Mikołajczak Natalia. The influence of roasting and baking on fatty acids composition of consumer oilseeds. Journal of Education, Health and Sport. 2017;7(9):460-470. eISSN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.1002064
http://ojs.ukw.edu.pl/index.php/johs/article/view/4935

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: 05.09.2017. Revised 10.09.2017. Accepted: 10.09.2017.

THE INFLUENCE OF ROASTING AND BAKING ON FATTY ACIDS COMPOSITION OF CONSUMER OILSEEDS

Wpływ prażenia i pieczenia na skład kwasów tłuszczowych konsumpcyjnych nasion oleistych

Natalia Mikołajczak

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

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

Abstract

Introduction and aim: Foods rich in nutrients have a positive effect on the human body. They are beneficial both for the health and the mind of human. Good sources of essential fatty acids and other biologically active compounds are oilseeds. It is important to include them in your daily diet. They can be added to dishes or serve as a snack.
Brief description of the state of knowledge: The aim of this study was to evaluate of fatty acid composition in selected consumer oilseeds: sunflower, sesame, flax after application of typical technological processes such as roasting and baking, in different temperature, power and time ranges. In the research materials (before and after modification), the fatty acid composition was determined by gas chromatography.
Summary: Based on obtained results, it was found that roasting and baking have an influence on the change in the content and composition of fatty acids. The strength of influence was dependent on the parameters (e.g. type of seed, temperature, time, power), which were used in the research. The roasting in the oven caused changes in the composition of saturated and unsaturated fatty acids, both in flax and sunflower seeds. The roasting in the microwave at 900 W affected on saturated fatty acids composition in flax seeds, similarly sunflower. In the case of sesame seeds, the influence of time on the content of mono- and polyunsaturated fatty acids was noted. The baking process caused significant changes in the fatty acid composition in the seeds from the crust of bread (flax seeds, sunflower seeds).

Key words: roasting, baking, fatty acid composition, flax seeds, sunflower seeds, sesame seeds

Introduction

The characteristic feature of oilseeds is the ability to collect large amounts of fat in fruits or seeds [1], which is one of the most important nutrients for the human body. It plays a significant role in many life processes [2], takes part in the synthesis of biologically active compounds, is a source of energy and also of unsaturated or saturated fatty acids [3].

Unsaturated fatty acids are of great importance to functions in the human body. They participate in the biosynthesis of many tissue hormones and in the transport and oxidation of cholesterol, also they are building block of cell membranes. Commonly known properties of unsaturated fatty acids are their beneficial effect on cardiovascular system [4], as well they prevent the development of many civilization diseases like cancer, atherosclerosis, obesity, diabetes [3, 5, 6]. The negative effect of saturated fatty acids on human health is mainly due to their effects on level of total cholesterol, in particular LDL (Low Density Lipoproteins) fraction, which leads to hypercholesterolaemia. Despite this, saturated acid are a good source of energy [7].

The oilseeds production in the world is constantly growing. It is associated with a wide possibility of their use - as sources for food production, animal feed, cosmetics, pharmaceuticals or also for technical fats (emulsifiers, biofuels, paints) [1]. The use of seeds in the food industry mainly involves the extraction of edible oils [8]. However, lately, more people are using them to make their dishes more attractive and to prepare snacks such as popcorn, roasted seeds, fried seeds, cookies, muesli bars, etc. [9, 10]. Often, seed additives are also used in baking [11]. Therefore, oilseeds (sunflower, sesame, flax) are often subjected to thermal processes such as roasting, drying, frying, microwaving, which have a positive influence on the taste and appearance of the product. However, heat treatment can cause changes in the content and structure of biologically active compounds [12].

In the literature, there is a little information about the impact of modification such as roasting and baking on the bioactive compounds content. Therefore, the aim of the research was to investigate changes in the composition of fatty acids under the influence of selected technological processes (roasting in the oven, roasting in the microwave, baking).

Material and methods

Research material

The material for the research was 3 types of consumer oilseeds – sunflower seeds, sesame seeds, flax seeds. All materials were purchased in a supermarket located in Olsztyn. Sunflower seeds were purchased by weight, while sesame seeds and flax seeds were purchased in packages of 200 g. The research materials were characterized by good taste, smell and appearance. The seeds also had an appropriate expiry date.

The oilseeds were studied before and after heat treating. Three types of heat treating were used: roasting in oven, roasting in microwave and baking [Tab. 1].

Preparation of the heat treated oilseeds:

Whole seeds were subjected to the following treatments:

- roasting in the oven, 10 g seeds were placed in 100 ml glass breaker and were heated in convection-steam electronic oven UNOX ChefTop Plus (Cadoneghe, Italy) at 180, 200, 220^{o}C for 10 and 15 minutes;
- roasting in the microwave, 10 g seeds were placed in 100 ml glass breaker and were heated in LG microwave (Warsaw, Poland) at various powers: 400, 650 and 900 W for 5 and 9 min;
- baking, seeds were added to the dough, which was baked in the oven at 230°C; baking of bread was made using the method of the Berlin Baking Institute - 152.5 ml of water, 3.5 g of salt dissolved in 20 ml of water, 10.5 g of pressed yeast dissolved in 20 ml of water were added to 250 g of wheat flour type 650 with 15% humidity, and then all components were mixed with a laboratory mixer for 5 min. 50 g seeds were added to the dough and mixed thoroughly. The dough was fermented in a fermentation chamber at 32°C for 120 min, where after 80 minutes the dough was

pierced by manual mixing and re-placed in the fermentation chamber for 40 minutes. At the end of the fermentation process, the dough formed into 250 g dough piece, which were placed in baking mold and sprinkled with 50 g of seeds. The piece left to obtain adequate growth. Breads were baked in a convection-steam electronic oven UNOX ChefTop Plus (Cadoneghe, Italy) at 230°C for 25 minutes. After cooling, from the crumb and the crust, the seeds were separated and were analyzed.

Oilseeds without modification (untreated seeds, control samples) and after modification (treated seeds) were ground in an Ika-Werke GmbH M20 laboratory mill (Staufen im Breisgau, Germany) and then fatty acid composition was determined.

Table 1. Types of modifications used in the study.

No.	type of modification	parameters		
		temperature [^{o}C]	power [W]	time [min]
1.	-	-	-	-
2.	roasting in the oven	180	-	10
3.		180	-	15
4.		200	-	10
5.		200	-	15
6.		220	-	10
7.		220	-	15
8.	roasting in the microwave	-	400	5
9.		-	400	9
10.		-	650	5
11.		-	650	9
12.		-	900	5
13.		-	900	9
14.	baking	≤100	-	25
15.		≤230	-	25

Determination of fatty acids composition

Methyl-esters of fatty acids were prepared according to Zadernowski and Sosulski [13] and their analysis was carried out by applying a GC–MS QP2010 PLUS (Shimadzu, Kyoto, Japan) system. The chromatographic conditions were described in the work of Czaplicki at al. [14].

Statistical analysis

The results were collected in tables and based on them, using Microsoft Excel 2010, the mean average, the standard deviation and the coefficient of variation were determined.

Overview of the results

Fatty acid composition of flax seeds

The fat in untreated flax seeds characterized by a high content of linolenic acid (C18:3), which belongs to the group of unsaturated fatty acids. Its share in flax seeds fat was almost 50%. Other fatty acids of this group, such as oleic acid (C18:1) and linoleic acid (C18:2), were characterized by a similar high level of content. The share of oleic acid was 23.42%, while the share of linoleic acid was 15.16%. Flax seeds fat contained low level of saturated fats. In this research, there was presence of two saturated acids – palmitic acid (C16:0) and stearic acid (C18:0), whose shares were 7.10% and 4.63%, respectively [Tab. 2].

Bean and Leeson [15] analyzed the composition of fatty acids of 23 different flax seeds. Their results are at a similar level of content as in this study. The shares of C16:0 and C18:1 were lower by 2-5%, while the share of C18:3 was higher by almost 10% than in this study. The higher

share of C18:3 (76.52%) was also noted by Mińkowski et al. [16]. Popis at al. [17] analyzed fatty acid composition of oil type flax seeds and their results were similar like presented at this study.

The used types of modifications had an influence on fatty acid composition in flax seeds [Tab. 2]. Application of roasting in the oven at 180 and 220°C (in both cases 10 and 15 min) caused a slight decrease in the share of C16:0 by 3-5%. An increase in the share of this fatty acid was observed at 200°C and 15 min modification, up to a value of 7.40%. Similar trends were observed with C18:1. The share of this fatty acid was at 180°C – 22.50% (10 min), 23.23% (15 min) and at 220°C – 22.12% (10 min), 22.75% (15 min), but at 200°C modification was noticed increase of its share up to 3% (15 min). The share of C18:0 was reduced by 7% during roasting in the oven at 220°C for 15 minutes, while its increase was observed at 200°C in both times (10, 15 min), and was 5%. The use of roasting in the oven at 200°C (both 10, 15 min) increased the share of C18:2, up to 16.18% (10 min) and 18.79% (15 min). In the case of C18:3 changes were in range of 1-3%.

Table 2. Fatty acid composition [%] in flax seeds - before and after modifications.

No.	modification type	modification parameters	mean value/ standard deviation	FATTY ACID COMPOSITION [%]				
				palmitic (C16:0)	stearic (C18:0)	oleic (C18:1)	linoleic (C18:2)	linolenic (C18:3)
1.	-	-	$\bar{x}$	7.10	4.63	23.42	15.16	49.69
			δ	0.35	0.01	0.33	0.48	1.15
2.	roasting in the oven	180°C/10 min	$\bar{x}$	6.83	4.46	22.50	15.09	51.11
			δ	0.12	0.12	0.19	0.21	0.65
3.		180°C/15 min	$\bar{x}$	6.95	4.87	23.23	15.18	49.76
			δ	0.06	0.03	0.03	0.08	0.03
4.		200°C/10 min	$\bar{x}$	7.14	4.87	23.48	16.18	48.32
			δ	0.06	0.03	0.03	0.08	0.03
5.		200°C/15 min	$\bar{x}$	7.40	4.38	24.27	18.79	50.35
			δ	0.47	0.29	1.00	0.79	0.83
6.		220°C/10 min	$\bar{x}$	6.92	4.56	22.12	15.45	50.95
			δ	0.18	0.04	0.16	0.25	0.12
7.		220°C/15 min	$\bar{x}$	6.73	4.35	22.75	15.12	51.05
			δ	0.13	0.09	0.15	0.03	0.15
8.	roasting in the microwave	400 W/5 min	$\bar{x}$	7.18	4.87	23.30	15.31	49.33
			δ	0.71	0.03	1.40	0.67	1.47
9.		400 W/9 min	$\bar{x}$	6.90	4.49	22.65	14.97	50.98
			δ	0.23	0.09	0.51	0.06	0.43
10.		650 W/5 min	$\bar{x}$	7.54	4.91	23.80	15.25	48.50
			δ	0.91	0.22	0.83	0.19	2.16
11.		650 W/9 min	$\bar{x}$	7.06	4.93	23.16	15.16	49.69
			δ	0.42	0.47	0.81	0.50	1.71
12.		900 W/5 min	$\bar{x}$	9.42	5.57	33.01	26.66	25.34
			δ	0.18	0.11	9.78	0.81	0.66
13.		900 W/9 min	$\bar{x}$	9.87	5.55	33.96	29.45	21.16
			δ	0.54	0.09	0.44	0.88	0.61
14.	baking	crumb/≤100°C	$\bar{x}$	7.17	4.96	23.32	15.73	48.81
			δ	0.05	0.01	0.39	0.28	0.07
15.		crust/≤230°C	$\bar{x}$	7.00	4.60	23.57	15.20	49.20
			δ	0.05	0.00	0.57	0.54	0.57
average				7.44	4.81	24.64	17.38	47.34
variation coefficient				12.91	7.95	18.48	26.82	22.33

The microwave process was important for fatty acid composition [Tab. 2]. The use of power 400-640 W at 5 and 9 min caused slight changes (1-4%) in the share of two saturated acids – C16:0

and C18:0. Significant increase in the share of these acids was observed with 900 W, 33% (5 min) and 40% (9 min) for C16:0 and 20% (both, 5 and 9 min) for C18:0. The shares of other fatty acids were in range of 22.65-23.80% for C18:1, in range of 14.97-15.31% for C18:2, and in range of 48.50-50.98% for C18:3. Significant changes were observed for 900 W, in both 5 and 9 min. Observed increase was about 20% for C18:0, 33% (5 min) - 39% (9 min) for C16:0, and 41.00% (5 min) - 45.00% (9 min) for C18:1.

Baking did not cause significant differences in fatty acid composition [Tab. 2]. In case of the crust, decrease in the share of individual fatty acids in flax seeds was small, in range of 1-2%. However, in the case of the crumb, there was 7% increase in the share of C18:0. Also 3% increase was observed for C18:2.

The use of selected modifications affected on fatty acids composition in fat of flax seeds [Tab. 2]. The most variable were C18:1 and C18:3, the coefficients of variation for these fatty acids were 26.82% and 22.22%, respectively. The lowest coefficient of variation was 7.95% and belonged to C18:0.

Fatty acid composition of sunflower seeds

In the fat of untreated sunflower seeds dominated two unsaturated fatty acids: C18:2 – 58.60% and C18:1 – 32.16%. The share of saturated fatty acids was 6.33% for C16:0 and 2.39% for C18:0. However, share of C18:3 was lower than 1% [Tab. 3].

Similar results, compared to this research, were received by Płucienik et al. [12]. They studied the sunflower seeds, which were from two seasons (2007 and 2008). Also Draganić et al. [18] in their article provided comparable results for the share of individual fatty acids. Only in their research did they find the presence of C18:3, and the share of C18:0 was almost twice higher.

The share of C16:0 in sunflower seeds subjected to roasting in the oven was 6.265% (180^{o}C, 15 min) – 7.35% (220^{o}C, 15 min). The use of this modification resulted in up to 30% increase in the share of this fatty acid (30 % for 180^{o}C, 10 min and 33% for 220^{o}C, 15 min). Similarly was with the share of the second saturated acid – C18:0. Its share increased by up to 60% (220^{o}C, 15 min) or 61% (180^{o}C, 10 min). In all analyzed variants of the roasting modification, a favorable change in C18:1 share was noted. The share of C18:1 was 34.61-39.29% (an increase of 8-23%). The lower limit of the range observed at 220^{o}C and 10 min roasting in the oven modification, but the upper limit belonged to 180^{o}C and 10 min roasting modification. C18:2 in all analyzed samples decreased, even nearly 20% (220^{o}C, 15 min). The share of C18:3 was small, but roasting in the oven caused significant changes, even up to 0% for 180^{o}C/10 min and 220^{o}C/10 min [Tab. 3].

The microwave process caused significant increase in the share of individual fatty acids [Tab. 3]. Increase of C16:0 share was from 2% (900 W, 9 min) to 75% (400 W, 9 min), C18:1 share was from 3% (900 W, 5 min) to 34% (400 W, 15 min), and C18:0 share even to 2.2 times (400 W, 9 min). In turn, downward trend was observed for C18:2, where the share was even 43.31% for 400 W and 9 min roasting in the microwave modification. This value was 1.4 times less than in the control sample. Using modification by microwaves caused disappearance of C18:3.

The use of baking had different effect on the composition of fatty acids of sunflower seeds present in both the crust and the crumb [Tab. 3]. The seeds in the crumb were characterized by increase in the share of fatty acids, about 10% for C16:0, 12% for C18:0 and 17% for C18:2. Only for C18:1, the value obtained in the research was lower and was 52.36%. However, the seeds separated from the crust showed increase of C18:3 to a value of 0.6% and C18:1 to a value of 34.79%. In other fatty acids was observed decline of 2 -5%.

As a result of the heat treatment, the share of saturated and unsaturated acids was changed as compared to the control sample [Tab. 3]. The most visible changes were observed for C18:3 share. This acid characterized by the highest coefficient of variation (68.06%). High variation coefficients (>17%) were recorded also for saturated fatty acids, C18:0 and C16:0.

Table 3. Fatty acid composition [%] in sunflower seeds - before and after modifications.

No.	modification type	modification parameters	mean average, standard deviation	FATTY ACID COMPOSITION [%]				
				palmitic (C16:0)	staeric (C18:0)	oleic (C18:1)	linoleic (C18:2)	linolenic (C18:3)
1.	-	-	$\bar{x}$	6.33	2.39	32.16	58.6	0.52
			δ	0.07	0.12	0.06	0.17	0.04
2.	roasting in the oven	180°C/10 min	$\bar{x}$	8.24	3.84	39.29	49.155	0.00
			δ	2.55	1.82	4.99	0.74	0.00
3.		180°C/15 min	$\bar{x}$	6.265	2.27	35.53	55.97	0.56
			δ	0.03	0.00	0.01	0.09	0.00
4.		200°C/10 min	$\bar{x}$	6.89	2.78	35.22	53.255	1.86
			δ	0.77	0.39	1.31	2.58	0.09
5.		200°C/15 min	$\bar{x}$	6.48	2.59	34.61	55.73	0.59
			δ	0.37	0.16	0.25	0.77	0.01
6.		220°C/10 min	$\bar{x}$	7.35	3.17	37.29	52.18	0.00
			δ	1.44	1.03	2.60	0.18	0.00
7.		220°C/15 min	$\bar{x}$	8.40	3.82	39.61	48.415	0.71
			δ	2.61	1.92	0.74	0.62	0.00
8.	roasting in the microwave	400 W/5 min	$\bar{x}$	6.53	2.42	34.88	56.17	0.00
			δ	0.06	0.06	1.06	1.06	0.00
9.		400 W/9 min	$\bar{x}$	11.06	5.21	43.02	43.31	0.00
			δ	0.74	0.00	0.55	0.39	0.00
10.		650 W/5 min	$\bar{x}$	6.73	2.53	33.96	56.77	0.00
			δ	0.28	0.19	0.41	0.06	0.00
11.		650 W/9 min	$\bar{x}$	7.02	2.83	34.165	54.96	2.03
			δ	0.47	0.12	1.38	1.16	0.00
12.		900 W/5 min	$\bar{x}$	6.62	2.29	33.14	57.94	0.00
			δ	0.19	0.16	0.50	0.15	0.00
13.		900 W/9 min	$\bar{x}$	6.44	2.41	34.74	56.41	0.00
			δ	0.09	0.15	0.23	0.29	0.00
14.	baking	crumb/≤100°C	$\bar{x}$	6.94	2.67	37.78	52.36	0.54
			δ	0.77	0.32	0.46	0.17	0.27
15.		crust/≤230°C	$\bar{x}$	6.59	2.35	34.79	55.97	0.60
			δ	0.36	0.05	1.23	1.12	0.00
average				7.19	2.91	36.01	58.81	0.93
variation coefficient				17.33	27.92	7.98	7.06	68.06

Fatty acid composition of sesame seeds

The shares of C18:1 and C18:2 in the fat from untreated sesame seeds were on the same level, 42.56% for C18:1 and 41.15% for C18:2. Saturated acids were in these seeds at a relatively low level. The share of C16:0 was 10.98%, while the share of C18:0 was 5.32%. There was no presence of C18:3 in sesame seeds fat.

Ashgar et al. [19] in their research obtained similar results, the share of all unsaturated fatty acids in sesame seeds was 85% of total fatty acids. Similar results were also received by Kondratowicz-Pietruszka [20] and Hassan [21]. The first author examined seeds with a dark brown

color and strong aroma, while the second author analyzed sesame seeds of Giza 32 and Shandawil 3 varieties from Egypt.

Table 4. Fatty acid composition [%] in sesame seeds - before and after modifications.

No.	modification type	modification parameters	mean average, standard deviation	FATTY ACID COMPOSITION [%]				
				palmitic (C16:0)	staeric (C18:0)	oleic (C18:1)	linoleic (C18:2)	linolenic (C18:3)
1.	-	-	$\bar{x}$	10.98	5.32	42.56	41.15	0.00
			δ	0.02	0.17	0.55	0.35	0.00
2.	roasting in the oven	180°C/10 min	$\bar{x}$	11.28	5.11	42.37	40.00	2.46
			δ	1.15	0.39	1.17	0.97	0.00
3.		180°C/15 min	$\bar{x}$	10.39	5.23	43.61	41.62	0.00
			δ	0.24	0.13	0.48	0.35	0.00
4.		200°C/10 min	$\bar{x}$	10.48	5.07	42.00	41.25	2.22
			δ	0.13	0.30	0.14	0.88	0.00
5.		200°C/15 min	$\bar{x}$	10.91	5.04	42.52	41.53	0.00
			δ	0.00	0.00	0.00	0.00	0.00
6.		220°C/10 min	$\bar{x}$	10.70	5.64	42.10	40.59	0.00
			δ	0.00	0.00	0.00	0.00	0.00
7.		220°C/15 min	$\bar{x}$	10.11	5.36	41.70	41.77	0.48
			δ	0.00	0.00	0.00	0.00	0.00
8.	roasting in the microwave	400 W/5 min	$\bar{x}$	12.04	5.10	42.86	42.55	0.00
			δ	1.75	0.00	1.14	0.71	0.00
9.		400 W/9 min	$\bar{x}$	10.93	5.44	41.73	41.30	1.18
			δ	0.62	0.14	0.34	0.70	0.00
10.		650 W/5 min	$\bar{x}$	10.91	5.28	42.11	41.69	0.00
			δ	0.08	0.34	0.23	0.19	0.00
11.		650 W/9 min	$\bar{x}$	11.00	5.73	42.09	41.16	0.00
			δ	0.08	0.63	0.94	0.23	0.00
12.		900 W/5 min	$\bar{x}$	10.45	5.06	41.51	42.05	0.93
			δ	0.00	0.00	0.00	0.00	0.00
13.		900 W/9 min	$\bar{x}$	12.38	4.94	43.93	41.21	0.00
			δ	1.28	0.00	2.41	0.21	0.00
14.	baking	crumb/≤100°C	$\bar{x}$	10.49	4.95	42.54	42.02	0.00
			δ	0.98	0.22	0.37	0.69	0.00
15.		crust/≤230°C	$\bar{x}$	10.75	5.15	42.58	41.52	0.00
			δ	0.98	0.12	0.01	0.21	0.00
average				10.92	5.23	42.42	41.43	1.45
variation coefficient				5.53	4.53	1.58	1.47	58.62

The share of C16:0 in sesame seeds after roasting in the oven was in the range of 10.11% (220°C, 15 min) – 10.98% (180°C, 10 min). At the lower limit of value 8% decrease was observed, but at the top is 3% increase, compared to the control sample. Second saturated acid, C18:0, were observed in the lowest values for modifications at 200°C in both times, 10 min and 15 min. These values were 5.07% and 5.04%, respectively. Increase (6%) in the content of this acid was observed

only for 200°C during 10 min of roasting time. No visible changes were observed for the share of C18:1 and C18:2 [Tab. 4].

The use of roasting in the microwave caused significant decrease in C16:0 share at 220°C and 5 min. The highest share of this acid was characterized by the seeds obtained after roasting at 180°C and 5 min (it was 12.04%) as well as 220°C and 9 min (it was 12.38%). 8% increase in C18:0 share was observed for modification at 200°C and 9 min, while the biggest decline was noted at the same time duration of roasting but for modification at 220°C. Changes in the share of C18:1 and C18:2 were slight and amount to 2-3% up or down. Similar to roasting in the oven, microwaving caused increase the share of C18:3. Increase was observed for 5 min roasting at 180°C and 200°C, and it was 0.48% (180°C) and 1.18% (200°C) [Tab. 4].

The saturated fatty acids present in sesame seeds – C16:0 and C18:0 were characterized by decreases during baking. Bigger negative changes were observed for the crumb (5-7% decrease). The shares of unsaturated fatty acids, C18:1 and C18:2, were maintained at a similar level, both for the crumb and the crust [Tab. 4].

The share of saturated fatty acids in sesame seeds fat was 10.92% (C16:0) and 5.23% (C18:0), these results were lower than their share in the control sample. Similarly for C18:1, whose share was also slightly lower. C18:3 was not present in the control sample, but its share in sesame seeds fat after modification was 1.40%. For this acid, there was also the highest value of the coefficient of variation (about 60%), while for other acids were in the range of 1.47% (C18:2) – 5.53% (C16:0) [Tab. 4].

Effect of modifications on saturated, monounsaturated and polyunsaturated fatty acids in oilseeds

The most visible changes in the share of fatty acid in flax seeds fat were observed for the microwave process, 32% for saturated fatty acids (SFA), 45% for monounsaturated fatty acids (MUFA), and 2.5% for polyunsaturated fatty acids (PUFA), compared to control samples [Tab. 5]. In addition, roasting in the oven and baking processes had a positive effect on the share of MUFA, increase of 18% (roasting in the oven) and 50% (baking).

The use of roasting in the oven, roasting in the microwave and baking on the sunflower seeds resulted in a significant reduction in PUFA share [Tab. 5]. The biggest decrease in share was observed in the case of microwave roasting (decrease of 27%). The roasting processes resulted in significant increase in SFA (was 12.22% for roasting in oven and 13.67% roasting in microwave) and MUFA share (was 39.01% for roasting in oven and 43.02% roasting in microwave).

The use of modifications in sesame seeds did not cause significant changes in SFA, MUFA, PUFA share [Tab. 5].

Discussion of results

Only small differences in the fatty acids composition of sesame seeds were shown in the study. Bigger changes were found for flax seeds subjected to roasting in the microwave and for sunflower seeds subjected to roasting in the oven.

Similar observations noticed Płuciennik et al. [12]. They studied the influence of roasting in hot air on fatty acid composition in sunflower seeds and observed that the roasting process minimally reduced of unsaturated fatty acids content (reduction of C18:2 by 1.76% and C18:1 by 7.25%). Anjum et al. [22] tested the KL-39 and FH-330 sunflower seeds varieties. They found that microwaving process increased share of C18:1, decreased share of C18:2, but the share of saturated fatty acids stayed at the same level. Biernat et al. [23], when studied the composition of fatty acids of different nuts and seeds, noted that sesame seeds had the highest share of monounsaturated fatty acids (41.51% of total fatty acids), what could explain their lower sensitivity to temperature.

Table 5. Share ranges of groups of fatty acids [%] in studied oilseeds.

seed type	modification parameters	minimum value/ maximum value	FATTY ACIDS [%]		
			saturated (SFA)	monounsaturated (MUFA)	polyunsaturated (PUFA)
flax	control	-	11.73	23.42	64.84
	roasting in the oven	min.	9.59	22.12	64.50
		max.	12.01	27.55	66.39
	roasting in the microwave	min.	9.52	22.65	50.61
		max.	15.42	33.96	66.32
	baking	min.	11.60	23.32	64.54
		max.	12.13	35.17	64.82
sunflower	control	-	8.72	32.15	59.12
	roasting in the oven	min.	8.53	34.61	48.77
		max.	12.22	39.01	56.31
	roasting in the microwave	min.	8.84	33.14	43.31
		max.	13.67	43.02	57.94
	baking	min.	8.94	34.79	52.62
		max.	9.60	37.77	56.27
sesame	control	-	16.29	42.56	41.15
	roasting in the oven	min.	15.47	42.00	40.59
		max.	16.40	43.07	42.36
	roasting in the microwave	min.	14.85	41.51	41.16
		max.	16.74	43.93	42.98
	baking	min.	15.44	42.53	41.51
		max.	15.90	42.58	42.02

Summary

The modifications used in the research such as roasting in the oven, roasting in the microwave and baking had the influence on the fatty acid composition of consumer oilseeds (flax, sunflower, sesame). The strength of influence was dependent on the type of fatty acid and the type of seed. Parameters of roasting such as temperature, power, time, or location of seeds during baking were also important factors.

Significant changes in composition of saturated (palmitic, stearic) and unsaturated fatty acids (oleic, linoleic, linolenic) were observed during roasting of flax seeds. In addition, the share of linolenic acid in flax seeds fat was characterized by a downward trend with increasing temperature and process time. In sunflower seeds were observed increase of the share of saturated fatty acids (higher temperatures and longer roasting time) and monounsaturated fatty acids (oleic), with decrease in the share of polyunsaturated fatty acids (decreased with increasing temperatures). There was no significant change in the share of sesame seed fatty acids.

After the microwave process, there were noticeable changes in the composition of flax seed fatty acids only when using the highest microwave power (900 W). In this case, increase in the share of saturated fatty acids (palmitic, stearic) was observed, similarly for sunflower seeds. In case of sunflower seeds also was noted slight increase in the share of monounsaturated fatty acids. For microwave roasting of sesame seeds, the influence of the time on the share of mono- and polyunsaturated fatty acids was noticeable.

The baking process had a variety influence on the fatty acids composition of the oilseeds. For sesame seeds no significant changes were observed, for flax seeds were observed increase of stearic and palmitic acids, while in sunflower seeds this process reduced the linolenic share in seeds placed in the bread crust. Therefore, oilseeds should not be used as a topping, because the high temperature and long time baking causes significant losses of bioactive components.

References

1. Bojanowska M, Pabich M. Rośliny oleiste w Polsce i na świecie w ostatnich latach. Autobusy. 2012; 159-162.
2. Domagała P, Żuralska R, Mziray M. Rola niezbędnych nienasyconych kwasów tłuszczowych oraz ich znaczenie w wybranych schorzeniach. Pielęg XXI w. 2014; 46:27-30.
3. Krełowska-Kułas M. Znaczenie tłuszczu w żywieniu człowieka. (w:) Zeszyty Naukowe nr 834. Uniwersytetu Ekonomicznego w Krakowie, Wydawnictwo UEK. Kraków. 2009; 39-53.
4. Bojarowicz H, Woźniak B. Wielonienasycone kwasy tłuszczowe oraz ich wpływ na skórę. Probl Hig Epidemiol. 2008; 89: 471-475.
5. Przysławski J. Podstawowe składniki odżywcze. II.3. Tłuszczowce (lipidy). (w:) Bromatologia – zarys nauki o żywności i żywieniu. Pod redakcją Henryka Gertiga i Juliusza Przysławskiego. Wydawnictwo Lekarskie PZWL. Warszawa. 2007; 75-107.
6. Ziemlański Ś. Zapotrzebowanie człowieka na tłuszcze. (w:) Normy żywienia człowieka. Fizjologiczne podstawy. Pod redakcją Światosława. Wydawnictwo PZWL. Warszawa. 2001; 78-114.
7. Szponar L, Mojska H, Ołtarzewski MG. Tłuszcze. (w:) Normy żywienia człowieka. Podstawy prewencji otyłości i chorób niezakaźnych. Wydawnictwo Lekarskie PZWL. Warszawa. 2008; 91-136.
8. Świetlikowska U. Surowce spożywcze. SGGW. Warszawa. 1990.
9. Wójtowicz A, Pasternak E, Juśko S, Hodora K, Kozłowicz K. Wybrane cechy jakościowe chrupek kukurydzianych z dodatkiem odtłuszczonych nasion lnu. Acta Sci Pol. 2012; 11(3-4):25-33.
10. Tunole-Akitunde TY, Oke MO, Akitunde BO. Sesame seeds. Chorwacja. 2012; 6:81-98.
11. Morris D. Food sources of alpha-linolenic acid. Flax Council of Canada. On-line: www.flaxcouncil.ca. 2012.
12. Płucienik E, Kita A, Figiel A. Wpływ temperatury prażenia na właściwości nasion słonecznika Rośliny Oleiste – Oilseed Crops. 2010; 31(1):135-144.
13. Zadernowski R, Sosulski F. Composition of total lipids in rapeseed. J Am Oil Chem Soc. 1978; 55:870-872.
14. Czaplicki S, Tańska M, Konopka I. Sea-buckthorn oil in vegetable oils stabilisation. Ital J Food Sci. 2016; 28:412-425.
15. Bean LB, Leeson S. Fatty acid profiles of 23 samples of flaxseed collected from commercial feed mills in Ontario in 2001. J Appl Poult Res. 2002; 11:209-211.
16. Mińkowski K, Zawada K, Ptasznik S, Kalinowski A. Wpływ związków fenolowych nasion na stabilność oksydacyjną i aktywność antyrodnikową wytłoczonych z nich olejów bogatych w PUFA n-3. Zywn-Nauk Technol Ja. 2013; 4(89):118-132.
17. Popis E, Ratusz K, Przybysz M, Krygier K, Sakowska A, Konarska M. Światowa oraz polska produkcja lnu oleistego i oleju lnianego. Problemy Rolnictwa Światowego. 2015; 30(2):106-116.
18. Draganić I, Lekić S, Branković T, Todorović G. Fatty acids and tocopherol content in sunflower seeds affected by accelerated ageing and priming with antioxidant solutions. Turk J Field Crops. 2011; 16(2):100-104.
19. Asghar A, Majeed MN, Akhtar MN. A review on the utilization of sesame as functional food. Am J Food Nutr. 2014; 4(1):21-34.
20. Kondratowicz-Pietruszka E. Charakterystyka profilu kwasowego olejów roślinnych bogatych w polinienasycone kwasy tłuszczowe. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie. 2011; 874:59-77.

21. Hassan MAM. Studies of Egyptian sesame seeds (*Sesamum indicum* L.) and its products 1- physicochemical analysis and phenolic acids of roasted Egyptian sesame seeds (*Sesamum indicum* L.). World J Dairy Food Sci. 2012; 7(2):195-201.
22. Anjum F, Anwar F, Jamil A, Iqbal M. Microwave roasting effects on the physico-chemical composition and oxidative stability of sunflower seed oil. J Am Oil Chem Soc. 2006; 83(9):777-784.
23. Biernat J, Drzewiecka M, Łoźna K, Hyla J, Bronkowska M, Grajeta H. Skład kwasów tłuszczowych orzechów i nasion dostępnych aktualnie w handlu w kontekście prozdrowotnych zaleceń żywieniowych. Bromatol Chem Toksyk. 2014; 47(2):121-129.

Acknowledgment
The author would like to thank Katarzyna Chmielewska, M.Sc., for her assistance in the preparing of the samples.