Mikołajczak Natalia. FATTY ACIDS COMPOSITION OF SELECTED PLANT OILS OBTAINED FROM SEEDS AND STONES OF FRUITS AND THEIR IMPACT ON HUMAN HEALTH. Journal of Education, Health and Sport. 2018;8(8):1117-1132. eISNN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.1433685
http://ojs.ukw.edu.pl/index.php/johs/article/view/6070

The journal has had 7 points in Ministry of Science and Higher Education parametric evaluation. Part B item 1223 (26/01/2017).
1223 Journal of Education, Health and Sport eISSN 2391-8306 7

The authors declare that there is no conflict of interests regarding the publication of this paper.

Received: 03.08.2018. Revised: 12.08.2018. Accepted: 31.08.2018.

FATTY ACIDS COMPOSITION OF SELECTED PLANT OILS OBTAINED FROM SEEDS AND STONES OF FRUITS AND THEIR IMPACT ON HUMAN HEALTH

Skład kwasów tłuszczowych wybranych olejów roślinnych uzyskanych z nasion i pestek owoców oraz ich wpływ na zdrowie człowieka

Natalia Mikołajczak
Chair of Plant Raw Materials Chemistry and Processing
Faculty of Food Sciences, University of Warmia and Mazury in Olsztyn

University of Warmia and Mazury in Olsztyn,
Chair of Plant Raw Materials Chemistry and Processing
Pl. Cieszyński 1, 10-726 Olsztyn
e-mail: natalia.mikolajczak@uwm.edu.pl

Abstract

Introduction and aim: Oils are usually obtained (by pressing or extraction) from such plant raw materials as rapeseed, sunflower, flax and soy. Currently, there is an increasing interest among consumers of new types of oil obtained from non-traditional plant raw materials. A lot of attention is paid to seeds and stones of fruit, which are also the main by-product in the food industry. However, the use of seeds and stones of fruit as raw materials largely depends on the fat content and the fatty acid composition. Therefore, this article aims to collect literature data on the share of individual fatty acids in plant oils obtained from seeds and stones of fruits, also to present their impact on human health.
Brief description of the state of knowledge: Literature data on the share of fatty acids in oils obtained from seeds of fruits such as apples, pears, red raspberries, and from stones such as sour cherries, plums, apricots, were collected in tables. On their basis, parameters such as minimum (MIN) and maximum (MAX) values, mean value (MV), standard deviation (SD) were determined, and the coefficient of variation (CV) for particular acids was estimated. The share of unsaturated acids in oils obtained from seeds and stones of fruit was over 88% (sour

cherry stones oil) - 95% (red raspberry seeds oil). The share of C18:1 acid was in the range of 12.80% (red raspberry seeds oil) - 69.32% (plum stones oil), share of C18:2 acid 19.71% (plum stones oil) - 67.94% (apple seeds oil), and share of C18:3 acid 0.16% (plum stones oil) - 30.19% (red raspberry seeds oil). The share of saturated fatty acids in oils from seeds and stones of fruit was relatively low, in range of 4% (red raspberry seeds oil) - 12% (sour cherry stones oil), the main acid of this group was C16:0 acid (2.89% (red raspberry seeds oil) - 9.43% (sour cherry stones oil)). The share of other individual fatty acids from both this groups usually was lower than 1%. The ratio of fatty acids from n-3 and n-6 families ranged 1:1.75 (red raspberry seeds oil) - 1:237.76 (pear seeds oil).
Summary: Analysis of the literature data showed that oils from seeds and stones of fruits are a valuable source of unsaturated fatty acids (they play many important functions in the human body), in particular C18:1 and C18:2 acids. The share of saturated acids is low, only C16:0 occurs in significant quantities. The ratio of acids from the n-3 and n-6 families in oils (except for red raspberry seeds oil) is unfavorable, this limits its use in the food industry.

Key words: fatty acids composition, plant oils, fruit seeds, fruit stones, human health

Introduction

Plant oils are obtained from various parts of oil plants, in which the fat content is higher than 15% [37]. Due to the nature of raw materials and botanical parts of the plant it can be obtained from seeds, fruits, nuts, as well as sprouts [40]. The best-know oil plants cultivated on an industrial scale include rape, mustard, poppy, sunflower, flax, soy and maize [5].

According to Codex Alimentarius, cold pressed oils are obtained from oily raw materials by mechanical processes such as pressing, but the use of high temperature is excluded [9]. Only in the case of oils and fats of the virgin type, it is possible to use the elevated temperature to increase the extraction of the fat fraction [21]. Expeller presses are the main devices used in the process of oil pressing, they have replaced the previously used hydraulic presses due to the inability to produce in a continuous form [22]. An acceptable method of purification of plant oils obtained by cold pressing is washing with water, sedimentation, filtration and centrifugation [9]. Cold pressing is the oldest natural method of obtaining oil [30]. It is environmentally friendly due to the lack of the need to use chemical solvents, uncomplicated, and also cheap [47]. This method allows obtaining very high quality oil, because the use of low temperature does not cause, in principle, any qualitative changes in the extracted oil. The main, and also the only disadvantage of this process is the lower oil yield compared to the extraction process [48]. The extraction method is rarely used in industry as an independent method for obtaining oil. It usually occurs in the form of a combined method (mainly due to economic reasons), in which at the beginning of the pressing, and later extraction process is used [17]. Extraction oil is characterized by the presence of many pollutants due to the high capacity of the solvent (mainly hexane) to extract also the accompanying substances. As a consequence, this leads to the necessary use of additional oil refining processes (e.g. hydratation). The obtained oils, both after pressing and after extraction, are usually mixed and form so-called crude oil (pressed oil with a small admixture (1/3) of extraction oil) [48].

Every year, as a byproduct of food processing, a large number of different types of seeds are discarded [26]. Recently, there has been growing interest in oils from unconventional sources [28, 29], and by-products of the fruit and vegetable industry can be a good source of this type of oil [26]. Continuous expansion in the food industry pays particular attention to seeds and stones of fruit as a potential source of oils, their use largely depends on

the content of oil and the composition of fatty acids [1]. This article aims to collect literature data on the share of individual fatty acids in plant oils obtained from unconventional raw materials such as seeds and stones of fruits, which are the most commonly grown in Poland (apple, pear, red raspberry, sour cherry, plum, apricot). The influence of fatty acids (saturated, monounsaturated and polyunsaturated) on human health is also presented.

Oils obtained from fruit seeds

Apple seeds oil

In the available literature, there are several publications presenting the composition of fatty acids of cold pressed oil from apple seeds [Tab. 1]. However, most research show the composition of fatty acids in apple seeds oil obtained using chemical solvent extraction [Tab. 2]. The numerical data on the share of fatty acids in apple seeds oil were collected in the table. On their basis, parameters such as minimum (MIN) and maximum (MAX) values, mean value (MV), standard deviation (SD) were determined, and the coefficient of variation (CV) for particular acids was estimated.

The fatty acid that dominated in cold pressed apple seeds oil was C18:2 acid (linoleic acid). Its share was over 56% of the share of all fatty acids. A similarly high, but more than 25% lower share (in comparison to C18:2 acid) was characterized by C18:1 acid (oleic acid). The share of other unsaturated fatty acids was relatively low, amounted to 0.72% for C16:1 acid (palmitoleic acid) and 0.78% for C18:3 acid (α-linolenic acid).

For C16:0 acid (palmitic acid), the highest percentage share for saturated fatty acids was found, its average share estimated on the basis of literature results was 7.50%. Slightly lower shares were found for C18:0 acid (stearic acid) and C20:0 acid (arachidic acid), which were 1.47 and 1.56%, respectively.

Tab. 1.
Fatty acids composition (%) of apple seeds oil obtained by cold pressing method.

No.	FATTY ACIDS (%)								reference
	palmitic acid C16:0	palmitoleic acid C16:1	stearic acid C18:0	oleic acid C18:1	linoleic acid C18:2	α-linolenic acid C18:3	arachidic acid C20:0	others	
1.	5.49	1.43	1.11	32.26	57.03	0.71	1.54	0.43	[11]
2.	9.50	0.00	1.82	29.36	55.54	0.85	1.56	1.37	[35]
MIN	5.49	0.00	1.11	29.36	55.54	0.71	1.54	0.43	
MAX	9.50	1.43	1.82	32.26	57.03	0.85	1.56	1.37	
MV	7.50	0.72	1.47	30.81	56.29	0.78	1.55	0.90	
SD	2.84	1.01	0.50	2.05	1.05	0.10	0.01	0.66	
CV	37.83	141.42	34.27	6.66	1.87	12.69	0.91	73.85	

MIN – minimum value, MAX – maximum value, MV – mean value, SD – standard deviation, CV – coefficient of variation calculated according to the equation: $\frac{SD}{\bar{x}} \times 100\%$

Apple seeds oil obtained with the use of chemical solvents was characterized (similar to cold pressed oil) by a high share of C18:2 acid (58.27%) [Tab. 2]. In addition, a high share was also found for C18:1 acid (30.32%). The shares of fatty acids such as C18:3 and C20:1 (eicosenoic acid) were low, amounted to only 0.40 - 0.44%. Based on a literature review, the presence of C16:1 acid was found at the trace level.

The saturated fatty acid that dominated in apple seeds oil obtained by extraction method was C16:0 acid. Its share was 7.10%. The shares of fatty acids such as C18:0 and C20:0 were lower, almost 4- and 6-fold than the C16:0 acid share, respectively. In extracted oil, C22:0 (behenic acid) was also present, but its share was only 0.16%.

In oil from apple seeds, many authors have also identified other fatty acids, given in a summed form. Their share was in the range of 0.13 - 2.10%. The authors reported that they contained such saturated fatty acids as C12:0 (lauric acid), C14:0 (myristic acid), C17:0 (margaric acid) and unsaturated fatty acid such as C22:1 acid (erucic acid).

Tab. 2.
Fatty acids composition (%) of apple seeds oil obtained by extraction method.

No.	FATTY ACIDS (%)										reference
	palmitic acid C16:0	palmitoleic acid C16:1	stearic acid C18:0	oleic acid C18:1	linoleic acid C18:2	α-linolenic acid C18:3	arachidic acid C20:0	eicosenoic acid C20:1	behenic acid C22:0	others	
1.	8.49	0.08	1.92	32.71	53.98	0.30	1.53	0.51	0.28	nd.	[4]
2.	8.67	0.08	1.98	30.53	56.31	0.25	1.34	0.40	0.25	nd.	[4]
3.	8.07	0.07	2.30	36.57	50.34	0.25	1.48	0.45	0.25	nd.	[4]
4.	8.28	0.08	1.90	34.32	52.97	0.28	1.27	0.48	0.25	nd.	[4]
5.	9.18	0.12	1.75	27.02	60.01	0.34	1.14	0.36	0.17	nd.	[4]
6.	9.01	0.09	1.97	31.85	54.49	0.40	1.28	0.46	0.23	nd.	[4]
7.	8.89	0.12	1.75	27.02	60.01	0.34	1.14	0.36	0.17	nd.	[4]
8.	7.07	0.08	1.85	33.37	54.24	0.76	1.65	0.49	0.34	0.17	[51]
9.	7.80	0.06	1.60	28.88	59.37	0.45	1.09	0.52	0.06	0.17	[14]
10.	5.85	0.09	1.75	26.86	63.17	0.51	1.10	0.44	0.06	0.17	[14]
11.	6.92	0.11	1.42	26.25	63.21	0.42	0.96	0.43	0.07	0.16	[14]
12.	5.78	0.07	1.59	27.88	61.88	0.50	1.27	0.52	0.27	0.24	[14]
13.	6.14	0.06	1.61	27.79	62.27	0.43	1.01	0.42	0.14	0.13	[14]
14.	5.84	0.09	1.60	26.82	63.35	0.40	1.22	0.45	0.06	0.17	[14]
15.	8.25	0.18	1.30	21.62	66.18	0.78	0.96	0.40	0.12	0.21	[14]
16.	7.14	0.17	1.26	20.68	67.94	1.35	0.79	0.40	0.07	0.21	[14]
17.	7.10	0.09	1.63	29.00	59.67	0.46	1.23	0.55	0.07	0.20	[14]
18.	8.33	0.11	1.62	24.95	62.73	0.68	1.00	0.33	0.06	0.19	[14]
19.	7.60	0.12	1.53	21.45	66.29	1.08	1.15	0.51	0.07	0.20	[14]
20.	7.10	0.10	1.50	27.40	62.00	0.40	0.60	0.20	0.20	0.50	[27]
21.	7.00	0.20	1.00	24.40	64.10	0.30	0.60	0.20	0.10	2.10	[27]
22.	6.80	0.20	2.10	25.70	62.70	0.20	1.10	0.30	0.10	0.80	[27]
23.	4.80	0.10	1.70	32.80	56.30	0.20	1.70	0.40	0.30	1.90	[27]
24.	5.30	0.10	1.50	35.80	54.50	0.50	0.70	0.20	0.20	1.20	[27]
25.	5.80	0.10	2.00	36.60	52.90	0.10	1.00	0.30	0.20	1.00	[27]
26.	6.80	0.10	1.30	38.60	50.80	0.00	0.90	0.30	0.10	1.10	[27]
27.	6.10	0.10	1.40	34.60	56.10	0.30	0.60	0.20	0.10	0.50	[27]
28.	5.70	0.20	2.10	42.10	48.20	0.60	0.60	0.20	0.10	0.20	[27]
29.	6.51	0.05	1.75	37.49	51.40	0.30	1.54	0.56	0.40	nd.	[43]
30.	6.60	0.00	1.96	38.55	50.70	0.19	1.49	0.51	0.00	nd.	[43]
MIN	4.80	0.00	1.00	20.68	48.20	0.00	0.60	0.20	0.00	0.13	
MAX	9.18	0.20	2.30	42.10	67.94	1.35	1.70	0.56	0.40	2.10	
MV	7.10	0.10	1.69	30.32	58.27	0.44	1.11	0.40	0.16	0.55	
SD	1.19	0.05	0.29	5.61	5.50	0.28	0.32	0.11	0.10	0.59	
CV	16.81	44.36	17.18	18.50	9.44	63.78	28.27	28.85	62.45	107.46	

MIN – minimum value, MAX – maximum value, MV – mean value, SD – standard deviation, CV – coefficient of variation calculated according to the equation: $\frac{SD}{\bar{x}} \times 100\%$, nd. – no data

Analysis of the literature data showed that apple seeds oil is a valuable source of unsaturated acids, in particular C18:2 and C18:1. The total share of unsaturated acids is as high as 90% of the total fatty acids. However, the share of saturated fatty acids is small (almost 10%), in larger amounts, only C16:0 acid is present. The ratio of fatty acids from the n-3 and n-6 families is 1:72.12 (cold pressing) and 1:132.43 (extraction).

Some authors also suggest that C22:1 acid is present in apple seeds oil. Currently, C22:1 acid is treated as a potentially harmful compound for human body. Its share in apple seeds oil is only small. However, it has been shown that the high share of this acid in food can cause fatness and damage to the myocardium, and also pathological changes in many organs [34].

Pear seeds oil

The literature review showed that the major form analyzed by researchers is pear seeds oil obtained by the extraction process [Tab. 3]. The share of C18:2 acid in the pear seeds oil was the highest, it was almost 60% of the sum of all fatty acids. An almost 2-fold lower share was found for C18:1. The share of C18:3 acid, which belongs to the group of acids from the n-3 family, was less than 0.25%. Similarly, low amounts of unsaturated acids were found for C16:1 (0.06%) and C20:1 (0.14%) acids.

From the group of saturated acids, a relatively high share was characterized by C16:0 acid. However, its share was lower by almost 87% in comparison to the C18:2 acid share (the major unsaturated acid). A noticeable share was also found for C18:0 acid (1.71%). The shares of the others saturated fatty acids were less than 1% and amounted to 0.56% for C20:0 and 0.10% for C22:0 acids.

The share of other fatty acids in extracted pear seeds oil was found only by Yukui et al. [51]. According to this research, the share of other acids was only 0.25%. However, the names of fatty acids that have been included in this group were not given.

Tab. 3.
Fatty acids composition (%) of pear seeds oil obtained by extraction method.

No.	FATTY ACIDS (%)										reference
	palmitic acid C16:0	palmitoleic acid C16:1	stearic acid C18:0	oleic acid C18:1	linoleic acid C18:2	α-linolenic acid C18:3	arachidic acid C20:0	eicosenoic acid C20:1	behenic acid C22:0	others	
1.	7.86	0.28	1.14	29.55	58.51	0.51	1.08	0.42	0.65	nd.	[13]
2.	7.86	0.19	1.04	38.17	50.73	0.34	1.04	0.63	0.00	nd.	[13]
3.	7.54	0.00	1.29	27.39	63.78	0.00	0.00	0.00	0.00	nd.	[13]
4.	8.22	0.00	1.26	31.68	58.84	0.00	0.00	0.00	0.00	nd.	[13]
5.	8.24	0.00	1.23	29.82	59.68	1.04	0.00	0.00	0.00	nd.	[13]
6.	6.13	0.00	1.19	32.06	59.84	0.00	0.78	0.00	0.00	nd.	[13]
7.	7.33	0.00	1.31	31.30	59.03	0.00	1.03	0.00	0.00	nd.	[13]
8.	8.52	0.00	1.09	28.16	62.23	0.00	0.00	0.00	0.00	nd.	[13]
9.	9.52	0.00	5.51	27.66	56.91	0.20	0.20	0.01	nd.	nd.	[16]
10.	7.29	0.14	1.99	23.16	64.86	0.36	1.43	0.31	0.27	0.25	[51]
MIN	6.13	0.00	1.04	23.16	50.73	0.00	0.00	0.00	0.00	ns.	
MAX	9.52	0.28	5.51	38.17	64.86	1.04	1.43	0.63	0.65	0.25	
MV	7.85	0.06	1.71	29.90	59.44	0.25	0.56	0.14	0.10	0.25	
SD	0.89	0.10	1.36	3.92	3.94	0.34	0.57	0.23	0.22	ns.	
CV	11.37	170.09	79.93	13.10	6.63	137.86	102.29	168.89	219.12	ns.	

MIN – minimum value, MAX – maximum value, MV – mean value, SD – standard deviation, CV – coefficient of variation calculated according to the equation: $\frac{SD}{\bar{x}} \times 100\%$, nd. – no data, ns. – not specified

Pear seeds oil is a source of primarily unsaturated fatty acids. Their share in this oil accounts for almost 90% of all fatty acids. In particular, pear seeds oil provides significant amounts of diunsaturated fatty acid (C18:2) as well as monounsaturated fatty acids (mainly C18:1). The share of saturated fatty acids is up to 10%, C16:0 and C18:0 acids are in significant amounts. The ratio of fatty acids from the n-3 and n-6 families is 1:237.76.

Red raspberry seeds oil

The analysis of fatty acid composition in cold pressed red raspberry seeds oil showed that more than half of all fatty acids present in this oil was C18:2 acid [Tab. 4]. In addition, a high share was also observed for C18:3 acid (30.19%). The share of C18:1 acid was also high, reached almost 13%.

In red raspberry seeds oil, the largest amount of acid from saturated fatty acids group was found for C16:0 acid. Its share was 3.02%. Almost 3-fold lower share (compared to the C16:0 acid share) was found for C18:0 acid, and more than 5-fold for C20:0 acid.

The share of other fatty acids given by the researchers ranged from 0.98 to 1.40%. The authors suggested that C16:1 acid was present in this group. Obiedzińska et al. [30] did not find the presence of other fatty acids.

Tab. 4.
Fatty acids composition (%) of red raspberry seeds oil obtained by cold pressing method.

No.	FATTY ACIDS (%)							reference
	palmitic acid C16:0	stearic acid C18:0	oleic acid C18:1	linoleic acid C18:2	α-linolenic acid C18:3	arachidic acid C20:0	others	
1.	2.70	1.00	12.00	54.50	29.10	0.00	0.00	[30]
2.	3.08	0.71	15.00	50.70	29.20	1.22	nd.	[11]
3.	6.20	1.89	15.51	45.45	29.05	0.91	0.98	[35]
4.	2.40	0.90	11.00	54.20	29.70	0.40	1.40	[8]
5.	2.43	0.90	10.87	53.67	31.68	0.37	nd.	[45]
6.	1.30	1.00	12.40	53.00	32.40	nd.	nd.	[33]
MIN	1.30	0.71	10.87	45.45	29.05	0.00	0.00	
MAX	6.20	1.89	15.51	54.50	32.40	1.22	1.40	
MV	3.02	1.07	12.80	51.92	30.19	0.58	0.79	
SD	1.67	0.42	2.00	3.45	1.47	0.48	0.72	
CV	55.26	39.10	15.61	6.64	4.87	83.20	90.56	

MIN – minimum value, MAX – maximum value, MV – mean value, SD – standard deviation, CV – coefficient of variation calculated according to the equation: $\frac{SD}{\bar{x}} \times 100\%$, nd. – no data

In the available literature, only 3 publications concerned the share of fatty acids in red raspberry seeds oil, which was obtained by extraction method [Tab. 5]. Analysis of the share of unsaturated fatty acids showed that the oil contained C18:2 acid in an amount of 54.93%, C18:3 acid at 26.78% and the C18:1 acid at 13.63%. The dominant acid from the group of saturated fatty acids was C16:0 acid (2.89%). The shares of other fatty acids from this group such as C18:0 and C20:0 was small (less than 1%).

Bada et al. [3] showed that other fatty acids such as C16:1, C20:1, C22:0 were also present in red raspberry seeds oil. Their combined share was set at 1.71%.

Tab. 5.
Fatty acids composition (%) of red raspberry seeds oil obtained by extraction method.

No.	FATTY ACIDS (%)							reference
	palmitic acid C16:0	stearic acid C18:0	oleic acid C18:1	linoleic acid C18:2	α-linolenic acid C18:3	arachidic acid C20:0	others	
1.	2.79	0.89	12.00	55.38	27.22	0.44	1.71	[3]
2.	2.69	0.97	11.99	54.52	29.11	nd.	nd.	[31]
3.	3.20	0.96	16.90	54.90	24.00	nd.	nd.	[41]
MIN	2.69	0.89	11.99	54.52	24.00	0.44	1.71	
MAX	3.20	0.97	16.90	55.38	29.11	0.44	1.71	
MV	2.89	0.94	13.63	54.93	26.78	0.44	1.71	
SD	0.27	0.04	2.83	0.43	2.58	ns.	ns.	
CV	9.34	4.64	20.78	0.78	9.65	ns.	ns.	

MIN – minimum value, MAX – maximum value, MV – mean value, SD – standard deviation, CV – coefficient of variation calculated according to the equation: $\frac{SD}{\bar{x}} \times 100\%$, nd. – no data, ns. – not specified

In red raspberry seeds oil, over 95% of all fatty acids are unsaturated. In particular, this oil provides such fatty acids as C18:2 and C18:3. The share of saturated acids is very low (less than 5%), the main representative of this group of fatty acids is C16:0. The ratio of fatty acids from the n-3 family to the n-6 family is 1:1.72 (cold pressing) and 1:2.05 (extraction).

Oils obtained from fruit stones

Sour cherry stones oil

A review of the literature showed that, as in the case of pear seeds oil, most of the available research concern the composition of fatty acids only for the oil obtained with a chemical solvent [Tab. 6]. Analysis of the shares of individual fatty acids in the oil extracted from sour cherry stones showed that it contained significant amounts of C18:1 and C18:2 acids. Their shares were 44.11% and 41.46%, respectively. The share of C18:3 acid was small, over 18-fold lower compared to the share of C18:1 acid. The lowest share for unsaturated fatty acids was found for C16:1, it was 2.36%.

In sour cherry stones oil, only 2 types of saturated fatty acids were observed, C16:0 and C18:0. The share of C16:0 acid was the highest for this group of fatty acids, it was almost 10.00%. However, the share of C18:0 was more than 73% lower than C16:0 acid share.

The authors also found the presence of other fatty acids in sour cherry stones oil, located in the range of 0.20 - 1.40%. However, no information was given what acids were included in this group.

Tab. 6.
Fatty acids composition (%) of sour cherry stones oil obtained by extraction method.

No.	FATTY ACIDS (%)							reference
	palmitic acid C16:0	palmitoleic acid C16:1	stearic acid C18:0	oleic acid C18:1	linoleic acid C18:2	α-linolenic acid C18:3	others	
1.	11.00	nd.	6.40	42.90	38.20	nd.	1.40	[36]
2.	6.23	nd.	1.33	46.80	40.58	5.06	nd.	[50]
3.	5.93	nd.	1.08	47.94	41.23	3.80	nd.	[50]
4.	15.40	0.20	1.00	36.90	45.70	0.50	0.30	[53]
5.	8.60	0.44	2.86	46.00	41.59	0.08	0.20	[20]
MIN	5.93	0.20	1.00	36.90	38.20	0.08	0.20	
MAX	15.40	0.44	6.40	47.94	45.70	5.06	1.40	
MV	9.43	0.32	2.53	44.11	41.46	2.36	0.63	
SD	3.91	0.17	2.29	4.44	2.71	2.45	0.67	
CV	41.50	53.03	90.36	10.07	6.54	103.85	105.13	

MIN – minimum value, MAX – maximum value, MV – mean value, SD – standard deviation, CV – coefficient of variation calculated according to the equation: $\frac{SD}{\bar{x}} \times 100\%$, nd. – no data

Sour cherry stones oil provides a significant amount of unsaturated acids, their share is over 88%. The largest amounts are found for acids such as C18:1 and C18:2, and their shares are similar to each other. The share of saturated acids is estimated at almost 12%, and C16:0 is predominant. The ratio for acids from the n-3 and n-6 families is 1:17.57.

Apricot stones oil

Only 4 publications about the composition of fatty acids in cold pressed apricot oil were found [Tab. 7]. The share of C18:1 acid accounted for almost 70% of all fatty acids present in this type of oil. In addition, over 20% share was also found for C18:2 acid. The shares of other unsaturated acids such as C16:1 and C18:3 did not exceed 1%.

Only 2 types of saturated fatty acids were found in apricot stones oil, C16:0 and C18:0. The share of C16:0 acid was 5.54%, while C18:0 was almost 4-fold lower.

Tab. 7.
Fatty acids composition (%) of apricot stones oil obtained by cold pressing method.

No.	FATTY ACIDS (%)						reference
	palmitic acid C16:0	palmitoleic acid C16:1	stearic acid C18:0	oleic acid C18:1	linoleic acid C18:2	α-linolenic acid C18:3	
1.	5.00	0.60	1.50	70.60	21.00	0.70	[15]
2.	7.80	0.50	0.90	62.10	27.80	1.40	[15]
3.	5.10	0.70	2.00	69.70	20.50	0.40	[15]
4.	4.25	nd.	1.36	70.90	20.93	0.74	[19]
min.	4.25	0.50	0.90	62.10	20.50	0.40	
max.	7.80	0.70	2.00	70.90	27.80	1.40	
MV	5.54	0.60	1.44	68.33	22.56	0.81	
SD	1.56	0.10	0.45	4.18	3.50	0.42	
CV	28.09	16.67	31.45	6.12	15.52	52.05	

MIN – minimum value, MAX – maximum value, MV – mean value, SD – standard deviation, CV – coefficient of variation calculated according to the equation: $\frac{SD}{\bar{x}} \times 100\%$, nd. – no data

Apricot stones oil obtained by extraction was characterized by a large amount of C18:1 acid (almost 70% share of all fatty acids). The high share was also found for C18:2 acid, however, it was over 3-fold lower. The C16:1 acid share was only 0.65% and the presence of C18:3 was trace.

The C16:0 acid dominated in apricot stones oil (among saturated fatty acids). Its share was almost 5%. The share of C18:0 was found in amount of 1.26%.

In research of many authors, the presence of other fatty acids than the basic ones was also specified. Shariatifar et al. [38] reported their share in the range of 1.60 - 12.60%. The authors included such acids as C17:0 and C20:1 in this group. Bachheti et al. [2] did not find any other fatty acids, and Turan et al. [44] and Lazos [20] described other fatty acid share in apricot stones oil as trace.

The oil from apricot stones is characterized by a high share of unsaturated acids (over 92%), in particular it is a source of C18:1 acid. However, apricot stones oil also provides a large amount of C18:2 acid. The share of saturated acids is small (over 6%), the main acid is C16:0. The ratio of n-3 and n-6 families is 1:27.85 (cold pressing) and 1:124.88 (extraction).

Tab. 8.
Fatty acids composition (%) of apricot stones oil obtained by extraction method.

No.	FATTY ACIDS (%)								reference
	palmitic acid C16:0	palmitoleic acid C16:1	stearic acid C18:0	oleic acid C18:1	linoleic acid C18:2	α-linolenic acid C18:3	arachidic acid C20:0	others	
1.	4.93	0.88	1.26	68.00	24.20	0.01	0.08	0.31	[20]
2.	5.60	0.60	1.50	67.10	19.70	nd.	nd.	1.60	[38]
3.	5.40	0.70	1.50	60.00	23.50	nd.	nd.	12.60	[38]
4.	5.30	0.70	1.40	68.60	21.60	nd.	nd.	2.30	[38]
5.	4.10	0.60	0.80	69.10	20.50	nd.	nd.	3.80	[38]
6.	5.50	0.60	1.50	68.30	21.90	nd.	nd.	2.20	[38]
7.	4.90	0.70	1.40	68.00	22.30	nd.	nd.	2.60	[38]
8.	5.90	0.20	1.30	67.40	21.60	nd.	nd.	3.50	[38]
9.	2.30	0.90	1.20	70.60	20.60	nd.	nd.	4.30	[38]
10.	5.41	nd.	0.82	71.33	21.33	0.10	0.10	1.22	[25]
11.	5.51	nd.	0.82	63.57	28.57	0.10	0.10	1.53	[25]
12.	5.41	nd.	0.82	68.27	24.49	0.10	0.10	1.12	[25]
13.	5.51	nd.	1.12	67.35	24.69	0.10	0.10	1.53	[25]
14.	5.00	nd.	1.63	69.90	22.96	0.10	0.10	1.02	[25]
15.	5.51	nd.	1.02	68.47	23.88	0.20	0.10	1.33	[25]
16.	5.82	nd.	2.14	73.06	19.08	0.10	0.00	0.82	[25]
17.	6.70	0.80	1.10	64.40	26.90	0.10	nd.	nd.	[53]
18.	3.35	0.71	1.10	70.34	22.48	1.03	nd.	nd.	[24]
19.	4.08	0.67	1.29	62.34	30.33	0.73	nd.	nd.	[24]
20.	5.93	0.42	1.31	67.19	24.41	0.91	nd.	nd.	[24]
21.	3.66	0.32	1.68	80.97	13.33	0.00	nd.	nd.	[24]
22.	4.50	0.61	1.12	71.00	22.30	0.11	0.10	0.26	[44]
23.	4.84	0.55	1.23	72.51	20.41	0.08	0.10	0.28	[44]
24.	4.94	0.65	1.23	70.72	22.05	0.07	0.09	0.26	[44]
25.	4.92	0.58	1.20	72.08	20.74	0.07	0.10	0.30	[44]
26.	5.60	0.74	1.37	67.01	24.83	0.08	0.12	0.26	[44]
27.	4.81	0.60	1.11	70.13	22.93	0.08	0.09	0.25	[44]
28.	5.23	0.65	1.03	66.53	26.14	0.07	0.08	0.28	[44]
29.	4.93	0.62	1.23	71.66	21.10	0.07	0.10	0.27	[44]
30.	4.51	0.64	1.33	75.83	17.17	0.14	0.12	0.27	[44]
31.	5.56	1.08	0.00	69.36	24.00	0.00	0.00	nd.	[32]
32.	3.31	nd.	2.68	73.58	19.26	0.00	0.00	0.00	[2]
min.	2.30	0.20	0.00	60.00	13.33	0.00	0.00	0.00	
max.	6.70	1.08	2.68	80.97	30.33	1.03	0.12	12.60	
MV	4.97	0.65	1.26	69.21	22.48	0.18	0.08	1.70	
SD	0.89	0.18	0.44	3.92	3.21	0.28	0.04	2.53	
CV	18.01	27.62	34.84	5.66	14.30	154.95	46.06	148.72	

MIN – minimum value, MAX – maximum value, MV – mean value, SD – standard deviation, CV – coefficient of variation calculated according to the equation: $\frac{SD}{\bar{x}} \times 100\%$, nd. – no data

Plum stones oil

Based on a review of 5 publications about the fatty acid composition present in the oil extracted from plum stones, it was found that the oil contained the high share (almost 70%) of C18:1 acid [Tab. 9]. The share of C18:2 acid was almost 4-fold lower than the share of C18:1. The presence of C16:1 acid was found only at 0.57%, while the share of C18:3 was trace.

The 7.09% share was characterized by C16:0 acid (saturated fatty acid), while the C18:0 share was lower by more than 77%. The share of C20:0, similar to C18:3, was trace.

Matthäus and Özcan [25] reported that the plum stones oil was also characterized by the presence of other fatty acids. The authors found in it the presence of C17:1 acid (vaccenic acid).

Tab. 9.
Fatty acids composition (%) of plum stones oil obtained by extraction method.

No.	FATTY ACIDS [%]								reference
	palmitic acid C16:0	palmitoleic acid C16:1	stearic acid C18:0	oleic acid C18:1	linoleic acid C18:2	α-linolenic acid C18:3	arachidic acid C20:0	others	
1.	6.03	0.00	0.00	74.19	19.14	0.22	0.13	nd.	[32]
2.	7.30	nd.	1.30	78.50	9.70	0.20	0.10	1.10	[25]
3.	5.40	nd.	1.40	63.90	26.90	0.10	0.10	1.20	[25]
4.	7.50	1.40	1.50	59.50	27.10	0.00	0.10	nd.	[46]
5.	9.20	0.3	3.90	70.50	15.70	0.30	nd.	nd.	[53]
MIN	5.40	0.00	0.00	59.50	9.70	0.00	0.10	1.10	
MAX	9.20	1.40	3.90	78.50	27.10	0.30	0.13	1.20	
MV	7.09	0.57	1.62	69.32	19.71	0.16	0.11	1.15	
SD	1.47	0.74	1.41	7.67	7.47	0.12	0.01	0.07	
CV	20.75	130.08	87.23	11.06	37.88	70.79	13.95	6.15	

MIN – minimum value, MAX – maximum value, MV – mean value, SD – standard deviation, CV – coefficient of variation calculated according to the equation: $\frac{SD}{\bar{x}} \times 100\%$, nd. – no data

Plum stones oil is a source of unsaturated fatty acids, whose share accounts for nearly 90% of all fatty acids. In particular, the oil is characterized by a high share of C18:1 acid. The share of saturated fatty acids is estimated at 10%, the largest amounts are attributed to C16:0 acid. In addition, the presence of C17:1 acid is also found in plum stones oil. An action of this acid in the human body is described as potentially beneficial [10]. The ratio of the share of fatty acids from the n-3 family to the share of fatty acids from the n-6 family is 1:123.19.

The impact of fatty acids of oils obtained from seeds and stones of fruit on human health

Saturated fatty acids

The share of saturated fatty acids in oils obtained from seeds and stones of fruits is relatively small, ranges from 6 to 10%. It is common knowledge that saturated fatty acids have a negative impact on human health. First of all, they are attributed to the concentration of cholesterol (total and its LDL fraction) in the blood serum, hypercholesterolemic action, an activity promoting platelet aggregation, and thus increasing the risk of blood clots in vessels [42].

Monounsaturated fatty acids

Oils obtained from seeds and stones of fruits are characterized by monounsaturated fatty acids share in the range of 12 - 70%, their share depends to a large extent on the type of raw material. The beneficial effect of monounsaturated fatty acids is mainly related to the increase in the concentration of HDL cholesterol (High Density Lipoproteins) in the blood serum [42]. In addition, these acids are responsible for regulating the content of LDL fraction, and also contribute to the creation of an appropriate ratio of both these cholesterol fractions [30].

Polyunsaturated fatty acids

The share of fatty acids with at least 2 unsaturated bonds in the fatty acid molecule is high in oils obtained from seeds and stones of fruits (88-96%). Polyunsaturated fatty acids are the starting material for the synthesis of many tissue hormones and building cell membranes. A commonly known property of these fatty acids is their beneficial effects on the circulatory system, they inhibit platelet aggregation and reduce cholesterol level (they also participate in its transport and oxidation), as a result, they limit the development of cardiovascular disease such as atherosclerosis and coronary heart disease [6]. Polyunsaturated acids also have anti-inflammatory and anti-allergic effects, mainly through the inhibition of excessive immune response and increasing the level of the body's immune barrier [18]. In addition, an important aspect of beneficial effects of unsaturated fatty acids is their anti-cancer effect, associated with both inhibiting the spread and proliferation of cancerous tissue, as well as reducing the development of nascent tumors [52].

The n-6 fatty acids are essential in the treatment of many diseases, i.e. peptic ulcer disease, obesity and diabetes [34], while the n-3 family contributes to the proper development of the child's brain and vision, both in the fetal and postnatal period, are also important in the prevention of old-age diseases [6]. It is important to maintain an appropriate proportion of fatty acids from the n-6 (omega-6) and n-3 (omega-3) families [39]. This ratio should not be more than 5:1, because it can affect the correctness of metabolic changes in the human body [30]. The excess of n-6 fatty acids in the diet is harmful to human health, it can lead to disturbances in the development and functioning of the brain, to the formation of inflammation, as well as the development of degenerative diseases [7, 49].

Summary

The collected literature data showed that oils obtained from seeds and stones of fruit such as apples, pears, red raspberries, sour cherries, apricots and plums, are a source of unsaturated fatty acids (88 - 95%), in particular C18:1 (12.80% (red raspberry seeds oil) - 69.32% (plum stones oil) and C18:2 (19.71% (plum stones oil) - 67.94% (apple seeds oil)) acids. However, stones oils are characterized by a high share of C18:1 acid, whereas seeds oils have a higher C18:2 acid share. A good source of C18:3 acid is red raspberry seeds oil (26.78 - 30.19%). Unsaturated fatty acids have many important functions in the body. They are building components of cells and components of phospholipids of cell membranes, play an important role in the transport and metabolism of cholesterol, have a hypotensive effect, and also have anti-cancer properties. The share of saturated fatty acids in oils from seeds and stones of fruit is relatively low (6 - 12%), the main acid of this group is C16:0 acid (2.89% (red raspberry seeds oil) - 9.43% (sour cherry stones oil)). It should be noted that the content of fatty acids in plant raw materials is not constant, depends on many factors i.e. thermal, agrotechnical, genetic, and also from the production process [23].

The ratio of fatty acids from n-3 and n-6 families for red raspberry seeds oil is 1:1.75 - 2.05. This proportion of fatty acids is low and definitely beneficial from the nutritional point.

The remaining oils are characterized by a high (or even very high) ratio of fatty acids from n-3 and n-6 families (1:17.57 (sour cherry stones oil) – 1:237.76 (pear seeds oil)). Although the high ratio limits their use in the food industry, but they definitely can be used in other industries, mainly in the cosmetics industry.

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