina) seed oil. *Journal of King Saud University - Engineering Sciences*, doi:10.1016/jjksues.2018.04.004

[16] Jiang, Q., Rao, X., Kim, C. Y., Freiser, H., Zhang, Q., Jiang, Z., Li, G. (2011). Gamma-tocotrienol induces apoptosis and autophagy in prostate cancer cells by increasing intracellular dihydrosphingosine and dihydroceramide. *International Journal of Cancer*, *130*(3), 685–693. doi:10.1002/ijc.26054

[17] Kaur, N., Chugh, V., Gupta, A. K. (2014). Essential fatty acids as functional components of foods- a review. *Journal of food science and technology*, 51, 2289–2303. https://doi.org/10.1007/s13197-012-0677-0

[18] Lutfor Rahman, M., Nurul Absar, Md., Ibrahim H. M., Hossan, M. K., Seatara Khatun, G.R.M., Astak, M K., Jahidul Islam, Md. (2013). Lipid, Fatty Acid and Glyceride Composition of Five Different Varieties of Rice Bran oil. *Bangladesh Res. Pub J*, *9*(2), 111–115

[19] Reimers, A., Ljung, H. (2019). The emerging role of omega-3 fatty acids as a therapeutic option in neuropsychiatric disorders. *Therapeutic Advances in Psychopharmacoly,* doi: 10.1177/2045125319858901.

[20] Mostafa, R. A., Moharram, Y. G., Attia, R. S., and El–Sharnouby, S. A. (2013). Formulation and characterization of vegetable oil blends rich in omega-3 fatty acids. *Emirates Journal of Food and Agriculture*, 32, 426–433

[21] Rana, A. Y., Alyaa, D., Omar, E., Mohamed, A. F. (2022). Fat-soluble vitamins: updated review of their role and orchestration in human nutrition throughout life cycle with sex differences. *Nutrition & Metabolism*, *19*, 60. https://doi.org/10.1186/s12986-022-00696-y

[22] Rabrenovic, B., Dimic, E., Maksimovic, M., Sobajic, S., Gajic-Krstajic, L. (2011). Determination of fatty acid and tocopherol compositions and the oxidative stability of walnut (Juglans regia L.) cultivars grown in Serbia. *Czech Journal of Food Sciences*, 29(1), 74–78. doi:10.17221/180/2010-cjfs

[23] Simopoulos A. P. (2006). Evolutionary aspects of diet, the omega-6/omega-3 ratio and genetic variation: nutritional implications for chronic diseases. *Biomedicine & pharmacotherapy*, 502–507. https://doi.org/10.1016/j.biopha.2006.07.080

[24] Simopoulos, A. (2016). An Increase in the Omega-6/Omega-3 Fatty Acid Ratio Increases the Risk for Obesity. *Nutrients*, *8*(3), 128. doi:10.3390/nu8030128

[25] Simopoulos, A. P. (2008). The Importance of the Omega-6/Omega-3 Fatty Acid Ratio in Cardiovascular Disease and Other Chronic Disease. *Experimental Biology and Medicine*, *233*(6), 674-88. doi:10.3181/0711-mr-311

[26] Fujii, M., Nakashima, H., Tomozawa, J., Shimazaki, Y., Ohyanagi, Ch., Kawaguchi, N., Ohya, S., Kohno, Sh., and Nabe, T. (2013). Deficiency of n-6 polyunsaturated fatty acids is mainly responsible for atopic dermatitis-like pruritic skin inflammation in special diet-fed hairless mice. *Experimental dermatology*, *22*(4), 272–277. doi: 10.1111/exd.12120

[27] Asif, M. (2011). Health effects of omega-3,6,9 fatty acids: *Perilla frutescens* is a good example of plant oils. *Orient. Pharm. Exp. Med., 11*, 51–59. https://doi.org/10.1007/s13596-011-0002-x

[28] Sultan, S. M., Dikshit, N., Vaidya, U. J. (2015). Oil content and fatty acid composition of soybean (Glysine max L.) genotypes evaluated under rainfed conditions of

Kashmir Himalayas in India. *Journal of Applied and Natural Science*, *7*(2), 910–915. doi:10.31018/jans.v7i2.706
[29] WHO. (2008). *Interim summary of conclusions & fatty acids. In The joint FAO/WHO expert consultation on fats & fatty acids in human nutrition*. Geneva.
[30] Menshov, P.N., Kaukhova, I.E., Bolotova, V.TS., Sergiyenko, A.V., and Zilfikarov I.N. (2015). Study of the gastroprotective activity of oil, obtained from rosehip seeds, Pharmasiya *4*(201), 172-175
[31] Caisheng, Q., Hong, W., Yuan, G., Songhua, L., Yufu, W., Arshad, M. A., Xinbo, G., Devra, I. J. (2020). Comparison of fatty acid composition, phytochemical profile and antioxidant activity in four flax (Linum usitatissimum L.) varieties. *Oil Crop Science*, *5*(3), 136–141. https://doi.org/10.1016/j.ocsci.2020.08.001.