Mikołajczak Natalia. Fatty acids in different rapeseed varieties and their impact on human health. Journal of Education, Health and Sport. 2018;8(8):69-80. eISNN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.1297649
http://ojs.ukw.edu.pl/index.php/johs/article/view/5605

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 2018;
This article is published with open access at Licensee Open Journal Systems of Kazimierz Wielki University in Bydgoszcz, Poland
Open Access. This article is distributed under the terms of the Creative Commons Attribution Noncommercial License which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author (s) and source are credited. This is an open access article licensed under the terms of the Creative Commons Attribution Non commercial license Share alike. (http://creativecommons.org/licenses/by-nc-sa/4.0/) which permits unrestricted, non commercial use, distribution and reproduction in any medium, provided the work is properly cited.

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

Received: 01.06.2018. Revised: 08.06.2018. Accepted: 25.06.2018.

Fatty acids in different rapeseed varieties and their impact on human health

Kwasy tłuszczowe w różnych odmianach nasion rzepaku i 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: Rape is one of the most important oil plants grown all over the world. Oil obtained from rapeseeds has been dominating on the plant oil market for years, both in terms of production and consumption. It is considered the healthiest plant oil of all currently available. The purpose of this article was to review the available literature on the share of fatty acids in seeds of winter and spring rape, as well as to determine the impact of these fatty acids on the human body.
Brief description of the state of knowledge: The collected data clearly indicated that rapeseed fat is a valuable source of unsaturated fatty acids, in particular monounsaturated acid (63 (spring rape) - 66% (winter rape)) and acids from omega-3 family (8.89 (pollinated varieties) - 9.35% (winter varieties)) and omega-6 family (16.35 (spring varieties) - 19% (hybrid varieties)). Rapeseed fat was also characterized by low share of saturated fatty acids (6.67 (winter varieties) - 11% (spring varieties)).
Summary: Based on the literature review, it was found that rapeseed fat is a valuable source of unsaturated fatty acids (on average 92%), in particular C18:1 acid. In addition, share of C18:2 and C18:3 is also high, where the ratio of omega-6 and omega-3 is 2:1. The share of saturated fatty acids is relatively low (on average 8%). In addition, it can be concluded that the variety as an important factor determining the fatty acids composition of rapeseeds. The seeds of spring varieties are characterized by a higher share of saturated acids, and the seeds of winter varieties are more abundant in unsaturated acids. The highest share of C18:1 acid

states for winter and pollinated varieties, C18:2 for hybrid varieties and C18:3 for winter varieties.
Key words: fatty acids composition, rapeseed varieties, rapeseed fat, health benefits

Introduction

Rape (*Brassica napus* L. ssp. *oleifera Metzg*.) is one of the most important oil plant grown all over the world. Its seeds, right after soy, occupy an honorable second place in terms of cultivation, while the production of rapeseed oil is third in order, after soy and palm oil [1].

Oil obtained from rapeseeds has been dominating on the domestic vegetable oil market for years, both in terms of production and consumption. Moreover, according to the majority of consumers, it is considered the healthiest vegetable oil of all currently available [2]. Its delicate aroma and yellow color are one of the main distinguishing factors determining its wide use in many aspects of everyday life. It is ideal for frying, can be used as an addition to soups and salads, is also an ideal component of many cosmetics [3].

The wide use of rapeseed oil is determined not only by its highly desirable sensory characteristics, but above all by its beneficial fat composition. Rapeseed oil is distinguished by its high share of unsaturated fatty acids, of which oleic acid dominates. In larger quantities, there are also the main representatives of omega-3 and omega-6 fatty acids, additionally characterized by a perfect proportion of each other. A low share of saturated acids is also advantageous, is only a small percentage of the total fat share in the seeds. The lipid profile of the oil chosen in this way contributes to normal mental performance and reduces the likelihood of such diseases as cancer, atherosclerosis, obesity or diabetes. So good lipid profile contributes to normal mental performance and reduce the incidence of such diseases as cancer, atherosclerosis, obesity or diabetes [3].

The continuous development of rapeseed, which results directly from biological progress, leads to new varieties, both spring and winter rape. The aim is to achieve more and newer varieties with a relatively higher yield, and above all, a more beneficial fatty acid composition. It is widely believed that the choice of rape variety is one of the important factors determining the differences in the composition of fatty acids of seeds, as well as oils [4].

The purpose of this article was to review the available literature on the share of fatty acids in different varieties of rapeseeds, as well as to determine the impact of these fatty acids on the human body.

Fat content of rapeseeds

The economic importance of rapeseed is closely related to the high share of fat in seeds, which is at the level of 40-45% [5]. Differences in the share of this component result mainly from the form of rape variety. In the case of the winter form, the fat share may be from 43 to even 49%, while in spring varieties, the amount of fat is slightly lower, in the range of 40-47% [6].

Morphological elements of rapeseeds are not equally valuable from the fatty point of view, because they differ in fat share in its individual components. The seed coat is characterized by a small amount of fat, ranging from 6 to 14% of dry matter. However, such parts of seeds as cotyledons and germinal root contain from 50 to even 56% fat in the dry mass of seeds [5].

The fat content is not the only criterion for differentiating rapeseed components. An important aspect is also played by the quality of oil obtained from them. The oil extracted from the seed coat is characterized by inferior quality parameters as compared to the oil obtained from other parts of the raw material. This oil has a higher density and darker color compared to the oil pressed from cotyledons. In addition, it exhibits lower oxidative stability

and a higher degree of oxidation and hydrolysis of lipids, and thus contains a smaller amount of full triacylglycerols, and a higher level of mono- and diacylglycerols as well as phospholipids and free fatty acids [7].

Fatty acids composition of selected varieties of rapeseeds fat

Spring varieties

On the basis of literature, both Polish and foreign, the share of individual fatty acids in rapeseed fat from spring rape varieties was reviewed [Table 1]. As a result, 14 different varieties of spring rape were selected, and data on the share of fatty acids were collected in the table. On their basis, parameters such as mean value ($\bar{x}$), standard deviation (δ) were determined, and the coefficient of variation (CV) for particular acids was estimated. It should also be noted that the share of fatty acids from individual authors was very different. It might result from the influence of various factors on the research conducted by them, both internal and external.

The analysis of the fatty acid profile showed that rapeseeds of spring varieties had a high share of C18:1 (oleic acid), which constituted as much as 62% of all acids. In large quantities there was also C18:2 (linoleic acid) with a share of 11-21%, and C18:3 (α-linolenic acid) with a share of 8-11%. A slightly lower shares were attributed to two saturated acids - C16:0 (palmitic acid) and C18:0 (stearic acid), which average were about 4.5% and 5.8%, respectively. All varieties were in accordance with the current regulations governing the C22:1 share (erucic acid), and characterized by a relatively low level of this fatty acid up to 0.39% of all fatty acids.

Table 1. Fatty acids composition of fat extracted from spring rape varieties.

Variety	Crop years	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	erucic acid C22:1	
Pactol	2004-2006	7.91	-	11.09	56.31	13.41	9.37	-	1.40	0.17	[8]
Silvo	2004-2006	6.44	-	11.54	57.00	13.33	9.31	-	1.69	0.69	[8]
Topas	2004-2006	5.57	-	14.93	57.49	10.52	8.83	-	0.93	0.91	[8]
Serw 4	2004-2006	3.59	-	12.26	58.48	13.47	10.32	-	1.40	0.21	[8]
Serw 6	2004-2006	2.18	-	14.24	58.67	13.53	10.03	-	1.20	0.15	[8]
RGS003	2005-2006	4.35	0.15	1.88	64.28	17.58	8.32	0.62	0.24	0.23	[9]
Hyola420	2005-2006	3.74	0.14	2.04	67.38	15.85	8.52	0.56	0.14	0.14	[9]
Option500	2005-2006	3.72	0.14	1.70	64.39	19.06	8.76	0.58	0.11	0.17	[9]
Saringol	2005-2006	3.55	0.01	2.30	63.62	17.99	9.76	0.62	0.14	0.39	[9]
Hyola401	2005-2006	4.06	0.06	2.09	67.17	16.07	8.06	0.69	0.15	0.13	[9]
Bios	2008	4.38	0.22	1.66	59.16	20.87	11.34	0.69	1.71	0.00	[10]
Feliks	2008	4.20	0.20	1.83	65.34	18.06	8.96	0.53	0.99	0.00	[10]
Huznar	2008	4.84	0.23	1.85	63.59	19.32	7.77	0.61	1.61	0.00	[10]
Bios	2007	4.65	-	1.92	59.94	19.87	10.83	-	1.46	-	[11]
$\bar{x}$		4.51	0.14	5.78	61.63	16.35	9.30	0.61	0.94	0.32	
δ		1.39	0.08	5.52	3.86	3.09	1.05	0.06	0.65	0.27	
CV		30.82	57.14	95.50	6.26	18.90	11.29	9.84	69.15	84.34	

$\bar{x}$ – average value, δ – standard deviation, CV – variation coefficient

The presented literature data allow to state that spring rape varieties are a good source of unsaturated fatty acids, and above all, a source of monounsaturated acids. The percentage share of fatty acids with at least one double bond in spring rape varieties amounts to 90%. A significantly lower value should be attributed to saturated acids, where their sum is about 10%. In addition, the ratio of acids from the omega-6 to omega-3 family is 2:1.

Winter varieties

On the basis of a literature review, 19 different varieties of winter rape were selected for the fatty acids profile analysis of rapeseeds fat. The obtained data was collected and presented in Table 2.

Basis on the data presented in the table and after determining the basic statistical parameters, it could be concluded that, as in the case of spring varieties, the winter varieties contained considerable amount of C18:1. Its share was about 65% of the sum of all acids. Subsequent acids found in larger amounts were polyunsaturated fatty acids – C18:2 and C18:3, whose average share was 18.52 and 9.35%, respectively. The winter varieties were also characterized by an share of C16:0, which on average was about 4.5% in. The shares of the other analyzed fatty acids were at a similar level. The average share of C18:0 was about 2%, while the average share of C20:1 (eicosenoic acid), C20:0 (arachidic acid) and C16:1 (palmitooleic acid) acids amounted to 0.92, 0.55 and 0.18%, respectively. In seeds of winter rape, C22:1 was also present, its share was low and was up to 0.38%.

Table 2. Fatty acids composition of fat extracted from winter rape varieties.

Variety	Crop years	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	erucic acid C22:1	
Monolit	2012	4.36	0.23	1.97	61.00	19.21	10.12	0.61	1.39	0.16	[5]
Bojan	2012	4.26	0.14	1.93	60.99	18.97	10.68	0.61	1.36	0.03	[5]
Bogart	2008	4.51	0.18	1.15	63.09	19.10	9.67	0.47	1.13	0.00	[10]
Bojan	2008	4.56	0.19	1.98	62.11	19.71	9.35	0.65	1.20	0.00	[10]
Bosman	2008	4.99	0.23	1.75	61.50	19.96	8.87	0.62	1.48	0.00	[10]
Monolit	2008	4.74	0.21	2.14	65.06	17.92	8.46	0.67	1.07	0.00	[10]
Licord	2005-2006	3.96	0.13	1.92	65.51	17.85	7.65	0.68	0.17	0.38	[9]
Okapi	2005-2006	4.23	0.16	1.54	67.07	17.87	7.55	0.34	0.10	0.12	[9]
SLM046	2005-2006	3.99	0.18	1.79	63.70	17.78	7.90	0.60	0.33	0.34	[9]
Zarfarm	2005-2006	4.30	0.12	2.02	65.71	17.79	8.30	0.31	0.10	0.18	[9]
Orient	2005-2006	4.47	0.19	1.78	64.65	18.09	7.59	0.57	0.15	0.28	[9]
Opera	2005-2006	4.51	0.19	1.83	64.43	18.21	8.89	0.54	0.11	0.25	[9]
Talaye	2005-2006	4.47	0.19	1.76	65.53	17.33	8.89	0.51	0.13	0.20	[9]
Kaszub	2004	4.23	-	1.15	62.28	18.68	11.03	-	2.08	-	[12]
Kronos	2004	4.38	-	1.58	63.00	18.91	10.79	-	1.33	-	[12]
Lisek	2004	4.53	-	1.80	64.89	17.39	10.09	-	1.29	-	[12]
Lubusz	2004	4.20	-	1.65	62.45	19.28	10.80	-	1.50	-	[12]
Mazur	2004	4.28	-	1.48	62.88	17.88	11.18	-	1.38	-	[12]
Kana	2007	4.88	-	1.89	62.32	19.17	9.40	-	1.26	-	[11]
$\bar{x}$		4.38	0.18	1.74	64.69	18.52	9.35	0.55	0.92	0.15	
δ		0.34	0.04	0.29	5.06	0.80	1.26	0.12	0.64	0.14	
CV		7.76	22.22	16.67	7.82	4.32	13.48	21.82	69.57	93.33	

$\bar{x}$ – average value, δ – standard deviation, CV – variation coefficient

As in the case of spring varieties, winter rape is a rich source of unsaturated fatty acids. It can also be concluded that rapeseed fat is a valuable nutrient that provides the consumer's body with significant amounts of monounsaturated fatty acid – C18:1. The share of unsaturated fatty acids is high as 92% of the sum of all fatty acids. Winter rapeseeds contains small amounts of saturated acids, which is definitely a desirable element from the nutritional point (the share is only 7%). The share of acids from the omega-6 family is higher than in the case of the omega-3 family. The sum of omega-6 fatty acids accounts for almost 19% of all fatty acids, while omega-3 fatty acids are almost twice lower. However, the ratio of both of these fatty acid families is 2:1, the same as for spring varieties.

Pollinated varieties

Data on the content of individual fatty acids in the seeds of pollinated rape type is shown in Table 3.

Pollinated varieties of rape were characterized by a definitely high content of C18:1, which was about 64% of all fatty acids in rapeseed fat. They were also characterized by a high content of C18:2. This value was around 29%. Other fatty acids with a relatively high share in the total lipid fraction of rapeseeds were C18:3 – about 9%, and C16:0 with a share about 5%. The rapeseeds of pollinated type was characterized by a share of C20:1 at the level of 1.23%. In addition, the rapeseeds of these types of varieties contained traces of C22:1, only 0.06% of all fatty acids.

Table 3. Fatty acids composition of fat extracted from pollinated rape varieties.

Variety	Crop years	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	erucic acid C22:1	
Bios	2008	4.38	0.22	1.66	59.16	20.87	11.34	0.69	1.71	0.00	[10]
Feliks	2008	4.20	0.20	1.83	65.34	18.06	8.96	0.53	0.99	0.00	[10]
Huznar	2008	4.84	0.23	1.85	63.59	19.32	7.77	0.61	1.61	0.00	[10]
Bogart	2008	4.51	0.18	1.15	63.09	19.10	9.67	0.47	1.13	0.00	[10]
Bojan	2008	4.56	0.19	1.98	62.11	19.71	9.35	0.65	1.20	0.00	[10]
Bosman	2008	4.99	0.23	1.75	61.50	19.96	8.87	0.62	1.48	0.00	[10]
Monolit	2008	4.74	0.21	2.14	65.06	17.92	8.46	0.67	1.07	0.00	[10]
Monolit	2012	4.36	0.23	1.97	61.00	19.21	10.12	0.61	1.39	0.16	[5]
Bojan	2012	4.26	0.14	1.93	60.99	18.97	10.68	0.61	1.36	0.03	[5]
Kana	-	4.67	0.17	1.34	67.62	17.88	7.12	0.19	0.93	0.03	[13]
Lirajet	-	4.10	0.29	1.46	67.67	17.11	7.58	0.49	1.09	0.20	[13]
Lisek	-	4.99	0.21	1.57	67.35	16.49	7.94	0.34	0.82	0.23	[13]
$\bar{x}$		4.55	0.21	1.72	63.71	18.72	8.99	0.54	1.23	0.05	
δ		0.30	0.04	0.29	2.89	1.25	1.30	0.15	0.29	0.09	
CV		6.59	19.05	16.86	4.54	6.68	14.46	27.78	23.58	180.0	

$\bar{x}$ – average value, δ – standard deviation, CV – variation coefficient

Evaluation of the fatty acid profile of fat from rapeseeds of pollinated varieties shows that they are rich in fatty acids containing double bonds. Above all, they are a valuable source of C18:1, which is the main representative of monounsaturated fatty acids. The total content of unsaturated fatty acids is very high, about 94% of all fatty acids in rapeseed fat. These

varieties are also characterized by a relatively high presence of saturated fatty acids, the content of which is about 7%. The omega-6 fatty acids are twice as high as those from the omega-3 family, and the ratio of both of these families to each other is equal to 2:1.

Hybrid varieties

The hybridized varieties are another analyzed type of rape. Data on the share of individual fatty acids present in the seeds of hybrid varieties, and determined the statistical parameters are shown in Table 4.

Base on the data, it was found that the hybrid varieties were characterized by a high share of C18:1 (about 62%), but slightly lower than in case of pollinated varieties. In large quantities in hybrid varieties of rapeseeds was also C18:2 with a share about 19%. Lower, but equally high share should be attributed to C18:3, its share was about 9% of the sum of all types of fatty acids. The share of individual saturated acids was at a similar level with each other. However, the predominant was C16:0 (5%), and the next one was C18:0 with a share about 2.5%. Similarly to the pollinated form, varieties of the hybrid form were characterized by a low share of C20:1, up to 1.72%. In the fatty acid profile of hybrid varieties, C22:1 was also presented, but its share was only 0.19%.

Table 4. Fatty acids composition of fat extracted from hybrid rape varieties.

Variety	Crop years	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	erucic acid C22:1	
Kaszub	2008	4.83	0.22	1.32	62.60	19.91	8.85	0.52	1.68	0.00	[10]
Pomorzanin	2008	4.76	0.23	1.76	63.71	19.25	7.94	0.66	1.71	0.00	[10]
Hyolla401	-	4.00	0.52	2.27	63.30	17.80	10.34	1.51	1.00	0.34	[14]
Pactol	2004-2006	7.91	-	11.09	56.31	13.41	9.37	-	1.40	0.17	[8]
Saringol	2005-2006	3.55	0.01	2.30	63.62	17.99	9.76	0.62	0.14	0.39	[9]
Orient	2005-2006	4.47	0.19	1.76	65.53	17.33	8.89	0.51	0.13	0.20	[9]
Zarfam	2005-2006	4.30	0.12	2.02	65.71	17.79	8.30	0.31	0.10	0.18	[9]
Okapi	2005-2006	4.23	0.16	1.54	67.07	17.87	7.55	0.34	0.10	0.12	[9]
Margo	1999-2000	5.73	0.28	2.02	57.71	22.33	9.72	0.42	1.17	0.10	[15]
Kaszub	2004-2005	4.69	-	1.74	61.36	20.40	10.02	-	1.54	0.26	[16]
Mazur	2004-2005	4.65	-	1.73	60.89	20.39	10.25	-	1.72	0.37	[16]
BOH3103	2004-2005	4.71	-	1.88	61.70	20.47	9.68	-	1.42	0.14	[16]
MR153	2004-2005	4.67	-	1.73	60.55	21.38	9.98	-	1.48	0.22	[16]
$\bar{x}$		4.81	0.22	2.55	62.31	18.95	9.28	0.61	1.05	0.19	
δ		1.06	0.15	2.58	3.07	2.29	0.90	0.38	0.68	0.13	
CV		22.04	68.18	101.2	4.93	12.08	9.70	62.30	64.76	68.42	

$\bar{x}$ – average value, δ – standard deviation, CV – variation coefficient

Hybrid rape varieties are a valuable source of acids with unsaturated bonds in their molecule. First of all, they provide a significant amount of C18:1. The analysis of the fat profile show that about 92% of the total fatty acids is unsaturated acids, a small percentage is attributed to saturated acids (8%). The vast majority are also omega-6 fatty acids, the share is about 19% and are twice as high as the share of omega-3 fatty acids. The ratio of these acids is adequate as in the other rapeseed varieties and is 2:1.

Modified varieties

As a result of applying various types of modifications, the fatty composition of rapeseed oils can be shaped. An example of this is the M-681 mutant obtained as a result of chemical mutagenesis from double-improved oilseed rape of the PN 1775/02 line [17]. The overriding objective of this modification was to reduce the share of polyunsaturated acid - C18:3. This fatty acid, which is one of the representatives of EFAs, from the point of view of health, is important in the human diet. Too high share of C18:3 in the oil may be unfavorable. It is characterized by high susceptibility to oxidation and polymerization reactions at high temperatures, which directly affects its durability, as well as the stability of oil-flavoring substances [30]. The most-preferred share of this fatty acid is about 3% [17].

As a result of chemical mutagenesis, a favorable level of C18:3 acid share was obtained. Its share decreased from 10% in the raw material to 2% in the created rapeseed mutant. In addition, an increase in C22:1 to 2% and a simultaneous decrease in C16:0 by 1% could be observed.

The fatty composition of the oil before and after the chemical modification of the PN 1775/02 rape is presented in Table 5.

Table 5. The fatty acid profile of seeds obtained by modification of the PN 1775-1702.

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	erucic acid C22:1	
before modification - PN 1775/02									
4.60	-	1.60	64.00	18.10	9.50	-	2.30	0.00	[17]
after modification - PN 1712/02 of mutant M-681									
3.60	-	1.60	64.00	18.10	1.70	-	2.30	2.10	[17]

Another example showing the change in the fatty acids composition of rapeseed fat are M-5 and M-8 mutants obtained by using two mutagenesis in winter oilseed rape PN 3756/93. Spasibionek et al. [18] demonstrated the possibility of obtaining permanent changes in the composition of polyunsaturated fatty acids, through the application of harsher conditions of the process and its repeated occurrence.

As a result of the applied modification, a change in the share of polyunsaturated fatty acids present in seeds of winter rape was obtained. The M-5 mutant was characterized by an increase in the share of C18:1 to about 78% and C18:3 to 23%, with more than a two-fold reduction in the proportion of C18:2. However, in the fatty composition of the M-8 mutant, a 5-fold reduction of C18:3 to a value of only 2.5% and an increase in linoleic acid (C18:2) to 23% was observed. The fatty acids composition of fat in seeds of winter rape PN 3756/93 and the mutants M-5 and M-8 are shown in Table 6.

Table 6. The fatty acid profile of seeds obtained by modification winter rape PN 3756/93.

FATTY ACIDS [%]			Reference
oleic acid C18:1	linoleic acid C18:2	α-linolenic acid C18:3	
before modification			
64.10	18.20	10.40	[18]
after modification – M5			
77.90	8.60	23.10	[18]
after modification – M8			
66.30	23.10	2.50	[18]

Spasibionek [19] conducted intensive selection work on obtaining varieties of oilseed rape with a modified share of fatty acids, but also without any visible morphological changes. As a result, they obtained 5 mutated genotypes (M-1286/42, M-1288/27 M-1290/361, M-1292/59, M-1292/271) with a modified fatty acid composition. In the obtained mutant lines, the share of C18:1 increased (by 7.5-10%), and the share of C18:2 decreased (by 3.2-6.10%). In addition, a decrease in the C18:3 acid share was observed, almost double [Table 7].

Significant changes in the direction of high oleic acid share and reduced share of C18:2 and C18:3 acids in the seed oil of the tested lines indicate a mutation of the gene or *fad2* and *fad3* genes determining the desaturase activity of oleic and linoleic acids [19].

Table 7. The fatty acid profile of seeds obtained by modification of the PN 5282/98.

FATTY ACIDS [%]					Reference
palmitic acid C16:0	stearic acid C18:0	oleic acid C18:1	linoleic acid C18:2	α-linolenic acid C18:3	
before modification - PN 5282/98					
4.70	1.50	67.10	16.80	8.60	[19]
after modification – M-1286/42					
4.70	2.00	74.60	13.60	4.10	[19]
after modification – M-1288/27					
4.30	2.00	74.70	13.20	4.80	[19]
after modification – M-1290/361					
4.40	1.90	75.30	12.90	4.50	[19]
after modification – M-1282/59					
4.20	2.20	77.10	10.70	4.80	[19]
after modification – M-1282/59					
4.40	2.30	76.40	11.70	4.00	[19]

Fatty acids in rapeseeds fat and their impact on human health

Saturated fatty acids

The share of saturated fatty acids in rapeseeds is relatively small (about 10%). One of the most well-known representatives of this type of fatty acids is 16:0 and 18:0. When comparing rapeseed oil with other vegetable oils, it can be noticed that the share of these unfavorable acids from the nutritional point of view in rapeseed oil is much lower. For example, soybean oil or olive oil contains almost twice as much saturated fatty acids [20].

Adverse effects of saturated fatty acids on human health are mainly due to their effect on cholesterol level, both total and LDL fraction (Low Density Lipoproteins, low density lipoprotein). They also exert hypercholesterolemic action and promote platelet aggregation, which increases the risk of blood clots in the vessels. Despite many adverse effects on the human body, they are a good source of energy [21].

Monounsaturated fatty acids

The presented literature data allow to state that rapeseeds are a good source of unsaturated fatty acids, the percentage share of them is 90%. Rapeseed fat is the main source of C18:1, which belongs to the group of monounsaturated fatty acids. Its share is at the level of 60%, and even higher [5]. The beneficial effect of monounsaturated fatty acids is mainly related to the increase in HDL cholesterol (High Density Lipoproteins) concentration in the blood serum [21]. In addition, they are responsible for regulating the share of the LDL fraction, referred to as "bad cholesterol" and also contribute to the creation of an appropriate proportion of both these cholesterol fractions [5]. The value of energy derived from monounsaturated fatty acids is much higher than that derived from saturated acids, which is beneficial and desirable from the nutritional point [21]. Another representative of this type of acids is 22:1. Its share in rapeseeds fat is low, constituting less than 1%, which results from the applicable legal provisions. It has been shown that the high proportion of this fatty acid in food limits the use of rape for processing purposes, as well as adversely affects the human body, causing fatty tissue and damage to the myocardium and pathological changes in many organs [22].

Polyunsaturated fatty acids

Rapeseeds fat is characterized by beneficial nutritional values, mainly due to the high share of unsaturated fatty acids (C18:2, C18:3) [23]. These essential fatty acids (EFA) play many important functions in the human body. They participate in the biosynthesis of many tissue hormones eicosanoids, among which leukotrienes, prostacyclins or prostaglandins can be distinguished, they also form a building block of cell membranes, and also participate in the transport and oxidation of cholesterol. A commonly known property of polyunsaturated fatty acids is their beneficial effects on the circulatory system, by inhibiting platelet aggregation or also influencing cholesterol lowering [24], thereby contributing to the reduction of atherosclerosis or ischemic heart disease [21]. Fatty acids from the omega-6 family are essential in the treatment of many diseases, including peptic ulcer disease, obesity and diabetes, while the omega-3 family contributes to the proper development of the brain and vision of the child, both in the fetal and postnatal period, and these acids are necessary in the prevention of old-age diseases [25]. Polyunsaturated fatty acids also have anti-inflammatory and antiallergic effects, mainly by suppressing the excessive immune response and increasing the level of the body's immune barrier [26]. In addition, an important aspect regarding the beneficial effects of EFA is their anti-cancer effect, associated with both inhibiting the spread and proliferation of cancerous tissue and reducing the development of nascent tumors [27].

In addition, rapeseed fat is characterized by balanced ratio between fatty acids from omega-6 and omega-3 families, which is 2:1. Eicosanoids, which are synthesized from omega-6 family acids, are powerful thrombosis mediators and act pro-inflammatory (unlike eicosanoids synthesized from the omega-3 family acids). Thus, the inappropriate ratio of omega-6 and omega-3, in particular the higher proportion of omega-6 acids, contributes to the clots formation, inflammation, and becomes the basis for the development of diseases such as atherosclerosis, obesity and diabetes [28].

Summary

It is believed that the choice of a variety is one of the main factors significantly affecting differences in fatty acid shares, both in seeds and oils obtained from them. Factors that also significantly affect the composition of rapeseed fatty acids include moisture and thermal conditions, agrotechnical conditions as well as genetic factors [4]. In addition, the harvesting conditions, such as the date, manner and duration of the harvest, or also the subsequent stages of preparing the raw material for processing, affect both the quantity and the quality of fat present in rapeseeds [29]. The composition of fatty acids of rapeseeds is also influenced by the use of nitrogen fertilization. Butkuté et al. [30] in their studies showed that with the increase in the number of doses of fertilizer, the share of C16:0, C20:1 and C18:2 increases, with a simultaneous decrease in the proportion of C18:3 and C18:1. In addition, the use of various plant protection products also affects the share of individual components of rapeseed fat, which was found in studies carried out by Warmiński et al. [31] and Rotkiewicz et al. [32].

The share of fatty acids in rapeseed fat is highly diversified. The largest amounts are unsaturated fatty acids, their share is on average 90% of the total fatty acids in rapeseed fat. In particular, the C18:1 acid dominates, its share is up to over 60% of all fatty acids. A high share is also attributed to C18:2 (an average of 19%) and C18:3 (an average of 9%). In addition, acids from the omega-6 and omega-3 families are in the right proportion to each other (2:1). Unsaturated fatty acids play an extremely important role in keeping the body in good condition. Their numerous health-promoting properties include: prevention of hypertension, slowdown of the aging process of cells, protection against free radicals, inhibition of platelet aggregation, and reduction of triglycerides and LDL cholesterol.

The share of individual fatty acids in rapeseed fat depends on the variety. The obtained values indicate a few percent differences in the share of individual fatty acids. The spring varieties are characterized by a high share of saturated acids (on average 10%), while the winter varieties contain the least (on average 7%). All varieties are characterized by a high proportion of unsaturated acids, whose shares are within 87 (spring varieties) - 94% (winter varieties). Among them, C18:1 predominates, and its higher share is found in winter and pollinated varieties (65-66%). The lowest share of C18:2 is observed for spring varieties, and C18:3 for pollinated varieties. Much larger variation concerns fatty acids occurring in small amounts, especially C22:1. The highest its share is found for spring varieties (on average 0.32%), and the lowest for pollinated varieties (only 0.05%).

In the literature is also observed the development of methods, in particular genetic once, which allow to modification of the share of individual fatty acids in rapeseed fat. These changes mainly focus on the contribution of unsaturated fatty acids such as C18:1, C18:2 and C18:3.

References

1. Gugała M., Zarzecka K., Sikorska A., 2014, Prozdrowotne właściwości oleju rzepakowego, Postępy Fizjoterapii, 2, 100-103.
2. Leśniak A., Ostasz L., 2006, Zmiany właściwości fizykochemicznych oleju rzepakowego poddanego obróbce termicznej i ich kinetyczna analiza. (IN:) Zeszyty Naukowe nr 710 Akademii Ekonomicznej w Krakowie, Wydawnictwo Akademii Ekonomicznej, Kraków, 81-96.
3. Zarzycka K., Sikorska A., 2014, Olej rzepakowy – najcenniejszy olej roślinny, Poradnik Gospodarski, 1, 40-41.

4. Malarz W., 2008, Wpływ wybranych czynników agrotechnicznych na rozwój i cechy jakościowe plonu odmian rzepaku jarego. (IN:) Zeszyty Naukowe Uniwersytetu Przyrodniczego we Wrocławiu nr 562. Rozprawy CCLI, Wydawnictwo UP, Wrocław, 562, 62-70.
5. Wroniak M., Anders A., Szterk A., Szymczak R., 2013, Wpływ obłuskiwania nasion na jakość sensoryczną i fizykochemiczną oraz wartość żywieniową oleju rzepakowego tłoczonego na zimno, Żywność. Nauka. Technologia. Jakość, 90, 90-106.
6. Bartkowiak-Broda I., Włakowski T., Ogrodowczyk M., 2005, Przyrodnicze i agrotechniczne możliwości kształtowania jakości nasion rzepaku, Pamiętnik Puławski, 139, 7-19.
7. Rotkiewicz D., Zadernowski R., 1997, Obłuskiwanie nasion rzepaku, Rośliny oleiste, 18, 492-504.
8. El-Beltragi H. E. S., Mohamed A. A., 2010, Variations in fatty acid composition, glucosinolate profile and some phytochemical shares in selected oil seed rape (*Brassica napus* L.) cultivars, Grasas y Aceites, 61, 143-150.
9. Shirani-Rad A., H., Zandi P., 2012, Comparison of winter and spring rapeseed cultivars considering their oil share and fatty acids composition, American-Eurasian Journal of Agricultural and Environmental Sciences, 12, 243-248.
10. Ambrosewicz M., Tańska M., Rotkiewicz D., 2010, Fatty acid composition as a coefficient of ways of usage oils from seeds of different varieties of rapeseed, Polish Journal of Natural Sciences, 61, 74-83.
11. Tańska M., Rotkiewicz D., Ambroswicz M., 2009, Technological value of selected polish varieties of rapeseed, Polish Journal of Natural Sciences, 24, 122-132.
12. Liersch A., Bocianowski J., Bartkowiak-Broda I., 2013, Fatty acid and glucosinolate level in seeds of different types of winter oilseed rape cultivars (*Brassica napus* L.), Communications in Biometry and Crop Science, 8, 39-47.
13. Krasucki W., Tys J., Szafran K., Rybacki R., Orlicki Ł., 2002, Wpływ różnych temperatur suszenia nasion rzepaku na ich skład chemiczny, Rośliny Oleiste, 23, 423-438.
14. Beig Mohammadi Z., Maghsoudlou Y., Safafar H., Sadeghi Mahoonak A. R., 2012, Physicochemical Properties and Stability of Oil Extracted from Three Canola Cultivars Grown in Golestan Province of Iran, Journal of Agricultural Science and Technology, 14, 577-586.
15. Kotecki A., Malarz W., Kozak M., Aniołowski K., 2001, Wpływ nawożenia azotem na skład chemiczny nasion pięciu odmian rzepaku jarego, Rośliny Oleiste, 22, 81-89.
16. Wójtowicz M., Jajor E., 2006, Wpływ nawożenia azotowego na skład chemiczny nasion pięciu odmian rzepaku ozimego, Rośliny Oleiste, 27, 31-434.
17. Mikołajczyk K., Spasibionek S., Bartkowiak-Broda I., 2004, Analysis of the low-linolenic mutant genotypes of winter oilseed rape (*Brassica napus L.*) with the use of DNA markers, Rośliny Oleiste, 25, 243-249.
18. Spasibionek S., Byczyńska B., Krzymański J., 2000, Mutanty rzepaku ozimego podwójnie ulepszonego o zmienionym składzie kwasów tłuszczowych, Rośliny Oleiste, 21, 715-724.
19. Spasibionek S., 2008, Variability of fatty acid composition in seed oil of winter rapeseed (*Brassica napus* L.) developed through mutagenesis, Rośliny Oleiste – Oilseed Crops, 29, 161-174.
20. Krełowska-Kułas M., 2009, Znaczenie tłuszczu w żywieniu człowieka. (IN:) Zeszyty Naukowe nr 834. Uniwersytetu Ekonomicznego w Krakowie, Wydawnictwo UEK, Kraków, 39-53.
21. Szponar L., Mojska H., Ołtarzewski M. G., 2008, Tłuszcze. (IN:) Normy żywienia człowieka. Podstawy prewencji otyłości i chorób niezakaźnych, Wydawnictwo Lekarskie PZWL, Warszawa, 91-136.

22. Pedersen A., Baumstark M. W., Marckmann P., Gylling H., Sandström B., 2000, An olive oil-rich diet results in higher concentrations of LDL cholesterol and a higher number of LDL subfraction particles than rapeseed oil and sunflower oil diets, Journal of Lipid Research, 41, 1901-1911.
23. Kondratowicz-Pietruszka E., Ostasz L., 2010, Charakterystyka profilu kwasów tłuszczowych przechowywanego oleju rzepakowego produkcji polskiej (IN:) Zeszyty Naukowe nr 833. Uniwersytetu Ekonomicznego w Krakowie, Wydawnictwo UEK, Kraków, 51-70.
24. Bojarowicz H., Woźniak B., 2008, Wielonienasycone kwasy tłuszczowe oraz ich wpływ na skórę, Problemy Higieny i Epidemiologii, 89, 471-475.
25. Przysławski J., 2007, Podstawowe składniki odżywcze. II.3. Tłuszczowce (lipidy). (IN:) Bromatologia – zarys nauki o żywności i żywieniu. Pod redakcją Henryka Gertiga i Juliusza Przysławskiego, Wydawnictwo Lekarskie PZWL, Warszawa, 75-107.
26. Kelley D. S., 2001, Modulation of human immune and inflammatory responses by dietary fatty acids, Nutrition, 17, 669-673.
27. Ziemlański Ś., 2001, Zapotrzebowanie człowieka na tłuszcze. (IN:) Normy żywienia człowieka. Fizjologiczne podstawy. Pod redakcją Światosława, Wydawnictwo PZWL, Warszawa, 78-114.
28. Simopoulos A. P., 2016, An increase in the omega-6/omega-3 fatty acid ratio increases the risk for obesity, Nutrients 8(128), doi:10.3390/nu8030128.
29. Tys J., 2009, Wpływ warunków produkcji i obróbki pozbiorowej nasion rzepaku na jakość oleju. (IN:) Teraz rzepak, teraz olej. Olej rzepakowy – nowy surowiec, nowa prawda. Tom II, Polskie Stowarzyszenie Producentów Oleju, Warszawa, 25-29.
30. Butkuté B., Mańauskiené A., Ńidlauskas G., Sliesaravicienė L., 2000, The effect of agronomic factors and growth conditions on protein and fat share in the seed of spring oilseed rape and on the variation of fatty acids, Ņemdirbyst+, Mokslo darbai, 70, 160-175.
31. Warmiński K., Murawa D., Adomas B., Pykało I., 2001, Olej i białko nasion rzepaku jarego odmiany populacyjnej Star i mieszańcowej Margo uprawianych w 1999 roku w zależności od stosowanych środków ochrony roślin, Rośliny Oleiste – Oilseed Crops, 22, 265-272.
32. Rotkiewicz D., Murawa D., Konopka I., Warmiński K., 2001, Wartość technologiczna nasion rzepaku jarego traktowanego różnymi kombinacjami środków ochrony roślin, Rośliny Oleiste – Oilseed Crops, 22, 291-302.