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FATTY ACID PROFILE AND FAT CONTENT IN SELECTED TYPES OF MUSTARDS

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The were evaluated fat and cis of fatty acids (C16:0, C18:0, C18:1, C:18:2, C18:3, C20:1, C22:1) content in total fatty acids of mustards. It were studied mustards with a significant degree of fragmentation. Total fat was determined by Soxhlet method. Fatty acid profile was determined by gas chromatography method. The obtained data were statistically analysed with use Statistica 10 method of analysis of concentrating. It was found that fatty acids are inhomogeneous in analysed mustards. Fat content was on average 3,99%, SFA participation were on average 5,86%, PUFA participation were on average 26,07% and erucic acid participation was on average 12,95%. Fatty acids $\omega 6/\omega 3$ proportions were in accordance with current nutritional recommendations. Low fat and saturated fatty acids content, high polyunsaturated fatty acids content and appropriate proportions $\omega 6/\omega 3$ make mustards specific functional product.

Key words: mustard, fat, fatty acids, quality.

Słowa kluczowe: musztarda, tłuszcz, kwasy tłuszczowe, jakość.

Maintaining the high quality is particularly important in case of food. The food should not only be appealing in terms of taste, smell and look but also be healthy and have proper nutritional values. Condiments are also considered food and are used to impart or enhance flavour, aroma and colour of a dish they are added to. They can also influence the digestive system as well as have antibacterial, antifungal and antioxidant properties (1).

Mustard is a condiment with its main ingredient being seeds of white, black and brown mustard. The mustard is prepared by mixing and grinding the seeds and adding vinegar, salt, sugar and other spices. There are lots of types of mustard that differ in species of the seed, the degree of grinding and other ingredients, to mention some of them: sarepska (brown Indian mustard), kremska (semi-sweet white mustard), dijon (dijon mustard), francuska (French mustard), bawarska (sweet/Bavarian mustard), angielska (English mustard), delikatesowa (Gourmet/Yellow mustard), jerozolimska stołowa (mild mustard), węgierska (spicy mustard), rosyjska (Russian mustard), miodowa (honey mustard) and chrzanowa (horseradish mustard) (2, 3, 4, 5).

The origins of mustard date back to the ancient Rome. The mustard production method has hardly changed despite its 2000 years of history and the fact that it evolved from powder into a thick sauce of a significant stickiness (3, 4, 6). In the beginning mustard was mainly used as a medicine and later also as a meat seasoning. First mus-

tard factories in Poland were established at the turn of the 19th and 20th centuries. The National Mustard Museum was built in year 1992 in Hout Herb (Wisconsin) and in 2009 it has been relocated to Madison (Wisconsin). The Museum has a large collection of about 550 mustards from 50 different countries.

Apart from its smell and taste, mustard is also said to have medical properties (it prevents constipation and digestive disorders due to its high dietary fiber content). Mustard contains antioxidants, which enhance brain functions; it is also rich in potassium that has beneficial influence on the nervous system (7). Another advantage is mustard's antibacterial and cleansing properties as well as the ability to lower the blood pressure. Curcumin is a food colouring and can be found in many types of mustard. It is an antioxidant and therefore it prevents skin aging and cancer; it has strong antibacterial, antifungal and anti-inflammatory properties (8). The glucosinolates that occur in mustard seeds also have healthful properties. The decay products of glucosinolates (isothiocyanates and indoles) influence the excretion and neutralization of carcinogens and mutagens by inducing enzymatic systems Phase I and Phase II of xenobiotic metabolism. However, there are also negative results of the products of decay of glucosinolates: toxic allyl isothiocyanates (in the seeds of black and brown Indian mustard), p-hydroxybenzyl isothiocyanate (in white mustard) and other derivatives can cause skin and intestine epithelium irritation, bronchitis, pneumonia, diarrhoea, miscarriage as well as have a negative effect on heart and kidney functions (9, 10).

Although there is a wide array of mustards, the most popular in Poland are just a few of them: brown Indian mustard and during the summer season – the ones that are suitable for barbecue. The production of mustard in 2010 in Poland amounted to 37.936 tons (11, 12).

The aim of this paper is to assess the fatty acids profile in selected types of mustards.

MATERIALS AND METHODS

The subject of the analysis (11 types of mustard available on the Polish market) was bought in November of 2011 in one of the supermarkets in Koszalin. All the products were fit for the consumption at the day of their purchase with the expiry date due in at least several months. The containers were clean, damage-free and bore no signs of having been opened before.

The subject of the analysis were the following mustards: 6 brown Indian mustards, 1 brown Indian gourmet mustard, 1 mild gourmet mustard, 2 gourmet mustards and 1 semi-sweet white mustard. The chosen condiments are made of finely grinded seeds (those made of whole seeds were deliberately avoided). The mustards are of two main types: 'popular' and 'gourmet'. It were studied mustards with a significant degree of fragmentation.

The analysed mustards were marked as follows: V1 – gourmet popular mustard, V2 – hot brown Indian mustard, V3 – hot brown Indian mustard, V4 – brown Indian mustard (new traditional recipe), V5 – (mild) gourmet mustard, V6 – semi-sweet white mustard, V7 – brown Indian popular mustard, V8 – brown Indian mustard, V9 – gourmet mustard, V10 – brown Indian mustard, V11 – gourmet mustard.

The fat content has been marked using the Soxhlet method (13) 3 times for each analysed sample. The analysis of the fatty acids composition has been carried out applying the gas chromatography. The fat was extracted from mustards using hexane. The esterification was performed using the alkaline methanolysis. The separation of fatty acid methyl esters (FAME) was performed using Hewlett Packard Gas Chromatograph 5890 (30m tubular column [RTX-225], hydrogen as a carrier gas [0.4 bar], temperature of a dispenser: 220°C, temperature of the detector: 300°C). The fatty acids identification was based on the retention time of fatty acid methyl esters mixture of a known composition (Wipol standard). In order to carry out the quantitative analysis, the sum of the chosen fatty acids (the ones with the highest percentage) was assumed to be 100% and the percentage of each of them was expressed as percentage by weight.

In the analysed mustards the following *cis* fatty acids have been marked: palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1), linoleic acid (C18:2), α -Linolenic acid (C18:3), eicosenoic acid (C20:1) and erucic acid (C22:1). The marking has been repeated 3 times. The results underwent the statistical analysis applying the Ward's method (minimum variance criterion minimizes the total within-cluster variance) using the Statistica Version 10.

RESULTS AND DISCUSSION

The results of the cluster analysis using Ward's method are shown in the picture 1. According to the analysis (Ward's method) of the fatty acids composition, the least homogeneous mustards (among the analysed types) are: V1 (gourmet popular mustard) and V10 (brown Indian mustard). The main differentiating factor was the percentage of oleic and erucic acids. The most homogeneous mustards proved to be V7 (brown Indian popular mustard) and V5 (mild gourmet mustard).

There are 4 groups comprising relatively homogeneous elements (with the bond distance <10). To the first group belong V10 (brown Indian mustard) and V9 (brown Indian gourmet mustard), to the second: V6 (semi-sweet white mustard) and V3 (hot brown Indian mustard), the third group consists of V11 (gourmet mustard) and V2 (hot brown Indian mustard) and the fourth is represented by V7 (popular brown Indian mustard), V5 (mild gourmet mustard), V8 (brown Indian mustard), V4 (brown Indian traditional mustard) and V1 (popular gourmet mustard) with V7 and V5 being the least homogeneous and V7 and V1 being the most homogeneous. The main differentiating factor was the percentage of erucic and oleic acids. The percentage of the rest of the acids is little diverse.

Fats play a crucial role in a human body. They are concentrated energy source (9 kcal/1g) and taste carriers. Fats also help in swallowing food, building cell membranes, they prevent from heat loss, determine the position of inner organs, provide with essential fatty acids (EFAs) that are essential for producing hormones, they are also a carrier of fat-soluble vitamin A, D and K (14; 15). Therefore the insufficient consumption of fats may result in diseases and vitamin A, D, E, K as well as EFAs deficiency (16). However, the excess of fats and lack of physical activity may cause overweight and obesity. It is recommended that the fats meet 20%-35% of the daily requirements for energy (depending on the age, weight and amount of physical effort) (17).

The percentage of fats in the analysed mustards was about 3,99%. The mustard that contains the most significant amount of fats is V8 (brown Indian mustard) – 5.1%, and the one that contains the least is V5 (gourmet mustard) – 3.1%.

The percentage of each fatty acid is shown in Table I. The differences within the groups were slight if taking into account the type of the mustard.

The saturated fatty acids (SFAs) are the main source of energy. The excessive SFA consumption correlates with the increase of low-density lipoproteins in blood that leads to cardiovascular diseases (18). The dietary guidelines allow <10% RDA of SFA. The analysis proved that the percentage of SFAs in analysed mustards amounts to 5.86%. The lowest SFA percentage represents V11 (gourmet mustard) – 4.9% and the highest was found in V4 (brown Indian traditional mustard) – 6.7%. The palmitic acid (C16:0) was the dominant.

Table I. Fat and fatty acids content in analysed mustards and proportion $\omega 6/\omega 3$

Tabela I. Zawartość tłuszczu i kwasów tłuszczowych w analizowanych musztardach oraz stosunek $\omega 6/\omega 3$

Sample	C16:0 (%)	C18:0 (%)	C18:1 (%)	C18:2 (%)	C18:3 (%)	C20:1 (%)	C22:1 (%)	Fat (%)	$\omega 6/\omega 3$
V 1	4,5 ±0,35	1,9 ±0,1	59,1 ±1,51	10,4 ±0,87	14,6 ±0,68	3,3 ±0,64	6,2 ±0,78	4,1 ±0,56	0,71:1
V 2	3,6 ±0,37	1,4 ±0,17	36,3 ±1,75	14,7 ±0,48	11,7 ±0,69	7,7 ±0,78	24,6 ±2,41	3,8 ±0,67	1,25:1
V 3	4,1 ±0,24	1,7 ±0,30	49,5 ±2,13	13,6 ±0,72	14,4 ±0,78	5,3 ±0,25	11,4 ±1,21	3,2 ±0,78	0,94:1
V 4	4,9 ±0,87	1,8 ±0,25	56,9 ±3,14	13,6 ±0,68	15,5 ±1,21	2,9 ±0,36	4,4 ±0,48	3,6 ±0,85	0,87:1
V 5	4,5 ±1,0	1,8 ±0,41	55,5 ±2,88	10,0 ±0,76	15,8 ±1,74	5,4 ±0,45	7,0 ±0,87	3,1 ±0,94	0,63:1
V 6	4,2 ±0,48	1,8 ±0,13	49,8 ±3,36	9,3 ±0,69	15,4 ±0,98	7,9 ±0,87	11,6 ±1,21	3,8 ±0,74	0,60:1
V 7	4,5 ±0,64	1,7 ±0,14	55,9 ±3,78	10,4 ±1,0	16,0 ±0,58	4,1 ±0,45	7,4 ±0,34	4,7 ±0,48	0,65:1
V 8	4,4 ±0,52	1,8 ±0,18	56,0 ±4,51	12,6 ±1,21	12,6 ±1,64	4,0 ±0,62	7,9 ±0,78	5,1 ±0,85	1:1
V 9	4,0 ±0,35	1,6 ±0,20	44,4 ±3,91	13,5 ±0,87	13,3 ±1,74	7,0 ±0,34	16,2 ±1,52	4,4 ±0,48	1,01:1
V 10	3,8 ±0,75	1,6 ±0,14	42,8 ±4,2	15,5 ±1,58	11,2 ±1,28	6,8 ±0,64	18,3 ±1,74	4,3 ±0,67	1,38:1
V 11	3,6 ±0,54	1,3 ±0,10	36,8 ±2,7	11,4 ±1,41	11,3 ±1,64	8,1 ±0,98	27,5 ±2,67	3,8 ±0,47	1:1

The percentage of monounsaturated fatty acids (MUFAs) in analysed mustards amounts to 68%. MUFAs can be used as an energy source and oleic acid (C18:1), which belongs to that group, has a beneficial influence on health by lowering the level of cholesterol in blood (19). It is even recommended so that they meet the 25% of requirements for energy (20). The highest level of MUFAs was found in V1 (popular gourmet mustard) – 59.1% and the lowest (12.3%) in V2 (hot brown Indian mustard).

Traces of erucic acid (C22:1) have been found in each of the analysed products with its highest percentage (27.5%) in V11 (gourmet mustard) and lowest (4.4%) in V4 (brown Indian traditional mustard). In 2003 the Food Standards Australia (21) established the PTDI (Provisional Tolerable Daily Intake) of erucic acid [500mg/day] due to the concern of its adverse effect to the heart. The eicosenoic acid (C20:1) had the slightest impact on the percentage of MUFAs of all analysed mustards, with its percentage being 5.68%. Polyunsaturated fatty acids (PUFAs) determine the fat nutrition value. They (all combined) should provide up to 10% RDA of energy (out of which 4-8% should come from omega-6 and 2% from omega-3) (20). PUFAs can be classified in various groups with two of them being ω -6 (C18:2) and ω -3 (C18:3). Their percentage in analysed mustards was at the level of 26.07%. The lowest level (22.7%) of PUFAs has been found in V10 (brown Indian mustard), yet the highest (29.1%) in V3 (hot brown Indian mustard). Fat acid ω -6 (C18:2) has a beneficial impact on the cardiovascular system. The lowest amount (9.3%) of linoleic acid (C18:2) was found in V6 (semi-sweet white mustard), the highest (15.5%) was found in V10 (brown Indian mustard). The α -Linolenic acid (C18:3) is a MUFA belonging to the ω -3 group and has a beneficial impact on immunological system, thrombocytes, tissues of smooth muscles, endothelium, liver and heart as well as on osteoblasts and nerve cells. It also has anti-inflammatory properties (14). The deficiency of the α -Linolenic acid may cause dermatitis, weakness of the nervous system and neurodegenerative diseases as well as the vision impairment. The highest percentage of α -Linolenic acid (ω -3) was found in V7 (popular brown Indian mustard) and the lowest (11.2%) in V10 (brown Indian mustard).

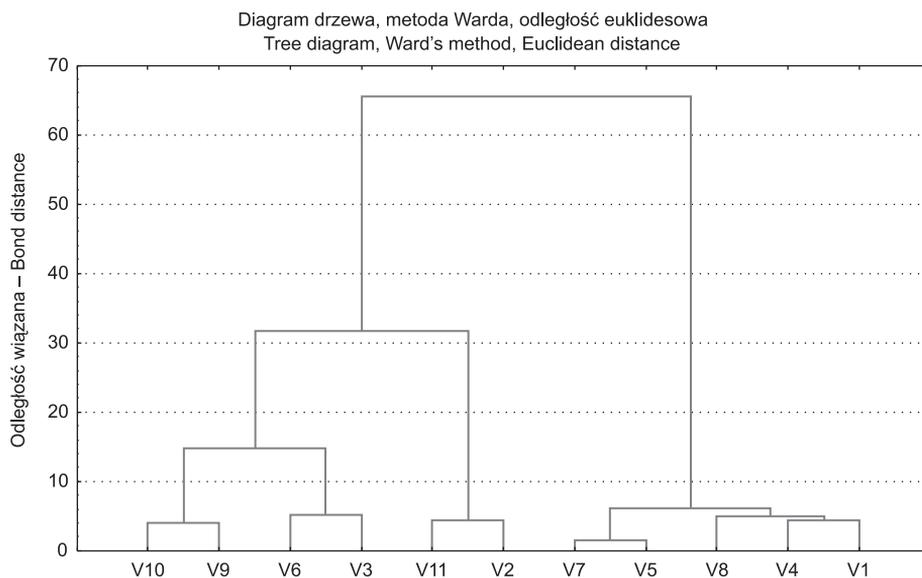


Fig. 1. Diagram of analysis of concentrating on the mustards studied made by the method of agglomeration (V1-V11 tab.I).

Ryc. 1. Diagram analizy skupień badanych musztard wykonany metodą aglomeracji (V1-V11 tab.I).

Polskie Forum Profilaktyki Układu Chorób Krążenia (Polish Organization for Prevention of Cardiovascular Diseases) (22) established the ω -6/ ω -3 ratio to be equal 4:1 or 5:1 due to the fact that nowadays people eat more and more highly processed foods thereby disturbing the ω -6/ ω -3 proportions in their diet. The recent studies show that such disproportion (excess of ω -6) may result in an inflammatory condition, allergy, proliferation of cancer cells and nipple, prostate and large intestine tumors, as well as cause the blood vessels to narrow (23). In all of the analysed mustards this ratio complies with the dietary guidelines and amounts to 0.91:1 (from 0.61:1 for V6 (semi-sweet white mustard) to up to 1.38:1 for V10 (brown Indian mustard). (Table I)

CONCLUSIONS

1. The analysed mustards vary in terms of the fatty acids percentage, showing that the mustard producers use different components.
2. Low fat, high polyunsaturated fatty acids content and appropriate proportions ω 6/ ω 3 make mustards specific functional product.

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ZAWARTOŚĆ TŁUSZCZU ORAZ PROFIL KWASÓW TŁUSZCZOWYCH W WYBRANYCH TYPACH MUSZTARD

Streszczenie

Oceniono zawartość tłuszczu oraz *cis* kwasów tłuszczowych (C16:0, C18:0, C18:1, C:18:2, C18:3, C20:1, C22:1) w sumie kwasów tłuszczowych wybranych typów musztard. Przebadano musztardy o znacznym stopniu rozdrobnienia. Zawartość tłuszczu oznaczono metodą Soxhleta, a profil kwasów tłuszczowych metodą chromatografii gazowej. Wykazano niejednorodność kwasów tłuszczowych w analizowanych musztardach. Zawartość tłuszczu wynosiła średnio 3,99%. Udział kwasów nasyconych wynosił średnio 5,86%, wielonienasyconych 26,07%, a kwasu erukowego 12,95%. Stosunek ω -6/ ω -3 we wszystkich analizowanych musztardach był zgodny z aktualnymi zaleceniami żywieniowymi. Niska zawartość tłuszczu, niski udział nasyconych kwasów tłuszczowych, wysoki udział wielonienasyconych kwasów tłuszczowych o odpowiednich proporcjach czyni musztardy specyficznym produktem o właściwościach funkcjonalnych

REFERENCES

1. Remiszewski M, Kulczak M., Jeżewska M., Korbas E., Czajkowska D.: Wpływ procesu dekontaminacji z zastosowaniem pary wodnej na jakość wybranych przypraw. ZNTJ., 2006; 3(48): 23-34. – 2. Juszcak L., Witczak M., Fortuna T., Banyś A.: Rheological properties of commercial mustards. J. Food. Eng., 2004; 63: 209-217. – 3. Sawicka B., Kotiuk E.: Evaluation on health safety of mustards in the aspect obligatory norms. Acta. Sci. Pol., Technol. Aliment., 2006; 5(2): 165-177. – 4. Sawicka B., Kotiuk E.: Evaluation of raw material for mustard production in middle-east Poland conditions. Nauka Przyr. #6. – 5. Vilmos R.: Rośliny przyprawowe i przyprawy węgierskiej kuchni. PWRiL, Warszawa, 1998; 4-26. – 6. Kotiuk E., Sawicka B., Karwowska M., Zmiany lepkości oraz wyróżników barwy musztardy w czasie przechowywania. Nauka Przyr. Technol., 2010; 4, 3, #40. – 7. Andraka I.: <http://www.sekretydiety.pl/dieta/albumwymieniownikow-50kcal/okazjonalny/rozne/musztarda> (dostępny 05.08.2013). – 8. Goel A., Kunnumakkara A., Aggarwal B.: Curcumin as “Curecumin”: From kitchen to clinic. Biochem. Pharmacol., 2008; 75(4):787-809. – 9. Lamy E., Schmitz S., Krumbein A., Mersch-Sundermann V.: Iso-

thiocyanate-containing mustard protects human cells against genotoxins in vitro and in vivo. *Mutat. Res.*, 2011; 726: 146-150. – 10. *Sawicka B., Kotiuk E.*: Gorczyce jako rośliny wielofunkcyjne. *Acta Sci. Pol., Agricultura.*, 2007; 6(2): 17-27.

11. *Rocznik Statystyczny Rzeczypospolitej Polski*. Główny Urząd Statystyczny, Warszawa, 2011. – 12. *Boruc R.* http://www.kotlin.com.pl/files/napisali_o_nas/artyluly_scany/Raport_PoradnikHandlowca_mazec2009.pdf (dostępny 05.08.2013). – 13. *Pn-En Iso 659:1999*. Nasiona oleiste. Oznaczanie zawartości oleju (Metoda odwoławcza). PKNMiJ, Warszawa. – 14. *Kolanowski W.*: Długołańcuchowe wielonienasycone kwasy tłuszczowe omega-3 – znaczenie zdrowotne w obniżaniu ryzyka chorób cywilizacyjnych. *Bromat. Chem. Toksykol.*, 2007; 40(3): 229-237. – 15. *Krygier K.*: Olej rzepakowy – jego wartość żywieniowa i użytkowa. *Przem. Spoż.*, 2009; 7(63): 16-18. – 16. *Ostrowska L.*: Leczenie dietetyczne otyłości – wskazówki dla lekarzy praktyków. *Forum Zaburzeń Metabolicznych*. 2010; 1(1): 22-30. – 17. *Jarosz M.*: Normy żywienia dla populacji Polskiej – nowelizacja. *IŻŻ*, Warszawa, 2012; 44-58. – 18. *Ascherio A, Willett W.C.*: Health effects of trans fatty acids. *Am. J. Clin. Nutr.* 1997; 66(4 Suppl): 1006-1010. – 19. *Mińkowski K., Grześkiewicz S., Jerzewska M.*: Ocena wartości odżywczej olejów roślinnych o dużej zawartości kwasów linolenowych na podstawie składu kwasów tłuszczowych, tokoferoli i steroli. *ZNTJ.*, 2011; 2(75): 124-135. – 20. *Skoczyńska A.*: Znaczenie żywienia w leczeniu chorych z rozpoznaniem zespołu metabolicznego. *Endokrynologia Otyłość i Zaburzenia Przemiany Materii*. 2011; 7(1): 25-33.

21. *Food Standards Australia New Zealand*. 2003. Erucic acid In food: A Toxicological Review and Risk Assessment. Technical report series. – 22. *Krygier K.*: Współczesna margaryna – aspekty technologiczne i żywieniowe, WN-T, Warszawa, 2011: 21-29. – 23. *Cichosz G., Czczot H.*: Rzekomo zdrowe tłuszcze roślinne *Merk. Lek.* 2011; 31: 239-243.

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