



ISSN 0035-7715
eISSN 2451-2311

ROCZNIKI PAŃSTWOWEGO ZAKŁADU HIGIENY

ANNALS OF THE NATIONAL INSTITUTE OF HYGIENE



Quarterly
2018
Volume 69
Number 2



NATIONAL INSTITUTE OF PUBLIC HEALTH
NATIONAL INSTITUTE OF HYGIENE

EDITOR and PUBLISHER:
NATIONAL INSTITUTE OF PUBLIC HEALTH
– NATIONAL INSTITUTE OF HYGIENE
Warsaw, Poland

ROCZNIKI PAŃSTWOWEGO ZAKŁADU HIGIENY

(ANNALS OF THE NATIONAL INSTITUTE OF HYGIENE)

Published since 1950

Quarterly, 4 issues in 1 volume per year (No 1 - March, No 2 - June, No 3 - September, No 4 - December)
The journal is devoted to research studies on food and water safety, nutrition, environmental hygiene, toxicology and risk assessment, public health and other related areas

Available at http://wydawnictwa.pzh.gov.pl/roczniki_pzh

Edited and published by the National Institute of Public Health - National Institute of Hygiene, Warsaw, Poland

EDITORIAL BOARD

Editor-in-Chief – Kazimiera Ćwiek-Ludwicka

Deputy Editor – Paweł Struciński

Editorial Secretary – Agnieszka Hernik

Editorial Assistant – Grzegorz Święckowski

Linguistic Editor – Piotr Hołownia

Statistical Editor – Daniel Rabczenko

SUBJECT EDITORS

Kazimierz Karłowski – food safety

Ewa Bulska – food and environmental analysis

Anna Gronowska-Senger – nutrition

Barbara Gworek – environmental hygiene

Jan K. Ludwicki – toxicology and risk assessment

Magdalena Bielska-Lasota, Grzegorz Juszczuk, Mirosław J. Wysocki – public health

INTERNATIONAL SCIENTIFIC BOARD

Stanisław Berger, Warsaw, Poland

Jens Peter Bonde, Copenhagen, Denmark

Brian T. Buckley, Piscataway, NJ, USA

Krzysztof Chomiczewski, Warsaw, Poland

Adrian Covaci, Antwerp, Belgium

Małgorzata M. Dobrzyńska, Warsaw, Poland

Jerzy Falandysz, Gdansk, Poland

Antoni K. Gajewski, Warsaw, Poland

Aleksander Giwercman, Malmö, Sweden

Muhammad Jamal Haider, Karachi, Pakistan

Grzegorz Juszczuk, Warsaw, Poland

Masahide Kawano, Ehime, Japan

Tao Li, Yunnan, China

Honggao Liu, Kunming, China

Halina Mazur, Warsaw, Poland

Julia Melgar Riol, Lugo, Spain

Krzysztof Pachocki, Warsaw, Poland

Andrea Raab, Aberdeen, Scotland, UK

Mark G. Robson, New Brunswick, NJ, USA

Martin Rose, York, UK

Kenneth S. Sajwan, Savannah, USA

Józef Sawicki, Warsaw, Poland

Jacques Scheres, Maastricht, The Netherlands

Jolanta Solecka, Warsaw, Poland

Andrzej Starek, Cracow, Poland

Ujang Tinggi, Archerfield Qld, Australia

Bogumiła Urbanek-Karłowska, Warsaw, Poland

Jesús Olivero Verbel, Cartagena, Colombia

Stefan M. Waliszewski, Veracruz, Mexico

Bogdan Wojtyniak, Warsaw, Poland

Jan Żmudzki, Puławy, Poland

Indexed/abstracted in: PubMed/MEDLINE, Scopus, Web of Science, EMBASE, EBSCO, Agro, Food Science and Technology Abstracts, Global Health, NISC SA Databases, Index Copernicus Int., Polish Medical Bibliography/Central Medical Library, Polish Ministry of Science and Higher Education (MNiSW), CNKI Scholar

Full articles are freely accessible on the journal's website: http://wydawnictwa.pzh.gov.pl/roczniki_pzh/annals
The printed version of the journal is identical to the on-line version.

Editorial office:

National Institute of Public Health - National Institute of Hygiene

24 Chocimska Street, 00-971 Warsaw, Poland

e-mail: roczniki.pzh@pzh.gov.pl

Editor-in-Chief phone: +48 22 54 21 266; fax +48 22 849 35 13, e-mail: cwludwicka@pzh.gov.pl

© Copyright by the National Institute of Public Health - National Institute of Hygiene, Warsaw, Poland

Edition: 150 copies

100 years
of the National Institute of Public Health
- National Institute of Hygiene
(1918 - 2018)

Publisher of Roczniki Państwowego Zakładu Higieny
- Annals of the National Institute of Hygiene





NATIONAL INSTITUTE OF PUBLIC HEALTH NATIONAL INSTITUTE OF HYGIENE

‘100 YEARS OF CARING FOR PEOPLE’S HEALTH IN POLAND’

The National Institute of Public Health – National Institute of Hygiene is the oldest public health institution in Poland.

We will be celebrating the centenary anniversary of its founding this year (2018). The Institute was originally established as the National Centre for Epidemiology, which in 1923 was renamed to the National Institute of Hygiene (*acronym in Polish* - PZH). Since 2007 it is called by its present name: The National Institute of Public Health – National Institute of Hygiene (*acronym in Polish* - NIZP-PZH).

Our Institute was created by the authorities of the reborn and newly independent Poland in response to health threats arising after the Russian October revolution and the German surrender in World War I within the old Russian and Austrian territories of partitioned Poland. The post-war ruins, poverty and mass movements of hundreds of thousands of refugees and repatriates resulted in many health epidemics; the gravest being typhus and typhoid fever.

The initial attempts to eliminate epidemics of infectious diseases and their prevention started in the newly independent Polish state in August 1919, when the Central Committee for Control of Typhus Epidemic was created. In March 1920, the Supreme Extraordinary Commissariat to Control Epidemics was established to whom we owe the organisation of sanitary cordons and effective control of epidemics at that time.

The National Institute of Hygiene was created as a scientific and laboratory base for the above activities, however from its inception, it was designed according to the farsseeing vision of Dr Ludwik Rajchman, as a modern institute embracing the basic domains of public health with its expert activity.

Over the years, the scope of the Institute’s activity has been adapted to the changing needs and challenges in the field of public health. Its scientific, servicing and training activities have always dealt with basic threats of population health.

The initial range of such scientific research and services had covered issues of prevention, diagnoses and treatment of infectious diseases along with occupational health and safety, mental health, nutrition, testing of foodstuffs and articles of common use, sanitation engineering, sanitation administration and supervision over sera, vaccines and other drugs. Some of these areas have required separate scientific establishments to be set up. Our Institute has by such means thus given rise to the following:

- National Medicines Institute
- Institute of Food and Nutrition
- The Prof. J. Nofer Institute of Occupational Medicine in Łódź
- Institute of Maritime and Tropical Medicine in Gdynia
- Institute of Antibiotics

In the meantime our Institute has been dealing with new challenges.

At present there are two separate scientific divisions at the NIZP-PZH:

Analyses and Strategies in Public Health, which monitors and analyses public health status, performs economic and systemic healthcare analyses as well as deals with health promotion, prevention of chronic disease and with education and communication in public health.

Epidemiological and Environmental Safety, which performs surveillance of infectious diseases, their spread and risk factors. It also promotes vaccination and its safety, undertakes diagnostics, differentiates microorganism pathogens, performs health risk assessments along with identifying and assessing potentially harmful factors of a chemical, physical or microbiological nature, as found in food, water, air and selected areas of the environment.

The institute collaborates with many scientific centres both at home and abroad, like the WHO, European Commission, ECDC, EFSA.

The centenary celebrations of the NIZP-PZH are entitled '100 years of caring for people's health in Poland'. Their honorary patron is the President of the Republic of Poland Mr. Andrzej Duda.

As part of the celebrations, a Jubilee Gala will be held on the 9th April 2018 at the National Philharmonic.

Three scientific conferences are also planned:

'100 years of dealing with pathogens'- June 2018

This conference will be dedicated to infections arising from various pathogens and the role of NIZP-PZH in their diagnoses, monitoring and eradication with particular focus on the significance of immuno-prevention. Other issues covered will be the indispensability of microorganisms in assuring normal bodily function and also the possibilities of using pathogens for treating cancer.

'Poland's health – yesterday, today and tomorrow' – October 2018

This conference will focus on the changing health status of Poles, from the conditions prevailing between the world wars right through to the present time along with the projection of future trends, taking into account the changing demographics. Due account will also be given to the transformations seen in field of epidemiology, hygiene issues, health education and health promotion. In addition, the relationships between the health situation and the national health system will be considered.

'Food, water and air – do we live in a safe environment?' – December 2018

The conference will concentrate on issues regarding the identification of health hazards found in food, water, air and those arising from anthropogenic chemical stress in the environment together with climate change and their interrelated effects on health risk assessments.

We most cordially invite you to attend in these scientific conferences so organised, and to read our scientific journals as published by our Institute.

The Institute Management Board, the Scientific Committee and the Organising Committee for the Centenary Anniversary Celebration of NIZP-PZH

ISSN 0035-7715
eISSN 2451-2311



ROCZNIKI PAŃSTWOWEGO ZAKŁADU HIGIENY

ANNALS OF THE NATIONAL INSTITUTE OF HYGIENE



**Quarterly
2018
Volume 69
Number 2**

EDITOR and PUBLISHER:
**NATIONAL INSTITUTE OF PUBLIC HEALTH
– NATIONAL INSTITUTE OF HYGIENE
Warsaw, Poland**

© Copyright by the National Institute of Public Health - National Institute of Hygiene,
24 Chocimska Street, 00-791 Warsaw, Poland
<http://www.pzh.gov.pl>

Printing house:
Agencja Reklamowa TOP
ul. Toruńska 148, 87-800 Włocławek
tel.: + 48 54 423 20 40, fax: + 48 54 423 20 80
<http://www.agencjatop.pl>

ROCZNIKI PAŃSTWOWEGO ZAKŁADU HIGIENY

[ANNALS OF THE NATIONAL INSTITUTE OF HYGIENE]

Volume 69

2018

Number 2

REVIEW ARTICLES

- Furan in roasted, ground and brewed coffee.
E. Gruczyńska, D. Kowalska, M. Kozłowska, E. Majewska, K. Tarnowska 111
- Garden nasturtium (*Tropaeolum majus* L.) - a source of mineral elements and bioactive compounds.
K. Jakubczyk, K. Janda, K. Watychowicz, J. Łukasiak, J. Wolska 119

ORIGINAL ARTICLES

- Analysis of acrylamide, 3-monochloropropane-1,2-diol, its esters and glycidyl esters in carbohydrate-rich products available on the Polish market.
A. Sadowska-Rociek, M. Surma, E. Cieślik 127
- The influence of preschool children's diets on the risk of lifestyle diseases. A pilot study.
M. Kostecka 139
- Food aversions and dietary preferences in pre-school children from Olsztyn.
J. Ciborska, J. Kłobukowski, I. Pierzchała 147
- Analysis of the choice of food products and the energy value of diets of female middle- and long-distance runners depending on the self-assessment of their nutritional habits.
D. Głóbska, M. Jusinska 155
- Analysis of nutrition and nutritional status of haemodialysis patients.
A. Bogacka, A. Sobczak-Czyszcz, E. Kucharska, M. Madaj, K. Stucka 165
- Dietary practices and nutritional status in survivors of breast cancer.
E. Kałedkiewicz, D. Szostak-Węgierek 175
- The assessment of the nutritional value of meals consumed by patients with recognized schizophrenia.
E. Stefańska, A. Wendolowicz, M. Lech, K. Wilczyńska, B. Konarzewska, J. Zapolska, L. Ostrowska 183
- Eating behaviours of primary school pupils from Śląskie, Malopolskie and Opolskie Voivodeships in Poland.
A. Dolipska, M. Majerczyk, A. Góra, K. Janion, E. Szczepanska 193
- Evaluation of health status of children attending primary schools with different organization of physical education lessons.
O.S. Kondratiuk, M.M. Korshun, S.I. Garkavyi, S.S. Garkavyi 203
- Health policy programs realised in Poland in 2016-2017.
P. Kurowska, A. Królak, W. Giermaziak 209
- Instruction for authors** 219

FURAN IN ROASTED, GROUND AND BREWED COFFEE

Eliza Gruczyńska, Dorota Kowalska, Mariola Kozłowska, Ewa Majewska, Katarzyna Tarnowska

Department of Chemistry, Faculty of Food Sciences, Warsaw University of Life Sciences (WULS – SGGW),
Nowoursynowska 159 C, 02-776 Warsaw, Poland

ABSTRACT

Coffee is the most popular hot beverage in the world. The annual coffee production in 2010, 2014 and 2016 was 8.1, 9.0 and 9.3 million tons respectively. There are more than 100 coffee species, but only two of them: Arabica (*Coffea arabica*) and Robusta (*Coffea canephora*) have gained commercial importance. During roasting of green coffee beans not only desirable compounds are formed, that exert positive influence on the taste and flavour of coffee, but also small quantities of undesirable ones. Furan (C₄H₄O) is one of the latter.

Furan is a volatile compound (boiling temp. of 31.4 °C) formed during thermal processing of food. The toxicity of furan has been well documented and it is classified as “possible human carcinogen” (Group 2B) by the International Agency for Research on Cancer. Various pathways have been reported for furan formation during food processing. It can be formed from carbohydrates, amino acids by their thermal degradation or thermal re-arrangement and by oxidation of ascorbic acid and polyunsaturated acids and carotenoids. High concentrations of furan have been reported in coffee, baked and roasted food and in food subjected to preserving in cans and jars. Furan levels in brewed coffee are typically near or below 120 µg/L, but it can approach thousands µg/kg in roasted whole beans or ground coffee. The highest concentration of furan in roasted coffee reaches the level of 7000 µg/kg. Taking into account that coffee is the most popular hot drink, it becomes the main contributor to furan exposure from dietary sources for adults.

In this article the published scientific papers concerned with the presence of furan in roasted non-brewed and brewed coffee have been reviewed. The formation mechanisms and occurrence of furan in coffee and the harmful influence of furan on the consumer health have been discussed.

Key words: furan, roasted coffee, brewed coffee, green coffee beans, roasted coffee beans

STRESZCZENIE

Kawa jest jednym z najpopularniejszych napojów w świecie. Roczna produkcja kawy w 2010, 2014 i 2016 roku wynosiła odpowiednio 8,1, 9,0 i 9,3 mln ton. Liczba wypijanych na świecie w ciągu dnia filiżanek kawy sięga 1,4 mld, a w ciągu roku – ponad 500 mld.

Istnieje ponad 100 gatunków kawy ale tylko 2 z nich: Arabika (*Coffea arabica*) i Robusta (*Coffea canephora*) – zyskały znaczenie handlowe. W procesach palenia ziaren kawowych powstaje wiele związków chemicznych wywierających korzystny wpływ na smak i aromat, ale także niewielkie ilości związków niepożądanych. Jednym z takich związków jest furan.

Furan (C₄H₄O) jest bezbarwną, lotną cieczą (temp. wrzenia 31,4 °C), powstającą z węglowodanów, aminokwasów, kwasu askorbinowego, kwasów wielonienasyconych i karotenoidów podczas termicznej obróbki żywności. Toksyczność furanu została dobrze udokumentowana a furan został sklasyfikowany jako „potencjalny czynnik rakotwórczy dla ludzi” (Grupa 2B) przez Międzynarodową Agencję Badań nad Rakiem. Wysokie stężenia furanu stwierdzono w żywności smażonej, pieczonej, prażonej, a także pakowanej w puszkach i słoikach. Najwyższe stężenia furanu występują w ziarnach palonej kawy – do 7000 µg/kg. W napojach kawowych zawartość furanu wynosi 20 – 120 µg/L.

Kawa jest najpopularniejszym napojem. Stanowiąc źródło znacznych ilości furanu jest ona głównym składnikiem diety dorosłych wprowadzającym furan do organizmu. W prezentowanej pracy dokonano przeglądu naukowych publikacji dotyczących obecności furanu w kawie palonej i w napojach kawowych. Przedstawiono mechanizmy powstawania furanu oraz poziomy jego zawartości w kawie oraz dyskutowano szkodliwy wpływ furanu na zdrowie konsumentów.

Słowa kluczowe: furan, kawa palona, kawa parzona, zielone ziarna kawy, palone ziarna kawy

Corresponding author: Eliza Gruczyńska, Department of Chemistry, Faculty of Food Sciences, Warsaw University of Life Sciences (WULS – SGGW), Nowoursynowska 159 C, 02-776 Warsaw, Poland, Tel.: +48 22 5937610, Fax: +48 22 5937635, E-mail: eliza_gruczynska@sggw.pl

INTRODUCTION

Coffee is the most popular (after water) beverage in the world and it is consumed for its unique taste, flavour and stimulating or relaxing effects. Coffee is also used for social reasons, which is evident from 400-year history of coffee houses [19]. The annual coffee production in 2010, 2014 and 2016 was 8.1, 9.0 and 9.3 million tons respectively [4, 5]. Every day over 1.4 billion (1.4×10^3 million) cups of coffee are consumed worldwide, it means more than 500 billion cups per year. In Poland the statistical annual consumption of coffee beans reaches 2.3 kg per person, while the European leaders are Finnish, who consume 12.2 kg [24]. The coffee business is the second largest after petroleum business and provides an employment for over 20 million people. Coffee is commercially cultivated on plantations in countries located between the tropics in more than 70 countries, but Brazil, Colombia, Ethiopia, Vietnam, Indonesia and India are the leading producers [19]. With an export of almost 1.57 million tons in 2013 and 2.18 million tons in 2015 of green coffee beans Brazil is the world's largest exporter [4, 46].

There are more than 100 coffee species, but only two of them: *Coffea arabica* (Arabica coffee) and *Coffea canephora* (Robusta coffee) have gained commercial importance with about 64% and 34% of total worldwide production respectively [47]. The details on the coffee origin and plants, species and varieties, producing countries and processing of crops to obtain green bean coffee by dry or wet technologies can be found elsewhere [41]. For this work the following aspects are important:

- chemical composition of green bean coffee, influence of roasting of green beans and then grinding on transformations of some chemical compounds during these processes;

- influence of reasonable and excessive drinking of coffee on consumer health;
- formation of furan during coffee roasting and its presence in brewed coffee.

This paper is a concise review of the papers that have been published mainly for the last ten years and concerned with the presence of furan in food. The special attention has been paid to the presence of furan in roasted and brewed coffee.

FURAN IN FOOD – ITS SOURCES AND TOXICITY

Furan is colourless, heterocyclic, aromatic compound with boiling temperature of 31.4 °C. Its presence in food has been known since the 1930s [21]. In the past the best source of information on the presence of furan and its derivatives in food was the review article by *Maga* [27]. Furan is formed in food as a result of heating or exposure to ionizing or ultraviolet radiation [12, 13]. Such processing of food as cooking, roasting, frying, baking, pasteurization and sterilization are the main causes of furan formation [40].

There are various pathways of furan formation, such as:

- thermal degradation of carbohydrates alone or in presence of amino acids,
- thermal degradation of some amino acids,
- oxidation of ascorbic acid at elevated temperatures,
- oxidation of polyunsaturated fatty acids (PUFA) and carotenoids.

All these potential pathways of furan formation have been illustrated in Figure 1.

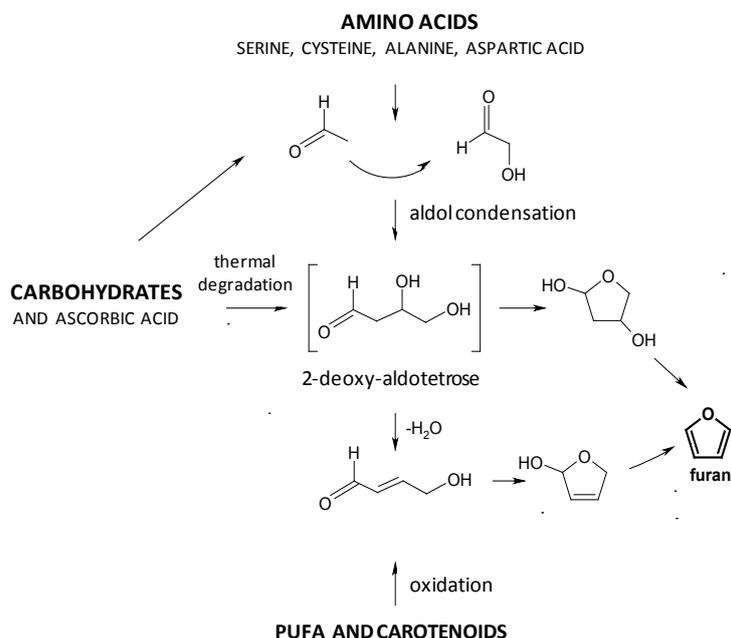


Figure 1. Pathways of furan formation in food [35]

There is a lot of papers on furan formation and its presence in food. In this paper only some examples of book chapters [17, 51], doctoral thesis [28], and some review papers [3, 9, 11, 12, 15, 23, 29, 32, 33, 35, 39, 40, 49] are cited. The paper [9] with 66 references is a concise review of the papers published till 2010. The cited research papers dealing with occurrence, formation and mitigation of furan in food are briefly summarized.

Presence of furan in food has gained extremely strong interest among food chemists. It has been known for years that furan is toxic and carcinogenic as it was proven with studies on laboratory animals (rats and mice). In 1995 IARC (International Agency for Research on Cancer) classified furan as “possibly carcinogenic to humans” (Group 2B) [20]. In the opinion of European Food Safety Authority (EFSA) evidence indicates that furan-induced carcinogenicity is probably attributable to a genotoxic mechanism [10]. Furan may cause gene mutations, chromosome aberrations and sister chromatid exchanges in cultured mammalian cells and chromosomal aberrations in mice bone marrow cells [6]. Its genotoxic mechanism was confirmed in numerous tests which allowed to detect different types of mutations caused by cytotoxic reactive metabolite of furan (cis-2-butene-1,4-dial – BDA) formed in the liver.

The BDA is able to react with deoxyribonucleotides *in vitro* and form unstable DNA adducts [6, 31]. Furan is rapidly absorbed and extensively metabolised after ingestion by rats and mice. Due to its low polarity, it penetrates biological membranes. Chronic exposure to furan may result in hepatocytes proliferation which promotes the liver carcinomas response. Furthermore, for rats of both sexes, a dose-dependent increase in the frequency of hepatocellular adenomas and mononuclear leukemia occurrence was observed. The high frequency of cholangiocarcinoma occurrence was also proven [6]. Regarding human organism, furan can penetrate through both the digestive and respiratory systems – whilst preparing food. The presence of furan has been proven in more than 300 products as a result of heat treatment. The second highest furan content (after coffee) amounting up to 200 µg/kg was found in baked products, such as cookies, chips and crispy breads [31]. It is worth mentioning that statistical Polish consumes about 2 kg such products per year [22] and with them about 400 mg of furan. Considerable amounts of furan were also determined in caramel, bread, roasting sauces and soy sauce [23]. Besides, the opinion that furan volatilizes from food packaged in non-hermetic containers is questioned by the results. Moreover, the high furan content was confirmed in food packed in sealed containers. A large surface of some products

packed this way indicates furan binding by adsorption. Furan may occur in products subjected to spray drying or microencapsulation, especially where the gas is trapped mechanically inside microgranules [23]. Furan was also found in ready-to-eat bottled meals for children in the amounts reaching 112 µg/kg [31].

In 2010 report of the Joint FAO/WHO Expert Committee on Food Additives (JECFA) provides the benchmark dose lower limit BMDL10 of 0.96 mg/kg body mass per day, which made possible to set a margin of exposure (MOE) [6, 31]. The risk assessment may have resulted in a health based guidance value such as Tolerable Daily Intake (TDI) or, in the case of substances that are both genotoxic and carcinogenic, the MOE with, if needed, a recommendation to reduce exposure to as low as reasonably achievable. This is so called ALARA approach [48]. By now no epidemiological study connected to furan in humans has been made available. JECFA calculated the following dietary exposures for furan: 1 µg/kg body mass per day for the general population, and 2 µg/kg body mass per day for consumers with high exposure to furan. These estimates cover potential dietary exposure for children as well as adults [9]. The mean dietary exposure (µg/kg body mass per day) to furan are in Europe – 0.29-1.17 for adults, 0.27-1.01 for infants of 3-12 months, in North America (USA) – 0.25-0.26 for adults, 0.23 for children of 2-5 years, 0.41 for infants up to 12 months, in South America (Brazil) – 0.46 for infants of 6-11 months [9].

Very similar data has been reported by *Van der Fels-Klerx* et al. [48].

Among all the food products for human beings, the richest source of furan is coffee.

ROASTED AND BREWED COFFEE

The chemical composition of coffee was extensively discussed by *Farah* [14], *Oestreich-Janzen* [34] and *Stalmach* et al. [44]. The roasting process starts at about 130 °C (sugars caramelisation after water evaporation). When the temperature reaches about 170-210 °C, the chemical reactions of the *Maillard* type occur in coffee beans. During them the key intermediate compounds (according to the *Heyns* and *Amadori* rearrangements) and eventually melanoidins are formed which play important role in coffee flavour and colour. The coffee beans change colour from green to clear-brown or dark brown depending on the temperature and time of roasting. The chemical composition (Table 1) and sensorial attributes of roasted coffee differ from these ones for green bean coffee [5, 47]. The roasted and ground coffee can be brewed in various ways giving beverages very popular among consumers.

Table 1. Chemical composition of green and roasted coffee [14]

Component	Concentration [g/100 g]			
	Arabica		Robusta	
	green	roasted	green	roasted
Carbohydrates				
Sacharose	6.0-9.0	4.2	0.9-4.0	1.6
Polysaccharides	34-44	31-33	0.4	37-38
Lignins	3.0	3.0	3.0	3.0
Pectins	2.0	2.0	2.0	2.0
Reducing Sugars	0.1	0.3	0.4	0.3
Nitrogen compounds				
Proteins	10.0-11.0	7.5-10.0	11.0-15.0	7.5-10.0
Cafeine	0.9-1.3	1.1-1.3	1.5-2.5	2.4-2.5
Trigonelline	0.6-2.0	0.2-1.2	0.6-0.7	0.3-0.7
Free amino acids	0.5	-	0.8-1.0	-
Lipids				
Caffeic oil, sterols, tocopherols	15.0-17.0	17.0	7.0-10.0	11.0
Diterpenes, free and esterified	0.5-1.2	0.9	0.2-0.8	0.2
Minerals	3.0-4.2	4.5	4.4-4.5	4.7
Acids and Esters				
Chlorogenic acids	4.1-7.9	1.9-2.5	6.1-11.3	3.3-3.8
Aliphatic acids	1.0	1.6	1.0	1.6
Chinoic acid	0.4	0.8	0.4	1.0
Melanoidins	-	25	-	25

The health aspects of coffee drinking have been the subject of many controversial debates. In the past a negative picture of the influence of coffee drinking on the consumer health was created. Even recently a substantial number of papers about coffee has been negative. In the United Kingdom, for example, 51% of media publications on coffee, caffeine and health have been negative, 22% – neutral, and 27% – positive [19].

Nowadays most papers present real or possible beneficial health implications of coffee drinking even in large amounts. The beneficial influence of coffee drinking on such diseases as: type 2 diabetes, cardiovascular disease, cancer of various organs, *Alzheimer's* and *Parkinson's* diseases and others has been studied, reported and discussed. As these problems are very extensive and obviously beyond the scope of this paper, only few examples of papers are given here [8, 26, 37]. The simplified composition of brewed regular coffee is shown in Figure 2. Apart from desirable compounds that exert positive influence on the taste and flavour of coffee, the undesirable ones are also formed. Among them there are: ochratoxine A [36], β -carbolines (harman and norharman) [14], polycyclic aromatic hydrocarbons [46], acrylamide [42, 43], 3-monochloropropane-1,2-diol (3-MCPD) [38] and furan [17, 18].



Figure 2. Cup of coffee (chemical composition, mg/100 mL) [14]

FURAN IN COFFEE

Analysing the information on chemicals gathered in Table 1 and in Figure 1 it becomes obvious that during roasting of coffee furan is formed. The presence of substrates, high temperature and low water activity create excellent conditions for furan formation. The porous structure of roasted coffee beans traps it. Roasted coffee beans contain furan in the largest quantities comparing with other food. It is generally

accepted that furan concentrations in coffee change in the following order: roasted beans > roasted powder >> instant powder > brewed [48]. Some published

data of the presence of furan in roasted solids (beans, ground beans, powders) and brewed coffee is listed in Tables 2 and 3.

Table 2. Furan in coffee – data selected from [51]

Coffee Type	Country	Furan content [$\mu\text{g}/\text{kg}$] or [$\mu\text{g}/\text{L}$]		
		Average	Minimum	Maximum
Cappuccino	Australia	32.3	23.0	50.0
Ground Coffee Brewed		23.0	22.0	24.0
Flat White		33.2	25.0	53.0
Latte		22.9	7.0	49.0
Long Black		42.0	16.0	77.0
Mocha		23.5	12.0	35.0
Short Black		112.5	15.0	210.0
Ground Roasted Powder	Brazil	2998.1	1946.4	5021.4
Instant Powder		413.0	279.0	547.0
Coffee (non specified)	EU	1691.0	2.0	6500.0
Instant		589.0	8.0	2200.0
Roasted Bean		2272.0	5.0	4895.0
Roasted Ground		1114.0	5.0	5749.0
Brewed Coffee	Japan		5.8	150.0
Canned Coffee			4.1	150.0
Coffee (Can)		34.0	35.0	120.0
Coffee (Carton)		65.0	39.0	83.0
Coffee (PET Bottle)			43.0	120.0
Coffee Mix (Liquid)	South Korea	3.6	1.1	5.5
Coffee Mix (Powder)		54.2	26.4	99.0
Ground Roasted Brewed		48.5	30.7	67.1
Ground Roasted Powder		814.1	267.1	2252.7
Instant Liquid		3.5	0.7	4.5
Instant Powder		90.1	22.6	224.5
Coffee Extract	Switzerland	98.0	73.0	125.0
Coffee Beans		4400.0	2650.0	5050.0
Instant Brewed		17.0	1.0	51.3
Instant Powder		783.3	44.0	2150.0
Roasted Brewed		82.9	13.0	199.0
Roasted Powder		1979.0	22.0	5938.0
Instant Brewed	USA	6.0	4.8	7.2
Roasted Brewed		46.7	39.6	84.2

As furan is highly volatile, its presence in brewed coffee depends on the brewing procedure, and also on temperature and time after brewing. *Mesias* and *Morales* [30] reported that the furan levels in coffee beverages prepared in popular vending machines ranged from 11 to 262 ng/mL (mean 171 ± 59.8 ng/mL) and decrease rapidly after simulating the behaviour of coffee consumption (~74% after 5 minutes standing at room temperature). Assuming furan content in coffee as 6 mg/kg (Table 3), average annual intake of furan from coffee only reaches 14 mg for statistical Poles, but as many as 73 mg for statistical Finns. Furan intake from coffee ranges from 0.02 to 0.43 $\mu\text{g}/\text{kg}$ body mass per day resulting in a mean exposure of 0.31 $\mu\text{g}/\text{kg}$ body mass per day. This is consistent with data reported in other sources [9, 48] and reaches about 50% of the total daily furan exposure for adults.

The GC-MS (gas chromatography–mass spectrometry) is the most suitable technique for determinations of furan in food. The GC-MS is usually preceded by headspace (HS) extraction or headspace solid-phase microextraction (HS-SPMS). Owing to the high volatility of furan, the samples and standards have to be carefully prepared and they need to be cooled and handled quickly [51]. The quantification of furan in samples has been based on internal standard additions (usually deuterated furan, d_4 -furan) or external calibration. Limits of furan detection (LOD) and quantification (LOQ) in food are in the range from 0.1 ng/g to 5 ng/g and from 0.4 to 13 ng/g respectively. The 32 European countries and Turkey have adopted official European Standard EN 16620:2015 for furan determination in coffee [45]. In Poland determination of furan in coffee and coffee products should be performed in accordance with the European Standard PN-EN 16620:2015 [45].

Table 3. Furan in coffee – data selected from the A to G papers published from 2009 to 2016

Coffee type BR – brewed / NBR – non-brewed	Furan content [$\mu\text{g}/\text{kg}$] or [$\mu\text{g}/\text{L}$]		Country	Reference
	Minimum	Maximum		
From Coffee Chains (BR)	44.5	234.4	Germany	[50]
Instant (BR)	0.6	11.1		
Ready to Drink (BR)	2.4	108.8		
Cameroon Arabica (BR/NBR)	34.5/54.4	40.5/60.2	Cameroon	[25]
Cameroon Robusta (BR/NBR)	123.0/211.0	138.9/241.5	Ethiopia	
Ethiopia (BR/NBR)	56.3/199.2	63.3/231.8		
India Robusta Cherry (BR/NBR)	54.1/124.0	66.5/143.8	India	
India Robusta Monsooned (BR/NBR)	92.0/445.1	111.0/528.3	Salvador	
Salvador (BR/NBR)	96.7/163.2	109.7/187.8		
Santos (BR/NBR)	63.8/466.7	67.7/587.3	Brazil	
Vietnam (BR/NBR) [#]	36.0/127.0	171.0/353.0	Vietnam	
Arabica Light (BR/NBR)	10.0/985.0	30.0/1373.0	Brazil	[1]
Arabica Medium (BR/NBR)	16.0/322.6	129.0/3631.0		
Arabica Dark (BR/NBR)	30.0/3262.0	170.0/4345.0		
Robusta Light (BR/NBR)	10.0/1722.0	125.0/2573.0		
Robusta Medium (BR/NBR)	12.0/3505.0	172.0/5468.0		
Robusta Dark (BR/NBR)	21.0/4859.0	279.0/5697.0		
Ground Beans (BR/NBR)	31/1222	76/1966	Denmark	[16]
Instant Powder (NBR)	39	1330		
Dark/Medium Espresso Instant Powder NBR	20	2593	Iran	[7]
Ground Coffee (NBR)	1375	6233		
Mixed Coffee Powder (NBR)	10	226		
Brewed Coffee (50 g/l)	10	35	Western Europe	[18]
Roasted Whole Beans (NBR)	2000	7000		
Roasted Whole Beans Ground (NBR)	1200	4200		
Coffee from automatic vending machine	11	262	Spain	[30] [‡]
Cartridge Ground Coffee	59.1	251	Canada	[2] [‡]
Cartridge Ground, French Press/Drip Method (Mean)		77.6/46.7		
Decaffeinated Coffee (BR)	6.63	121		
Decaffeinated Ground/Decaff.Instant (NBR)	1640/32	3450/896		
Espresso (BR)	34.9	352		
Medium Roasted (BR)	25.1	69.5		

[#] Brewed in Turkey mode. [‡] data in ng/g.

SUMMARY AND CONCLUSIONS

Furan is a potential human carcinogen that can be formed in variety of foods such as coffee, baby food, bread, snacks etc. It is formed in food as a result of heating or exposure to ionizing or ultraviolet radiation. Such processing of food as cooking, roasting, frying, baking, pasteurization and sterilization are the main causes of furan formation. There is an evidence that furan-induced carcinogenicity is probably due to a genotoxic mechanisms, although there have been no studies conducted on humans.

Coffee is the most popular hot beverage in the world. On the other hand during roasting of coffee beans large quantities of furan are formed. As

a consequence brewed coffee also contains furan. The available published information on the presence of furan in coffee (supported by detailed data) has been exhaustively analyzed. Furan dietary exposure and health aspects related to coffee drinking have also been discussed.

Average annual furan intake from coffee only ranges from 14 to 73 mg per person and 0.02 to 0.43 $\mu\text{g}/\text{kg}$ body mass per day respectively, that means about 50% of the total daily furan exposure limit for adults.

It might seem interesting to try to sum up the total intake of furan from all the sources in the diet, however it needs to be stressed that the annual consumption of furan with crisps and chips (that is the second highest

source of furan in food) is only about 0.4 mg per person, that means between 35 and 180 times less than furan from coffee.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Ariseto A.P., Vincente B., Ueno M.S., Tfouni S.A.W., De Figueiredo Toledo M.C.: Furan levels in coffee as influenced by species, roast degree, and brewing procedures. *J Agric Food Chem* 2011; 59: 3118-3124.
2. Becalski A., Halldorson T., Hayward S., Roscoe V.: Furan, 2-methylfuran and 3-methylfuran in coffee on the Canadian market. *J Food Compos Anal* 2016; 47: 113-119.
3. Blank I.: Furan in Processed Foods. In: Gilbert J., Şenyuva H.Z. eds. *Bioactive compounds in foods*. Blackwell Publishing Ltd., 2008.
4. Brondi A.M., Torres C., Garcia J.S., Trevisan M.G.: Differential scanning calorimetry and infrared spectroscopy combined with chemometric analysis to the determination of coffee adulteration by corn. *J Braz Chem Soc* 2017; 28: 1-7.
5. Caprioli G., Cortese M., Sagratini G., Vittori S.: The influence of different types of preparation (espresso and brew) on coffee aroma and main bioactive constituents. *Int J Food Sci Nutr* 2015; 66(5): 505-513.
6. Carthew P., DiNovi M., Setzer R.W.: Application of the margin of exposure (MoE) approach to substances in food that are genotoxic and carcinogenic. Example: Furan (CAS No. 110-00-9). *Food Chem Toxicol* 2010; 48: S69-S74.
7. Chaichi M., Ghasemzadeh-Mohammadi V., Hashemi M., Mohammadi A.: Furanic compounds and furfural in different coffee products by headspace liquid-phase microextraction followed by gas chromatography-mass spectrometry: survey and effect of brewing procedures. *Food Addit Contam Part B* 2015; 8(1): 73-80.
8. Chu Y.F.: *Coffee: emerging health effects and disease prevention*. IFT Press, Wiley-Blackwell, 2012.
9. Codex Alimentarius Commission. FAO/WHO. Joint FAO/WHO Food Standards Programme. Codex Committee on Contaminants in Foods (CCCF). Discussion Paper on Furan. 5th Session. The Hague, The Netherlands, 21-25 March 2011.
10. Commission Recommendation (EC) No 196/2007 of 28 March 2007 on the monitoring of the presence of furan in foodstuffs. *Off J EU L* 88/56, 29.3.2007.
11. Crews C.: Consumer exposure to furan from heat-processed foods and kitchen air. *EFSA Journal* 2009; 6(9): 1-65.
12. Crews C., Castle L.: A review of the occurrence, formation and analysis of furan in heat-processed foods. *Trends Food Sci Technol* 2007; 18: 365-372.
13. Fan X., Sokorai K.J.B.: Effect of ionizing radiation on furan formation in fresh-cut fruits and vegetables. *J Food Sci* 2008; 73(2): C79-C83.
14. Farah A.: Coffee constituents. In: Chu Y.F. ed. *Coffee: emerging health effects and disease prevention*. IFT Press, Wiley-Blackwell, 2012.
15. Fromberg A., Fagt S., Granby K.: Furan in heat processed food products including home cooked food products and ready-to-eat products. *EFSA Journal* 2009; 6(9): 1-49.
16. Fromberg A., Mariotti M.S., Pedresci F., Fogt S., Granby K.: Furan and alkylated furans in heat processed food including home cooked products. *Czech J Food Sci* 2014; 32(3): 443-448.
17. Guenther H.: Furan in coffee. In: Chu Y.F. ed. *Coffee: emerging health effects and disease prevention*. IFT Press, Wiley-Blackwell, 2012.
18. Guenther H., Hoenicke K., Biesterveld S., Gerhard-Rieben E., Lantz I.: Furan in coffee: Pilot studies on formation at roasting and losses during production steps and consumer handling. *Food Addit Contam* 2010; 27(3): 283-290.
19. Hatzold T.: Introduction. In: Chu Y.F. ed. *Coffee emerging health effects and disease prevention*. IFT Press, Wiley-Blackwell, 2012.
20. IARC. International Agency for Research on Cancer: *Monographs on the evaluation of carcinogenic risks to humans. Dry cleaning. Some chlorinated solvents and other industrial chemicals*. Lyon, France, IARC, 1995; 63: 393-407.
21. Johnston W.R., Frey C.N.: The volatile constituents of roasted coffee. *J Am Chem Soc* 1938; 60: 1624-1627.
22. Kosicka-Gębska M., Gębski J.: Słone przekąski w diecie młodych konsumentów [Salty snacks in the diet of young consumers]. *Bromat Chem Toksykol* 2012; 45(3): 733-738 (in Polish).
23. Kowalski B., Łobacz M., Kowalska D., Bekas W.: Furan w żywności: powstawanie, oznaczanie, pobór z diety, możliwości redukcji zawartości [Furan in foods: formation, analytical determination, dietary intake, reduction of contents]. *Bromat Chem Toksykol* 2008; 41(3): 219-223 (in Polish).
24. Kwaśnicki W., Piński A., Remin P., Sadowski A.: Ile zapłacimy za kawę? Dynamika i perspektywy cen kawy [How much will we pay for coffee? Dynamics and perspectives of coffee prices]. *Raport Centrum im. A. Smitha* 2017 (in Polish).
25. La Pera L., Liberatore A., Avelone G., Fanara S., Dugo G., Agozzino P.: Analysis of furan in coffee from different provenience by head-space solid phase microextraction gas chromatography-mass spectrometry: effect of brewing procedures. *Food Addit Contam* 2009; 26(6): 786-792.
26. Ludwig I.A., Clifford M.N., Lean M.E.J., Ashihara H., Crozier A.: Coffee: biochemistry and potential impact on health. *Food Funct* 2014; 5: 1695-1717.
27. Maga J.A.: Furans in food. *CRC Crit Rev Food Sci Nutr* 1979; 355-400.
28. Mariotti Celis M.S.: Study of furan formation in starchy foods processed at high temperature and technologies for its mitigation. Doctoral Thesis. Santiago de Chile, Pontificia Universidad, Catolica De Chile, Escuela De Ingenieria, 2014.

29. *Mariotti M.S., Granby K., Rozowski J., Pedreschi F.*: Furan: a critical heat induced dietary contaminant. *Food Funct* 2013; 4: 1001-1015.
30. *Mesias M., Morales F.J.*: Reliable estimation of dietary exposure to furan from coffee: An automatic vending machine as a case study. *Food Res Int* 2014; 61: 257-263.
31. *Minorzcyk M., Góralczyk K., Struciński P., Hernik A., Czaja K., Łyczewska M., Korcz W., Starski A., Ludwicki J.K.*: Risk assessment for infants exposed to furan from ready-to-eat thermally processed food products in Poland. *Rocz Panstw Zakl Hig* 2012; 63(4): 403-410.
32. *Mogol B.A., Gokmen V.*: Thermal process contaminants: acrylamide, chloropropanols and furan. *Curr Opin Food Sci* 2016; 7: 86-92.
33. *Moro S., Chipman J.K., Wegener J-W., Hamberger C., Dekant W., Mally A.*: Furan in heat-treated foods: formation, exposure, toxicity, and aspects of risk assessment. *Mol Nutr Food Res* 2012; 56: 1197-1211.
34. *Oestreich-Janzen S.*: Chemistry of coffee. Hamburg, Elsevier, 2013.
35. *Peres-Locas C., Yaylayan V.A.*: Origin and mechanistic pathways of formation of the parent furan – a food toxicant. *J Agric Food Chem* 2004; 52: 6830-6836.
36. *Pierzynowska J., Górnicka M., Frąckiewicz J., Tomczak A.*: Oszacowanie pobrania ochratoxyny A z kawą [Assessment of ochratoxin A intake with coffee]. *Probl Hig Epidemiol* 2016; 97(1): 87-90 (in Polish).
37. *Pourshahidi L.K., Navarini L., Petracco M., Strain J.J.*: A comprehensive overview of the risks and benefits of coffee consumption. *Compr Rev Food Sci Food Saf* 2016; 15: 671-684.
38. *Sadowska-Rociek A., Cieslik E.*: Assessment of 3-MCPD levels in coffee and coffee substitutes by simplified QuEChERS method. *J Verbr Lebensm* 2015; 10(2): 117-122.
39. *Santonicola S., Mercogliano R.*: Occurrence and production of furan in commercial foods. *Ital J Food Sci* 2016; 28: 155-177.
40. *Seok Y.J., Her J.Y., Kim Y.G., Kim M.Y., Jeong S.Y., Kim M.K., Lee J., Kim C.I., Yoon H.J., Lee K.G.*: Furan in thermally processed foods – a review. *Toxicol Res* 2015; 31(3): 241-253.
41. *Smith A.W.*: Introduction. In: *Clarke R.J., Macrae R.* eds. Coffee. Vol. 1: Chemistry. Elsevier Applied Science, 1985.
42. *Stadler R.H.*: The formation of acrylamide in cereal products and coffee. In: *Skog K., Alexander J.* eds. Acrylamide and other hazardous compounds in heat treated foods. Cambridge UK, CRC Press, Woodhead Publishing Ltd., 2006.
43. *Stadler R.H., Theurillat V.*: Acrylamide in coffee. In: *Chu Y.F.* ed. Coffee: emerging health effects and disease prevention. ITF Press, Wiley-Blackwell, 2012.
44. *Stalmach A., Clifford M.N., Williamson O., Crozier R.A.*: Phytochemicals in coffee and the bioavailability of chlorogenic acids. In: *Crozier A., Ashihara H., Tomas-Barneran F.* eds. Teas, cocoa and coffee. Plant secondary metabolites and health. Blackwell Publishing Ltd., 2012.
45. Standards: EN 16620: 2015, PN-EN 16620: 2015. Food Analysis – determination of furan in coffee and coffee products by headspace gas chromatography and mass spectrometry (HS GC-MS). Analiza żywności – oznaczanie furanu w kawie i produktach kawowych metodą chromatografii gazowej z analizą fazy napowierzchniowej w połączeniu ze spektrometrią mas (HS GC-MS). Warsaw, Polish Committee for Standardization, 2015.
46. *Tfouni S.A.V., Serrate C.S., Leme F.M., Camargo M.C.R., Teles C.R.A., Cipolli K.M.V.A.B., Furlani R.P.Z.*: Polycyclic aromatic hydrocarbons in coffee brew: influence of roasting and brewing procedures in two Coffea cultivars. *LWT – Food Sci Technol* 2013; 50: 526-530.
47. *Toledo P.R.A.B., Pezza L., Pezza H.R., Toci A.T.*: Relationship between the different aspects related to coffee quality and their volatile compounds. *Compr Rev Food Sci Food Saf* 2016; 15: 705-719.
48. *Van der Fels-Klerx H.J., Edwards S.G., Kennedy M.C., O'Hagan S., O'Mahony C., Scholz G., Steinberg P., Chiodini A.*: A framework to determine the effectiveness of dietary exposure mitigation to chemical contaminants. *Food Chem Toxicol* 2014; 74: 360-371.
49. *Vranová J., Ciesarová Z.*: Furan in food – a review. *Czech J Food Sci* 2009; 27(1): 1-10.
50. *Weizenegger J., Winkler G., Kuballa T., Ruge W., Kersting W., Alexy U., Lachenmeier D.W.*: Analysis and risk assessment of furan in coffee products targeted to adolescents. *Food Addit Contam* 2012; 29(1): 19-28.
51. *Williams G.M., Ariseto A.P., Baines J., DiNovi M., Feeley M., Schlatter J., Slob W., Toledo M.C.F., Vavasour E.*: Furan (487-587) and Appendix 1 (588-603). In: Safety evaluation of certain contaminants in food. WHO Food Additives Series 63 and FAO JECFA Monographs 8. Issued by World Health Organization and Food and Agriculture Organization of the United Nations. Rome, 2011.

Received: 20.11.2017

Accepted: 29.01.2018

GARDEN NASTURTIUM (*TROPAEOLUM MAJUS* L.) - A SOURCE OF MINERAL ELEMENTS AND BIOACTIVE COMPOUNDS

Karolina Jakubczyk, Katarzyna Janda, Katarzyna Watychowicz, Jagoda Łukasiak, Jolanta Wolska

Department of Biochemistry and Human Nutrition, Pomeranian Medical University, Szczecin, Poland

ABSTRACT

The garden nasturtium (*Tropaeolum majus* L.) belongs to the family *Tropaeolaceae*. Native to South America it was brought to Europe in XVI century. It is a plant with numerous healing properties. Medicinal plants such as the garden nasturtium contain trace elements and bioactive compounds which can be easily absorbed by the human body. The flowers and other parts of the garden nasturtium are a good source of micro elements such as potassium, phosphorus, calcium and magnesium, and macro elements, especially of zinc, copper and iron. The essential oil, the extract from the flowers and leaves, and the compounds isolated from these elements have antimicrobial, antifungal, hypotensive, expectorant and anticancer effects. Antioxidant activity of extracts from garden nasturtium is an effect of its high content of compounds such as anthocyanins, polyphenols and vitamin C. Due to its rich phytochemical content and unique elemental composition, the garden nasturtium may be used in the treatment of many diseases for example the illnesses of the respiratory and digestive systems. High content of erucic acid in nasturtium seeds makes it possible to use its oil as treatment in adrenoleukodystrophy. It is also applied in dermatology because it improves the condition of skin and hair. More recently, the flowers of this species have been used as a decorative and edible element of some types of dishes. Aim of the review was to summarize available data concerning garden nasturtium *Tropaeolum majus* L.

Key words: *nasturtium, Tropaeolum majus* L., chemical composition, bioactive compounds, healing properties

STRESZCZENIE

Nasturcja większa (*Tropaeolum majus* L.) należy do rodziny *Tropaeolaceae*. Pochodząca z Ameryki Południowej, do Europy została sprowadzona w XVI wieku. Roślina ta znana jest ze swoich licznych właściwości prozdrowotnych. Wykazano, że jest źródłem pierwiastków śladowych i związków bioaktywnych, które mogą być łatwo wchłaniane przez organizm człowieka. Kwiaty, liście i nasiona zawierają makro- i mikroelementy (potas, fosfor, wapń, magnez, cynk, miedź, żelazo). Olejki eteryczne oraz ekstrakty z kwiatów i liści wykazują właściwości antybakteryjne, przeciwgrzybicze, hipotensyjne, wykrztuśne i przeciwnowotworowe. Właściwości antyoksydacyjne ekstraktów z nasturcji większej wynikają z wysokiej zawartości związków o charakterze przeciwutleniającym- antocyjanów, polifenoli, czy też witaminy C. Ze względu na bogaty skład związków fitochemicznych i wartościowy skład pierwiastkowy roślina ta znalazła zastosowanie w leczeniu wielu dolegliwości, na przykład chorób układu oddechowego i układu pokarmowego. Wysoka zawartość kwasu erukowego w nasionach daje możliwość wykorzystania oleju z nich w adrenoleukodystrofii. Nasturcję większą stosuje się także w dermatologii, ze względu na korzystne oddziaływanie na stan skóry i włosów. W ostatnich kilku latach kwiaty nasturcji coraz częściej wykorzystywane są jako dekoracyjny i jednocześnie jadalny dodatek do potraw i napojów. Celem artykułu było zebranie danych dostępnych w piśmiennictwie na temat nasturcji większej (*Tropaeolum majus* L.).

Słowa kluczowe: *nasturcja, Tropaeolum majus* L., związki bioaktywne, właściwości prozdrowotne

BOTANICAL DESCRIPTION AND OCCURRENCE

The garden nasturtium (*Tropaeolum majus* L.) belongs to the *Tropaeolaceae* family [2, 23]. The plant is known under many names, some of them are: garden nasturtium, Indian cress or monks cress. It grows

wildly in the mountainous areas of Central and South America. In these two regions, it occurs as a perennial plant [2, 23]. It was brought to Europe from Peru in the 16th century and is successfully cultivated as an annual, decorative plant [1, 2, 23]. There are many varieties of the plant that are different in terms of structure, size and the colour of flowers. Among other types, we can

Corresponding author: Katarzyna Janda, Department of Biochemistry and Human Nutrition, Pomeranian Medical University in Szczecin, Broniewskiego Street 24, 71-460 Szczecin, telephone: +48 91 441 4818, Fax.: +48 91 441 48 07, e-mail: Katarzyna.Janda@pum.edu.pl

distinguish such varieties as: short shoots, long shoots, vines and semi-creeping, bushy or branchy plants [2, 5]. The garden nasturtium has creeping, fragile stalks which are between 30cm to 5m long. They creep on the ground or climb up supports [1, 28]. In Poland, there are two dominating varieties of the plant – the bushy one, and the vine. The latter (var. *altum*) has shoots up to 5m long, whereas the bushy form (var. *nanum*) reaches up to 30 cm of height [16]. The shoots are fleshy, thick and fragile, and they root easily while lying on the ground [28]. The leaves are round, with soft edges, yellow-green venation, and they have long petioles which entangle supports [1, 2, 5, 16, 28]. The flowers are large, with bilabial calyx and the lower lip is equipped with a spur [28]. They resemble small trumpets, 4-5cm wide, which grow out of the angles of the leaves on long pedicels [2, 5]. A long, up to 28 mm spur (nectary) grows out of one calyx [16]. The flowers can be single, half-full or full [28]. The crown of the flower consists of five petals and its colour ranges from yellow through orange to brick red [1, 28]. The root is short and branched [16]. The plant blooms and fruits from about May to November [1, 2, 28]. The fruit of the garden nasturtium is a schizocarp that splits up into three furrowed mericarps which are yellow-green and later shift to yellow-grey [23]. The whole plant has a characteristic pungent smell [28]. Because of its origins, the garden nasturtium is very sensitive to low temperatures. This is why sowing is performed in well aerated soil, around the half of May [5, 28]. The seeds sprout after 15-20 days, and the blooming occurs after 8-10 weeks [2]. The plant grows well in a well-lit or slightly shaded place [5]. It requires light soil of medium fertility and humidity [2]. Excessive use of nitrogen fertilizers has a negative effect on the plant as it leads to the formation of many leaves, but fewer flowers [28]. The cultivation of the plant involves soil aeration and the removal of weeds [2].

Chemical composition

The chemical composition in *Tropaeolum majus* L. is not fully known. The few available studies show the presence of some chemical components in particular parts of the plant, but the full characterization has not been performed. In the light of the available literature, it can be assumed that the chemical composition of the *Tropaeolum majus* L. is different depending on the part of the plant, the method and place of cultivation and the colour of flowers [7, 10, 11, 15, 26, 27, 29, 31]. Flowers are the most analyzed part of the plant in this context [10,11, 26, 27, 31]. The composition of seeds and flowers is significantly different (Table 1) [7, 26, 31]. Seeds turn out to be a richer source of protein, roughage and fats [7].

Table 1. Nutrients content in *T. majus* [7, 26, 31]

Components	Average content in flowers	Average content in seeds
Raw protein, %	26.7	1.99
Roughage, %	11.0	4.51
Ash, %	5.8	0.63
Non-protein nitrogen, %	0.6	-
Fats, %	7.6	0.33
Carbohydrates, %	-	7.14
Calories, kcal/100 g	-	21.44
Dry weight, %	11.27	-

In recent years, there has been an increase in the awareness of the importance of trace elements in relation to human health. Plants serve as a natural source of micro and macro elements. This is why phytotherapists recommend herbs, as they are a source of macro and micro elements that are easily absorbed and because numerous disorders result from their insufficiency. Diet supplements derived from plants and plant medicaments are usually characterized by higher bioavailability of elements than synthetic medicines. The knowledge of the content of elements present in plant resources applied in treatments is an important factor in the evaluation of their quality. It is important to know the content of elements in particular herb species and in their specific morphological parts. Furthermore, it is also imperative to evaluate their susceptibility to extraction, which determines their bioavailability. The content of elements in the particular above-ground and underground parts of the garden nasturtium is still largely unknown. Its flowers are the only resource studied in this regard. Two authors decided to characterize this resource [26, 31]. The data presented in literature is varied, which is probably the result of different conditions (sun exposure, type of soil, fertilizing), or maybe the plants themselves were of different varieties. These factors have a significant influence on the composition of elements in the plants' flowers, which may be related to their phytochemical properties. The flowers of the garden nasturtium are a good source of micro elements such as potassium, phosphorus, calcium and magnesium and macro elements, especially of zinc, copper and iron (Table 2). 100 g of nasturtium flowers covers 73-100% of the recommended dietary allowances (RDA) of zinc for an adult [26, 31]. Zinc is an essential micronutrient and an essential component of more than 300 metalloenzymes participating in the synthesis and degradation of carbohydrates, lipids, proteins, and nucleic acids as well as in the metabolism of other micronutrients [9]. Zinc supports normal growth and development during

pregnancy, childhood, and adolescence. It plays a role in immune system functioning, protein synthesis, wound healing, DNA synthesis and cell division. 100 g of the flowers of this plant provide from 0.55 to 0.64 mg of iron, which constitutes 3.9 to 4.6% of the recommended dietary allowances for this element in reference to adults [9]. Furthermore, the amount covers 7% of the daily need for phosphorus, 2.5% for potassium, 3% for calcium and 4% for magnesium. The flowers of the garden nasturtium are also a source of copper. According to various sources, they cover the daily need for this element from 1.2 to 5.2% [26, 31]. Studies showed that optimal intakes of elements such as sodium, potassium, magnesium, calcium, manganese, copper, and zinc could reduce individual risk factors, including those related to cardiovascular disease for both human beings and animals [18]. The studies carried out by Navarro-González et al. [26] documented the presence of strontium – 0.39 mg in 100 g of the plant's flowers. The element has anti-inflammatory and anti-itching properties. However, it has to be noted that the element might come from the pollution of the natural environment. This is why the area of harvesting of this resource has to be chosen carefully if the material is to serve in food or cosmetic industries.

Table 2. Minerals content in the flowers of *T. majus*

Mineral	[mg/100 g of fresh mass] [31]	[mg/100 g of fresh mass] [26]
P	48.13	0.050
K	245.33	0.225
Ca	33.72	0.055
Mg	14.93	0.035
Na	8.85	0.010
Fe	0.64	0.551
Mn	0.58	0.397
Cu	0.11	0.472
Zn	0.90	0.66
Mo	0.02	-
Si	-	0.040
Sr	-	0.388

The carotenoids and phenolic compounds were labelled in the flowers of *T. majus* (Table 3). The flowers were described as a good source of lutein, but the substance was partially esterified in this part of the plant. The content of compounds in particular groups is different depending on the colour of the flowers – yellow ones included 450 µg/g of lutein, and the yellow-brown ones 350 µg/g [27]. The dyes from the anthocyanin group paint the flowers of the garden nasturtium from yellow, through orange to red.

Table 3. Bioactive compounds in the flowers of *T. majus*

Compound group	Biologically active compounds
Carotenoids	Violaxanthin, Antheraxanthin, lutein, zeaxanthin, zeinoxanthin, β-cryptoxanthin, α-carotene, β-carotene [27]
Phenolic compounds	flavonoids (flavonols and anthocyanins): quercetin, myricetin, kaempferol, pelargonidin [26], delphinidin, cyanidin [11], the derivatives of hydroxycinnamic acid [26]

The main anthocyanin labelled in red flowers was delphinidin (114.5 mg/100 g of fresh mass) (Figure 1), in orange flowers – pelargonidin (58.2 mg/100 g of fresh mass) (Figure 2), whereas in yellow flowers the amount of pelargonidin and delphinidin was similar (31.9 mg/100 g of fresh mass) [10].

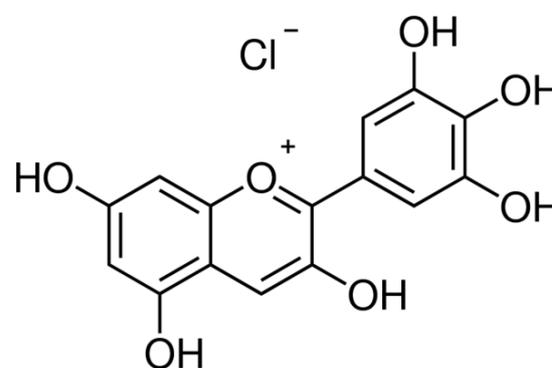


Fig. 1. The main dye in red flowers – delphinidin

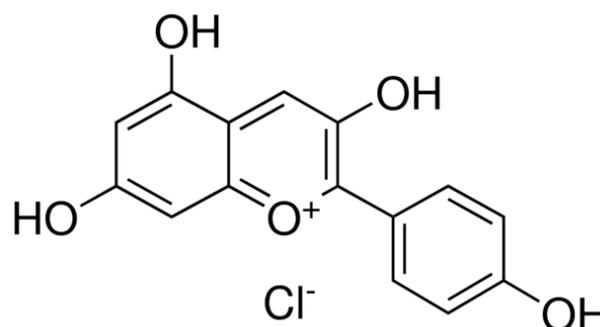


Fig. 2. The main dye in orange flowers – pelargonidin

Phenolic compounds content differs depending on the colour. Red flowers contained the biggest amount of myricetin (315.1 mg of the equivalents of myricetin/100 g of fresh mass) (Figure 3). The other compounds included 40.9 mg of kaempferol and 16.1 mg of quercetin. Orange flowers contained kaempferol (167 mg of the equivalents of kaempferol/100 g of fresh mass) (Figure 4), chlorogenic acid (81.2 mg of the

equivalents of chlorogenic acid/100 g of fresh mass), quercetin (9.7 mg of the equivalents of quercetin/100 g of fresh mass) and the lowest amount of myricetin (1.21 mg of the equivalents of myricetin/100 g of fresh mass). In the yellow flowers, the most numerous compounds of this group were the derivatives of the hydroxycinnamic acid (235 mg of the equivalents of chlorogenic acid), and the amount of these compounds was significantly larger in comparison to the two remaining varieties of flowers of *T. majus* (Figure 5). The total content of phenolic compounds was the lowest in yellow flowers [10]. Polyphenols' concentration was determined in infusions prepared from *T. majus* flowers. Their content, depending on the brewing temperature, varied from 97.3 up to 101.1 mg/l. The lowest amount of polyphenols was found in infusions prepared at 25°C, whereas the highest was obtained at 90°C. Antioxidant capacity, represented as % of DPPH (2,2-diphenyl-1-picrylhydrazyl) inhibition, for those infusions was also determined. Similarly, infusion prepared at 90°C had the highest antioxidant capacity, where at 25°C infusion characterized the lowest potential. Results of % DPPH inhibition varied within a range 16 – 36% [19].

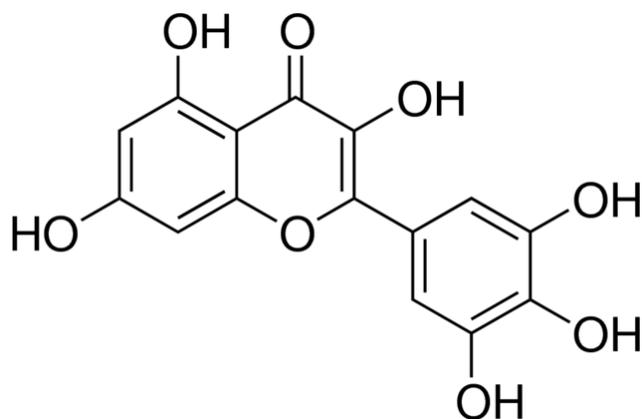


Fig. 3. Main phenolic compounds in red flowers – myricetin

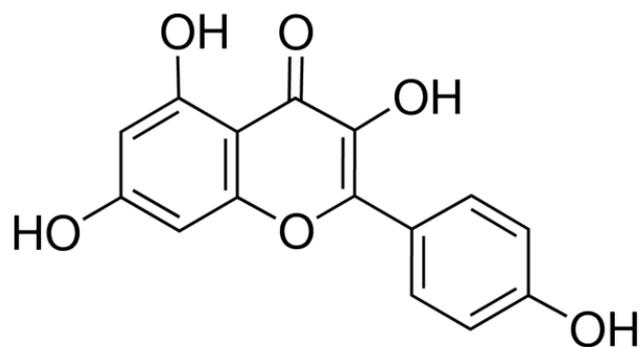


Fig. 4. Main phenolic compounds in orange flowers – kaempferol

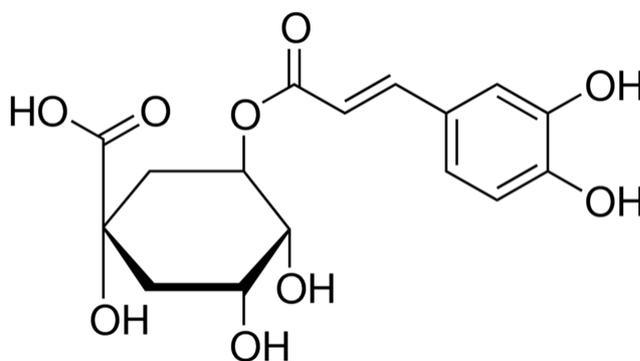


Fig. 5. The main phenolic compounds in yellow flowers – chlorogenic acid

The leaves and seeds of the garden nasturtium also consist of fatty acids, flavonoids, glucosinolates and tetracyclic triterpenes of cucurbitin. The chemical compounds belonging to the abovementioned groups labelled in *T. majus* are presented in Table 4.

Table 4. Fatty acids, flavonoids and glucosinolates in the leaves and seeds of *T. majus*

Compound group	Chemical compounds
Fatty acids	erucic acid, oleic acid, linoleic acid [29]
Flavonoids	isoquercetin, quercetin 3-glucoside, kaempferol [13, 14]
Glucosinolates	benzyl glucosinolate (glucotropaeolin), sinalbin [9]

The lutein was labelled in the leaves of *T. majus* and had a non-esterified form, similarly to the flowers [27].

The seeds and flower petals of *T. majus* include a large contribution of gondoic acid and erucic acid in triglycerides, whereas only trace amounts of linoleic and linolenic acids were found [30].

Mature seeds of *T. majus* have a cell wall built from xyloglucan polysaccharide (amyloid), and proteins and lipids as reserve substances [17]. The oil from the seeds of the garden nasturtium has a high content of monounsaturated fatty acids (>96%). The content of erucic acid reaches 80% in some varieties of the plant, whereas the content of eicosanoic acid is about 15%. The oleic acid, its content below 2%, shows an opposite correlation in relation to the erucic acid. According to Carlson and Kleiman [7], the varieties of the garden nasturtium can be divided into three groups on the basis of the content of oleic acid (<2%, 4-8% and 17,5%) or erucic acid (<68%, 68-74% and >76%). Small amounts of nervonic acid (<3%) and significant amounts of trierucin were also labelled in the oil from the seeds of *T. majus* [7].

44 chemical compounds responsible for the smell of the garden nasturtium were identified by means

of gas chromatography. Two of the compounds had the largest influence on the smell: (E)-hex-2-enal, responsible for the fruity note, and diethyl trisulfide which gives the aroma of sulphur [4]. Another aromatic compound labelled in *T. majus* is O,S-diethyl thiocarbonate [3].

THE HEALING PROPERTIES AND THE APPLICATION

Due to its rich phytochemical content, the garden nasturtium has been widely applied in folk medicine as a healing plant. Currently, it is used in such areas as medicine, cosmetology and cooking, and it is also valued as a decorative plant. The flowers of the garden nasturtium (*Tropaeoli Flos*), leaves (*Tropaeoli Folium*), herb (*Tropaeoli Herba*) and green or mature seeds (*Tropaeoli Semen*) are considered a herbal resource [16]. The abovementioned parts of the plant are used in order to create acetate, ethanol and water extracts, syrups, macerates, infusions and nasturtium alcohols [16, 29]. There is a rising tendency to use fresh nasturtium flowers and its immature green seeds as additional ingredients for a number of dishes [16]. Because of the presence of anthocyanins, especially in the orange flower petals, nasturtium extracts are often used as natural dyes in pharmaceutical and food industries. The properties of different parts of the resource cause different effects, which is probably related to the differences in chemical composition [29].

DIURETIC PROPERTIES AND THE EFFECT ON THE URINARY SYSTEM

The research carried out on rats confirmed that the water-ethanol extracts of the garden nasturtium have a diuretic effect. When administered orally (300 mg/kg) for 7 days, the extracts, rich in isoquercetin, caused an increase of Na⁺ in urine and had a diuretic effect [12]. Due to the large amount of glucotropaeolin (benzyl glucosinolate), the substance belonging to the group of glucosinolates [24], the leaves of the garden nasturtium also have an antibacterial influence on the urinary system [22]. In the human body, benzyl glucosinolate is transformed into benzyl isothiocyanate which, subsequently, undergoes transformation into the derivatives of acetylcysteine [34]. In the kidneys, these components are secreted to urine where a large portion of them is rehydrolysed to benzyl isothiocyanate [22, 34]. This phenomenon causes an increase in antibacterial activity through the inhibition of bacterial growth in the urinary system. The output amount of the consumed glucotropaeolin has to be large enough so that the appropriate amount of benzyl isothiocyanate is secreted to urine [22].

The problem with this phenomenon is that part of the substance undergoes decomposition when it is dried. This is why, to minimize the effect, the leaves of the plant should be used when they are fresh [22].

HYPOTENSIVE PROPERTIES AND INFLUENCE ON THE CIRCULATORY SYSTEM

Studies confirm that *T. majus* has a positive influence on the circulatory system. Hot infusions of the herb and macerates with honey stimulate circulation and purify blood. The alcoholic extracts, when applied on the skin and rubbed in, improve the circulation of lymph and blood in certain areas [32]. The research carried out on rats confirms that the water-ethanol extracts (10-300 mg/kg) and the ethanol fraction secreted from them, which is rich in isoquercetin (12.5-100 mg/kg), have a hypotensive effect in a dose-dependent manner. Regardless of whether they were applied via the duodenum or orally, they decreased the blood pressure of rats of both correct or increased blood pressure. Furthermore, no negative effects on the functioning of the heart were found in relation to the extracts or isoquercetin [13].

Antioxidative properties

The studies concerning the antioxidative potential of this plant focus mainly on the flowers of *T. majus*, which are a natural source of antioxidants [10, 11, 26, 31]. Vitamin C and anthocyanins are present in the petals [11, 16]. The antioxidant activity of the flowers of the garden nasturtium was measured by their ability to sweep DDPH and ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)) radicals and by the ORAC (Oxygen Radical Absorbance Capacity) method, which are often used in the evaluation of the antioxidant capacity of natural products [10, 11, 26, 31].

The ability of fresh orange petals to sweep the ABTS radicals was compared to the antioxidant capacity determined by the same method of the known food products. It was observed that the petals showed higher antioxidant capacity than American blueberries (45.9 µmol equivalents of trolox/g), which are considered to be one of the richest sources of antioxidants, and higher than blackberries (0-25.3 µmol of the equivalents of trolox/g of fresh mass), which are recommended for the improvement of nutritional value due to their high antioxidant capacity. In terms of the ability to sweep the DPPH radical, flowers of the garden nasturtium showed similar properties to those of cranberries (92.9 µmol of the equivalents of trolox/g of dry mass) and strawberries (121.6 µmol of the equivalents of trolox/g of dry mass). The flowers of the garden nasturtium are able to suppress these radicals probably through the reaction of electron transfer [11].

Table 5. Antioxidative properties of the flowers of *T. majus*

Method of measuring the antioxidative potential	Value according to Rop et al. [31]	Value according to Navarro-Gonzales et al. [26]
TPC (Total Phenolic Content)	3.31 g of the equivalents of gallic acid/kg of fresh mass	12.95 mg of the equivalents of gallic acid/g
TAC (Total Antioxidant Capacity)	5.12 g of the equivalents of ascorbic acid/kg of fresh mass	-
TFC (Total flavonoids Content)	1.35 g of rutin/kg of fresh mass	-
ORAC (Oxygen Radical Absorbance Capacity)	-	47.84 μ mol of the equivalents of trolox/g
TEAC (Trolox Equivalent Antioxidant Capacity)	-	9.51 μ mol of the equivalents of trolox/g

The antioxidative potential is often associated with the content of polyphenols. The content of phenols and other substances and the ability to reduce free radicals is presented in Table 6. Out of the three colours of flowers (red, orange and yellow), red flowers were labelled as having the highest content of flavonoids and the biggest capabilities of sweeping free radicals (ORAC) [10]. The content of polyphenols in all three colours of flowers was presented in Table 3. The content of vitamin C in orange flowers is 71.5 mg/100 g of fresh mass [11].

Table 6. Total polyphenol content (TPC) and the oxygen radical absorbance capacity (ORAC) in flowers depending on the colour of flowers of *T. majus* [10]

Flower colour	TPC value (mg of the equivalents of gallic acid/100 g of fresh mass)	ORAC value (μ mol of the equivalents of trolox/100 g of fresh mass)
Red	908.7	18719
Orange	687.7	11790
Yellow	538.4	7111

Studies confirm that the content of polyphenols in flowers influences the flowers' antioxidative potential and that the compounds play an important role as natural antioxidants [11]. Red flowers showed the highest antioxidative potential [10].

Influence on adrenoleukodystrophy

Adrenoleukodystrophy is a recessive illness linked to chromosome X. It causes the disturbance of proximal beta oxidation, which results in the accumulation of long chains of fatty acids. This leads to the inefficiency of the adrenal cortex, the demyelination of white matter in the central nervous system and the inefficiency of male gonads [25]. The seeds of the garden nasturtium contain a high amount of erucic acid, which is one of the main components

of the medicine used in the treatment of this illness – Lorenzo's Oil (a mixture of oleic and erucic acid) [7, 16]. Among plants rich in this type of acid, the family *Tropaeolaceae* – especially the garden nasturtium – is a resource with the highest content of the acid, which is at the level of 80% in the seeds. According to the most recent taxonomy, only one type belongs to this family – the garden nasturtium.

Influence on the respiratory system

The garden nasturtium is applied in the treatment of respiratory system illnesses [14, 20, 23, 32]. In folk medicine, it was used as a soothing medicine for chest illnesses. The extracts from the leaves were used in the treatment of tonsillitis and bronchitis [20, 23]. The syrups made from infusions and the macerates of *T. majus* also have an antiseptic and expectorant effect, which is useful during rhinitis [32, 33]. They also reduce the congestion of the respiratory tract [33]. In the Andean folk medicine, the garden nasturtium was used in the treatment of lungs and bronchia [29]. The infusions made from fresh or dried herb, combined with sugar or honey, are used in the treatment of respiratory system problems, cough, hoarseness and colds [14, 32]. After the consumption of the leaves of the garden nasturtium, there is a synthesis of the substances that inhibit the growth of the bacteria of diphtheria and a synthesis of the bacteria that cause the inflammation of lungs [29].

Influence on the digestive system

The water extracts prepared from dried herb and the macerates made of fresh herb have a strong bile-forming effect and they strongly stimulate the digestive system. The garden nasturtium is also credited for its ability to accelerate metabolism, regulate defecation and prevent cholelithiasis [16].

Anticancer effect

The glucosinolates present in the garden nasturtium undergo a number of thermal, enzymatic

and microbiological transformations in the body (with the contribution of the intestinal microflora). The compounds that are formed due to these processes may have an anticancer effect [8, 21].

Antibacterial and antifungal effects

Compounds present in the garden nasturtium inhibit the development of fungi, viruses, bacteria and protozoa [6, 16, 32]. The extracts from the garden nasturtium are effective in the treatment of bacteria resistant to sulphonamides and antibiotics [32]. The leaves have the strongest antibacterial effect [22]. Once they are consumed, there is a synthesis of substances that inhibit the growth of the bacteria of diphtheria and the bacteria that cause the inflammation of lungs [23, 29].

Influence on the skin and hair

T. majus is also used in dermatology. The vinegar extracts of the fresh garden nasturtium kill skin parasites such as mites, fleas and lice [32]. Nasturtium alcohol is used for problems with seborrhoea, eczema, pimples and skin lumps. Infusions of the dried herb diluted with nasturtium wine, water or vinegar can be used against acne [32]. The fresh herb, when used in wraps, helps in the treatment of bedsores and abscesses and it accelerates the healing of wounds and boils. The liquid created from the vinegar, alcoholic extract or wine of the herb of the garden nasturtium improves the colour and elasticity of the skin and facilitates the metabolic exchange in the skin [32]. Due to the high content of vitamin C, the garden nasturtium has antiscorbutic properties [29]. *T. majus* is a source of sulphur which strengthens hair and prevents it from falling out. The juice of the garden nasturtium leaves is useful against itching [16].

SUMMARY

The garden nasturtium is successfully cultivated as an annual decorative plant in many countries. It is used in phytotherapy, cosmetology and cooking. The garden nasturtium includes various biologically active compounds, such as flavonoids (isoquercetin, kaempferol) and carotenoids belonging to the group of phenolic compounds. This plant is also rich in micro and macro elements, such as potassium, phosphorus, calcium, magnesium, zinc, copper and iron. We need to underline that flowers of the garden nasturtium are a rich source of zinc which is responsible for many metabolic functions in the human body. Zinc is an essential component of metalloenzymes participating in the synthesis and degradation of carbohydrates, lipids, proteins, and nucleic acids as well as in the metabolism of other micronutrients. Thanks to these components, it has numerous healthy properties

– antioxidative, hypotensive, antibacterial and anticancer. The garden nasturtium is rich in benzyl glucosinolate which has a anticancer and antibacterial effect. The plant is also used in the treatment of the illnesses of the respiratory, digestive and urinary systems. It is a resource rich in erucic acid, which is the main component of the medicine used in the treatment of adrenoleukodystrophy. *T. majus* is a potential phytotherapist which can be used in the treatment of many illnesses thanks to its content. The plant is worthy of recommendation in the prophylaxis of common ailments and in natural home cosmetology.

REFERENCES

1. Aniol-Kwiatkowski J., Berdowski W., Kwiatkowski S.: Rośliny lecznicze atlas [Medicinal plants atlas]. Warszawa, Wydawnictwo Arkady, 1993:186.
2. Aszkiewicz E., Cis J., Dawid-Pań R., Kozłowski J.A., Kuczyński S., Nowak G. et al.: Zioła z apteki natury [Herbs from the pharmacy of nature]. Poznań, Publicat, 2007:118.
3. Breme K., Guillamon N., Fernandez X., Tournayre P., Brevard H., Joulain D., Berdague J.L., Meierhenrich U.J.: First identification of O,S-diethyl thiocarbonate in Indian cress absolute and odor evaluation of its synthesized homologues by GC-Sniffing. J Agric Food Chem 2009; 57(6): 2503-2507. <http://doi.org/10.1021/jf8035319>
4. Breme K., Tournayre P., Fernandez X., Meierhenrich U.J., Brevard H., Joulain D., Berdague J.L.: Characterization of Volatile Compounds of Indian Cress Absolute by GC-Olfactometry/VIDEO-Sniff and Comprehensive Two-Dimensional Gas Chromatography. J Agric Food Chem 2010; 58 (1): 473-480.
5. Bremness L.: Wielka księga ziół [The Complete book of herbs]. Warszawa, Wiedza i Życie, 1991:137.
6. Butnariu M., Bostan C.: Antimicrobial and anti-inflammatory activity of the volatile oil compounds from *Tropaeolum majus* L. (Nasturtium). Afr J Biotechnol 2011; 10 (31): 5900-5909. <http://dx.doi.org/10.5897/AJB11.264>
7. Carlson K.D., Kleiman R.: Chemical survey and erucic acid content of commercial varieties of nasturtium, *Tropaeolum majus* L. JAOCS 1993; 70 (11):1145-1148. <http://doi.org/10.1007/BF02632157>
8. Cho H.J., Lim D.Y., Kwon G.T., Kim J.H., Huang Z., Song H., et al.: Benzyl isothiocyanate inhibits prostate cancer development in the transgenic adenocarcinoma mouse prostate (TRAMP) model, which is associated with the induction of cell cycle G1 arrest. Int J Mol Sci 2016; 17(2):264. doi: 10.3390/ijms17020264
9. Devi C.B., Nandakishore T., Sangeeta N., Basar G., Devi N.O., Jamir S. et al.: Zinc in human health. Journal of Dental and Medical Sciences 2014; 13 (7):18-23.
10. Garzón G.A., Manns D.C., Riedl K., Schwartz S.J., Paddilla-Zakour O.: Identification of phenolic compounds in petals of nasturtium flowers (*Tropaeolum majus*) by high-performance liquid chromatography coupled to

- mass spectrometry and determination of oxygen radical absorbance capacity (ORAC). *J Agric Food Chem* 2015; 63(6): 1803-1811. <http://doi.org/10.1021/jf503366c>
11. Garzón G.A., Wrolstad R.E.: Major anthocyanins and antioxidant activity of Nasturtium flowers (*Tropaeolum majus*). *Food Chem* 2009; 114:44-49. <http://doi.org/10.1016/j.foodchem.2008.09.013>
 12. Gasparotto A., Boffo M.A., Botelho-Lourenço E.L. et al. Natriuretic and diuretic effects of *Tropaeolum majus* (Tropealaceae) in rats. *J Ethnopharmacol* 2009; 122:517-22. <http://doi.org/10.1016/j.jep.2009.01.021>
 13. Gasparotto A., Gasparotto F.M., Lourenço E.L., Crestani S., Stefanello M.E., Salvador M.J. et al.: Antihypertensive effect of isoquercitrin and extracts from *Tropaeolum majus* L.: Evidence for the inhibition of angiotensin converting enzyme. *J Ethnopharmacol* 2011; 134:363-374. <http://doi.org/10.1016/j.jep.2010.12.026>
 14. Grau J., Jung R., Münker B.: *Leksykon przyrodniczy. Ziola i owoce leśne* [Natural lexicon. Herbs and forest fruits]. Warszawa, Świat Książki, 1996: 263.
 15. Griffiths D.W., Deighton N., Birch A.N.E., Patrian B., Baur R., Städler E.: Identification of glucosinolates on the leaf surface of plants from the *Cruciferae* and other closely related species. *Phytochemistry* 2001; 57:693-700.
 16. Grzeszczuk M., Kawecka A., Jadczyk D.: Kwiaty jadalne - nasturcja większa *Tropaeolum majus* L. [Edible flowers - Garden nasturtium *Tropaeolum majus* L.]. *Panacea* 2010; 2:20-21.
 17. Hoth A., Blaschek W., Franz G.: Xyloglucan (amyloid) formation in the cotyledons of *Tropaeolum majus* L. seeds. *Plant Cell Rep* 1986; 5(1): 9-12. <http://doi.org/10.1007/BF00269706>.
 18. Imelouane B., Tahri M., Elbatrioui M., Aouinti F., Elbachiri A., Mater J.: Mineral contents of some medicinal and aromatic plants growing in Eastern Morocco. *J Mater Environ Sci* 2011; 2 (2):104-111.
 19. Jakubczyk K., Lukasiak J., Watychowicz K., Kozińska A., Lukomska A., Wolska J., Janda K.: Antioxidant properties of infusion from Nasturtium flowers. In: *Borowicz A.M., Osińska M.* (eds): *Horyzonty współczesnej fizjoterapii*. Poznań. Wydawnictwo Wyższej Szkoły Edukacji i Terapii im. prof. Kazimiery Milanowskiej 2016;119-128.
 20. Jędrzejko K., Klama H., Żarnowiec J.: *Zarys wiedzy o roślinach leczniczych* [The outline of knowledge about medicinal plants]. Katowice. Śląska Akademia Medyczna, 1997:245-246.
 21. Kim E.J., Hong J.E., Eom S.J., Lee J.Y., Park J.H.: Oral administration of benzyl-isothiocyanate inhibits solid tumor growth and lung metastasis of 4T1 murine mammary carcinoma cells in BALB/c mice. *Breast Cancer Res Treat* 2011; 130(1):61-71. doi: 10.1007/s10549-010-1299-8
 22. Kleinwächter M., Schnug E., Selmar D.: The glucosinolate-myrosinase system in nasturtium (*tropaeolum majus* L.): variability of biochemical parameters and screening for clones feasible for pharmaceutical utilization. *J Agric Food Chem* 2008; 56:11165–11170.
 23. Lewkowicz-Mosiej T.: *Leksykon roślin leczniczych* [Lexicon of medicinal plants]. Warszawa, Świat Książki, 2003:182-183.
 24. Lykkesfeldt J., Meller B.L.: Synthesis of benzylglucosinolate in *Tropaeolum majus* L. *Plant Physiol* 1993; 102:609-613.
 25. Morski J.: Adrenoleukodystrofia sprzężona z chromosomem X. Objawy, diagnostyka i leczenie oraz opis przypadku [X linked adrenoleukodystrophy. Clinical presentation, diagnosis, therapy and case report]. *Neurologia Dziecięca* 2013; 44:47-54.
 26. Navarro-González I., González-Barrio R., García-Valverde V., Bautista-Ortín A.B., Periago M.J.: Nutritional composition and antioxidant capacity in edible flowers: characterisation of phenolic compounds by HPLC-DAD-ESI/MSn. *Int J Mol Sci* 2015; 16:805-822. <http://doi.org/10.3390/ijms16010805>.
 27. Niizu P.Y., Rodriguez-Amaya D.B.: Flowers and leaves of *Tropaeolum majus* L. as Rich Sources of Lutein. *J Food Sci* 2005; 70 (9):605-609. <http://doi.org/10.1111/j.1365-2621.2005.tb08336.x>
 28. Ożarowski A., Rumińska A.: *Leksykon roślin leczniczych* [Lexicon of medicinal plants]. Warszawa, Państwowe Wydawnictwo Rolnicze i Leśne, 1990:331.
 29. Parus A., Gryś A.: Roślina przyszłości - nasturcja większa (*Tropaeolum majus* L.) [Plant of the future – *Tropaeolum majus* L.]. *Post Fitoter* 2012; 3:184-187.
 30. Radwan S.S.: Localization of lipids containing (Z)-11-eicosenoic acid and (Z)-13-docosenoic acid in *Tropaeolum majus*. *Phytochemistry* 1976; 15 (11): 1727-1729. [https://doi.org/10.1016/S0031-9422\(00\)97465-X](https://doi.org/10.1016/S0031-9422(00)97465-X)
 31. Rop O., Mlcek J., Jurikova T., Neugebauerova J., Vabkova J.: Edible flowers - a new promising source of mineral elements in human nutrition. *Molecules* 2012; 17:6672-6683. <http://doi.org/10.3390/molecules17066672>
 32. Różański H.: *Tropaeolum majus* – nasturcja jako przyprawa i lek [*Tropaeolum majus* – nasturtium as a spice and drug]. *Medycyna dawna i współczesna*. Available <http://rozanski.li/242/tropaeolum-majus-nasturcja-jako-przyprawa-i-lek/>. (Accessed 12.10.2016)
 33. Sharma Y., Hedge R.V., Venugopal C.K.: Health and nutrition from ornamentals. *IJRAP* 2011; 2:375-382.
 34. Traka M., Mithen R.: Glucosinolates, isothiocyanates and human health. *Phytochem Rev* 2009; 8:269–282.

Received: 31.10.2017

Accepted: 04.01.2018

ANALYSIS OF ACRYLAMIDE, 3-MONOCHLOROPROPANE-1,2-DIOL, ITS ESTERS AND GLYCIDYL ESTERS IN CARBOHYDRATE-RICH PRODUCTS AVAILABLE ON THE POLISH MARKET

Anna Sadowska-Rociek, Magdalena Surma, Ewa Cieřlik

University of Agriculture in Krakow, Faculty of Food Technology, Malopolska Centre of Food Monitoring, Krakow, Poland

ABSTRACT

Background. Carbohydrate-rich foods, such as breakfast products, snacks and biscuits because of its nutritional or sensory qualities are an inherent part of human diet. However, their production might contribute to the formation of acrylamide, 3-monochloropropane-1,2-diol (3-MCPD) and its esters and glycidyl esters.

Objective. The aim of this work was to assess the levels of acrylamide, free and bound 3-MCPD and glycidyl esters in selected carbohydrate-rich, thermal processed products, present on the market in Poland in 2016-2017.

Material and Methods. The survey involved 60 samples of snacks, breakfast products and biscuits. Acrylamide and free 3-MCPD was determined using modified QuEChERS approach. Analysis of 3-MCPD and glycidyl esters was based on the acid-catalysed method of sample preparation, derivatisation with PBA and GC-MS analysis.

Results. Free 3-MCPD contents were within the values of 9.3-63.3 $\mu\text{g kg}^{-1}$, with the highest mean content for muesli (33.3 $\mu\text{g kg}^{-1}$), and the lowest for baby biscuits (11.7 $\mu\text{g kg}^{-1}$). The levels of bound 3-MCPD were higher (from 9.3 $\mu\text{g kg}^{-1}$ to 1500 $\mu\text{g kg}^{-1}$). The highest average content was observed for sugar free biscuits (599 $\mu\text{g kg}^{-1}$), whereas the lowest for breakfast cereals (50.2 $\mu\text{g kg}^{-1}$). Glycidyl esters were detected only in four samples with the highest content at the level of 28.8 $\mu\text{g kg}^{-1}$. The acrylamide levels varied from 195 to 1352 $\mu\text{g kg}^{-1}$, with the highest content for organic biscuit samples (913 $\mu\text{g kg}^{-1}$), and the lowest for muesli (348 $\mu\text{g kg}^{-1}$).

Conclusions. Regular consumption of popular snacks such as potato chips, crackers and biscuits may result in risk to human health as the effect of high content of acrylamide or 3-MCPD. Due to a high level of these contaminants detected in some type of breakfast products, and products targeted for children, its consumption should be restricted, especially in younger population groups.

Key words: *thermal processing contaminants; acrylamide, 3-monochloropropane-1,2-diol; 3-MCPD; 3-MCPD esters; glycidyl esters*

STRESZCZENIE

Wprowadzenie. Produkty bogate w węglowodany, takie jak przekąski, produkty śniadaniowe i herbatniki ze względu na ich właściwości odżywcze lub sensoryczne, są nieodłączną częścią codziennej diety. Ze względu na fakt, że technologia ich produkcji wymaga zastosowania wysokich temperatur, co sprzyja tworzeniu niektórych zanieczyszczeń, mogą być one zanieczyszczone akrylamidem, 3-monochloropropano-1,2-diolem (3-MCPD) i jego estrami oraz estrami glicydolu.

Cel badań. Celem pracy była ocena występowania akrylamidu, wolnego i związanego 3-MCPD oraz estrów glicydolu w wybranych próbkach produktów bogatych w węglowodany, obecnych na rynku detalicznym w Polsce w latach 2016-2017.

Material i metody. Badania obejmowały 60 próbek przekąsek, produktów śniadaniowych i herbatników. Zawartość akrylamidu i wolnego 3-MCPD oznaczono za pomocą zmodyfikowanej metody QuEChERS. Estrы 3-MCPD i estrы glicydolu analizowano z wykorzystaniem hydrolizy kwasowej, derywatywacji z użyciem PBA i końcowej detekcji techniką GC-MS.

Wyniki. Zawartość wolnego 3-MCPD mieściła się w granicach 9.3-63.3 $\mu\text{g kg}^{-1}$, z najwyższą średnią zawartości w musli (33.3 $\mu\text{g kg}^{-1}$), a najniższą w herbatnikach przeznaczonych dla dzieci (11.7 $\mu\text{g kg}^{-1}$). Zawartość związanego 3-MCPD była znacznie wyższa (od 9.3 $\mu\text{g kg}^{-1}$ do 1500 $\mu\text{g kg}^{-1}$). Najwyższą średnią zawartość stwierdzono w herbatnikach bez dodatku cukru (599 $\mu\text{g kg}^{-1}$), natomiast najniższą w płatkach śniadaniowych (50.2 $\mu\text{g kg}^{-1}$). Estrы glicydolu wykryto jedynie w czterech próbkach (najwyższa zawartość – 28.8 $\mu\text{g kg}^{-1}$). Zawartość akrylamidu wahała się w zakresie 195-1352 $\mu\text{g kg}^{-1}$, przy czym najwyższą ilość oznaczono w próbkach herbatników ekologicznych (913 $\mu\text{g kg}^{-1}$), a najniższą w musli (348 $\mu\text{g kg}^{-1}$).

Corresponding author: Anna Sadowska-Rociek, University of Agriculture in Krakow, Faculty of Food Technology, Malopolska Centre of Food Monitoring, Balicka 122, 30-149 Krakow, Poland; phone: +48 12 662 48 27, fax: +48 12 662 48 25, e-mail: a.sadowska-rociek@ur.krakow.pl

Wnioski. Regularne spożywanie popularnych przekąsek, takich jak chipsy ziemniaczane, krakersy i herbatniki, z uwagi na wysokie zawartości w nich akrylamidu i 3-MCPD może przyczynić się do narażenia zdrowia. Ze względu na znaczną ilość badanych zanieczyszczeń w niektórych popularnych produktach śniadaniowych oraz produktach przeznaczonych dla dzieci, ich spożywanie powinno być ograniczone, zwłaszcza w młodszych grupach wiekowych.

Słowa kluczowe: zanieczyszczenia procesowe; akrylamid, 3-monochloropropano-1,2-diol; 3-MCPD; estry 3-MCPD; estry glicydołu

INTRODUCTION

Carbohydrate-rich foods, especially cereal products, because of its nutritional and sensory qualities are an inherent part of human diet being therefore a significant segment of global confectionery market. Recently, ready-to-eat breakfast products, such as breakfast cereals, muesli or granola, which use facilitates breakfast preparation, are becoming increasingly popular. Apart from cereal products, a high content of carbohydrates can be found in various kinds of processed sweets, e.g. biscuits or in savoury snacks. Despite of its low nutritional value, consumption of these products has been on an increase as a result of urbanisation and lifestyle changes. For most people these products have become a regular part of the diet and nowadays the products are eaten at least a few times a week. Taking into account that all aforementioned products are produced during thermal processing, the question is whether – besides of its nutritional or sensory qualities – the products are still safe for consumers.

Generally, thermal treatment of food containing lipids, certain amino acids, and sugars processed at temperatures above 160 °C can lead to the formation of many toxic compounds such as e.g. acrylamide, chloropropanols, its esters and glycidyl esters. 3-monochloropropane-1,2-diol (3-MCPD), the most abundant chloropropanol, is produced mainly by monoacyl- (MAG), diacyl- (DAG) and triacyl- (TAG) glycerol or free glycerol with chloride ions (present naturally or added) [17]. 3-MCPD occurs in foodstuffs not only as a free compound but also in the bound form with higher fatty acids. The formation of 3-MCPD esters (3-MCPDE, e.g. 1,2-bis-palmitoyl-3-chloropropanediol, 1,2-distearoyl-3-chloropropanediol, 1,2-dioleoyl-3-chloropropanediol) are associated mainly with the processes of oil refining, but they are also formed during thermal processing of food [21]. Glycidyl esters (GE) are generated mostly upon refining of oil [9, 15]. Hence, 3-MCPD in both forms might be found in dried savoury and sweet foods containing salt and fat, such as crisp bread, salty crackers, biscuits, but also in certain breakfast products [13, 38].

The second contaminant, acrylamide (AA), is a product of *Maillard* reaction with free asparagine and

reducing sugars during heat treatment at temperatures higher than 120°C under low moisture conditions. In food with a high fat content, the alternative acrylamide formation is a pathway via acrolein, which is formed by the degradation of lipids, mainly oxidized fatty acids or glycerol. Acrolein might be then oxidized to acrylic acid, which could react with ammonia to form acrylamide [41]. Initial surveys have shown that relatively high concentrations of acrylamide are found in potato chips, French fries, pan-fried potato products, crisp bread, biscuits, crackers and coffee [14, 25].

Free 3-MCPD is a potential carcinogen (Group 2B), affects kidneys, male fertility and renal function [20]. Glycidol was classified by the International Agency for Research on Cancer (IARC) as probably carcinogenic (group 2A) [19]. In the case of esters of chloropropanols and glycidyl esters, they have been shown to undergo complete decomposition in human digestive tract to free chloropropanols or glycidol [21]. For this reason, in 2014, European Commission adopted Recommendation 2014/661/EU on the monitoring of the presence of 2 and 3-monochloropropane-1,2-diol (2 and 3-MCPD), 2- and 3-MCPD fatty acid esters and glycidyl fatty acid esters in food [8]. Recently, European Food Safety Authority decreased Tolerable Daily Intake (TDI) level for total 3-MCPD (sum of 3-MCPD content both in free and bound form) to 0.8 µg kg⁻¹ bodyweight [13].

In case of AA, neurotoxicity, adverse effects on male reproduction, developmental toxicity and carcinogenicity were identified as possible critical endpoints for AA toxicity from experimental animal studies [14]. International Agency for Research on Cancer has classified acrylamide as probably carcinogenic to humans (Group 2A) [18]. Having this in mind, the European Commission in 2013 adopted on Commission Recommendation 2013/647/EU on investigations into the levels of acrylamide in food. According to the document, member States should to carry out investigations in cases where the levels of acrylamide in a foodstuff, tested in the monitoring exercise, exceeds certain acrylamide indicative values, published in the Annex to this Recommendation [7].

Therefore, the aim of this work was to assess the levels of acrylamide, free and bound 3-MCPD and glycidyl esters in selected carbohydrate-rich, thermal processed products, present on detail market

in Poland in 2016-2017. The results were discussed and compared to tolerable daily intake established by EU (in case of 3-MCPD) or to certain indicative values (in case of acrylamide). The evaluation of dietary exposure in case of acrylamide with respects to different age groups has been also provided.

MATERIALS AND METHODS

Chemicals and reagents

Hexane and acetonitrile, HPLC grade for liquid chromatography LiChrosolv® were purchased from Merck KGaA, Germany. Methanol, tetrahydrofuran, acetone, sulphuric acid (98%), sodium hydrogen carbonate, sodium bromide, magnesium sulphate anhydrous, and sodium chloride were purchased from ChemPur S.A., Poland. PSA (primary secondary amine), and C₁₈ (octadecyl) SPE Bulk Sorbent derived from Agilent Technologies, USA. 3-MCPD, 3-monochloropropane-1,2-diol-d₅ (3-MCPD-d₅) (internal standard), 3-monobromochloropropane-1,2-diol (3-MBPD), phenylboronic acid (PBA) (derivatisation agent), acrylamide, acrylamide-d₃ (internal standard) and *N,O*-bis(trimethylsilyl) trifluoroacetamide (BSTFA) were obtained from Sigma-Aldrich, USA. 1,2-bis-palmitoyl-3-chloropropanediol-d₅ (PP-3-MCPD-d₅, internal standard) and glycidyl palmitate were obtained from LGC Standards (Teddington, United Kingdom) and Leco Dry (infusorial soil) was from Leco (USA). All reagents were at least of analytical purity.

Deionised water (18 MΩ) was produced by a Milli-Q system (Millipore; USA). A sodium chloride solution of 200 mg mL⁻¹ (20%), saturated solution of sodium hydrogen carbonate and solution of sodium hydrogen carbonate (0.9%) were prepared in deionised water. Stock (1 mg mL⁻¹), intermediate (100 µg mL⁻¹) and working (2 µg mL⁻¹) standard solutions of each chloropropanol were prepared in 20% NaCl. Stock (1 mg mL⁻¹), intermediate (100 µg mL⁻¹) and working standard solutions of AA (1 µg mL⁻¹), and d₃-acrylamide (5 µg mL⁻¹) were prepared in acetonitrile. PP-3-MCPD-d₅ and glycidyl palmitate (both 5 µg mL⁻¹) were dissolved in ethyl acetate. PBA solution was prepared by dissolving 5 g PBA in 20 mL mixture of acetone and water (19:1, v/v).

Instrumentation

3-MCPD and AA analyses were performed using Varian IonTrap 4000 GC/MS (Varian, Inc., USA) with a CP-8410 auto-injector (Bruker, USA) and DB-5MS column (30 m x 0.25 mm x 0.25 µm; Agilent Technologies, USA). The injector temperature was set at 270 °C for AA analysis and 180 °C (3-MCPD determination), and an injection volume of 1.0 µL. Each injection was performed in triplicate. The GC

oven was operated with the following temperature program: 3-MCPD analysis: 60 °C (1.0 min) – 6 °C min⁻¹ – 190 °C (1.0 min) – 30 °C min⁻¹ – 280 °C (6.0 min); AA analysis: 50 °C – 3 °C min⁻¹ – 100 °C – 25 °C min⁻¹ – 250 °C (5.0 min). The analyses were carried out with a solvent delay of 8.0 min. Helium 5.0 (Linde Gas, Poland) was used as the GC carrier gas at a flow rate of 1.0 mL min⁻¹. The emission current of the ionisation filament was set at 15 µA. The ion trap mass spectrometer was operated in the internal ionisation mode. The trap and the transfer line temperatures were set at 180 °C and 230 °C for both analyses. Analyses were conducted in the selected ion monitoring mode (SIM) based on the use of one quantitative ion of PBA derivatives of 3-MCPD and BSTFA derivatives of AA. Confirmation ions and retention times were also used to ensure the identification of the analytes (Table 1). Acquisition and processing data were performed using Varian Start Workstation software and NIST 2.0 library.

MS1 Minishaker (IKA, Germany) and MPW 350 R Centrifuge (MPW Med. Instruments, Poland) were used during sample preparation. Accublock™ (Labnet, USA) with nitrogen 5.0 (Linde Gas, Poland) was accomplished to evaporate solvents and concentrate the extracts. Fat extraction was performed using TFE 2000 (LECO, USA).

Table 1. Parameters of GC-MS analysis of examined compounds

R _t [min]	Compound	Quantification ion	Confirmation ions
Chloropropanols*			
17.14	3-MCPD-d ₅	150.1	93.0, 149.1, 201.0
17.23	3-MCPD	147.0	91.0, 146.1, 196.0
19.02	3-MBPD	147.0	91.0, 146.1, 241.9
Acrylamide**			
9.13	AA-d ₃	132.1	132.2, 204.2, 220.1
9.17	AA	128.1	128.2, 129.2, 131.1

*analysed as PBA derivatives

**analysed as BSTFA derivatives

R_t – retention time; 3-MCPD-d₅ – 3-monochloropropane-1,2-diol-d₅; 3-MCPD – 3-monochloropropane-1,2-diol; 3-MBPD – 3-monobromopropane-1,2-diol; AA-d₃ – acrylamide-d₃; AA – acrylamide

Sample preparation

The samples analysed in this study involved 22 samples of snacks (potato chips, corn puffs, sticks, crackers, and peanuts), 13 samples of breakfast products (breakfast cereals, muesli and granola) and 25 samples of biscuits (sugar free, organic farming, gluten free, intended for children and classic). The selection of the products to analysis was based mostly on brand recognition among consumers, and the popularity of the products on Polish market.

Determination of AA and free 3-MCPD

The determination of free 3-MCPD and AA were conducted using modified QuEChERS approach [35, 37]. Briefly, 1 g of a thoroughly homogenized sample was weighted into a 50 mL polypropylene (PP) tube, spiked with 25 μL of 3-MCPD- d_5 and 40 μL of AA- d_3 , then 5 mL of water and 10 mL of acetonitrile was added and the mixture was shaken vigorously for 1 min. Next, 1 g of NaCl and 4 g MgSO_4 were added; the sample was shaken vigorously for 1 min., and centrifuged for 15 min. at 9000 rpm. 8 mL of the supernatant was transferred into a 15 mL PP tube and the extracts were kept in freezer ($-20\text{ }^\circ\text{C}$) for overnight to freeze out the fat. Thereafter the extract was immediately filtrated in a freezer by filter paper to remove precipitated co-extractives. 6 mL of filtrate were transferred to the 15 mL PP tube containing 0.15 g of PSA sorbent, 0.3 g of C_{18} sorbent and 0.9 g of MgSO_4 . The tubes were shaken for 2 min. and centrifuged for 15 min at 10,000 rpm. Two portions of the extract (2 mL each) were transferred into a 4 mL screw cup vials and the extracts were evaporated under a stream of N_2 to dryness. Each sample was prepared in triplicate.

AA derivatisation: the residues were dissolved in 500 μL of acetonitrile and placed in a vial containing 50 μL of BSTFA. The mixture was heated for one hour at $65\text{ }^\circ\text{C}$. After cooling to ambient temperature, 200 μL of hexane were added and liquid-liquid extraction was performed for 1 min using a vortex. 100 μL of upper hexane layer were transferred to insert and 1 μL of extract was analyzed by GC-MS.

3-MCPD derivatisation: the residues were dissolved in 100 μL of 20% NaCl aqueous solution and 25 μL of PBA solution was added. The mixture was heated at $90\text{ }^\circ\text{C}$ for 20 min. After cooling 300 μL of hexane was added, the mixture was shaken vigorously and 200 μL of upper hexane layer was transferred into an insert in an autosampler vial. The extracts were then analysed by GC-MS.

Determination of 3-MCPDE and GE

3-MCPDE and GE were determined in fat extracted from the samples, which had been previously spiked with 270 μL of PP-3-MCPD- d_5 . The extraction was performed using CO_2 in critical phase [33]. Extracted fat, collected in Eppendorf vials, was dissolved in two portions of tetrahydrofuran, 1 mL each, transferred to 7.5 mL glass tube, and 30 μL of NaBr solution in 5% H_2SO_4 was added to the sample, which was incubated at $50\text{ }^\circ\text{C}$ for 15 min. The reaction was stopped by adding 2 mL of a solution of sodium hydrogencarbonate 0.9%. Then, 2 mL of hexane were added to separate phases. After mixing the upper hexane phase was transferred to 4 mL glass vial and evaporated to dryness. The residue was diluted with 1 mL of tetrahydrofuran and 1.8 mL of sulphuric acid solution in methanol

(1.8%, v/v) was added to the sample. The mixture was incubated at $40\text{ }^\circ\text{C}$ for 20 h. The reaction was stopped by addition of 0.5 mL saturated sodium hydrogen carbonate solution and the organic solvents were evaporated under a nitrogen stream. Fatty acid methyl esters were separated from the sample by addition of 2 mL of aqueous sodium chloride solution (20%, w/v) followed by liquid-liquid extraction with hexane (2 x 2 mL). The released 3-MCPD and 3-MBPD present in the extract were then derivatised as previously and analysed by GC-MS.

Standards preparation

A series of standard solutions in acetonitrile were prepared by dilution of the standard mixture solution within the range of 0.002 – 2 $\mu\text{g mL}^{-1}$ (AA) and 0.004– 1 $\mu\text{g mL}^{-1}$ (3-MCPD and 3-MBPD) and derivatised according to the appropriate procedures. Each standard solution was prepared in triplicate.

Validation protocol

The results of method performance for the determination of free and esterified 3-MCPD in fat-rich cereal samples have been already published [33, 35], however, to confirm the usefulness of proposed procedures for glycidyl esters analysis as well as acrylamide determination in examined products, the method was in-house validated in terms of linearity, limit of detection (LOD), limit of quantification (LOQ), accuracy (recovery), and precision (repeatability and within-laboratory reproducibility). The parameters were evaluated by analysis of crackers (fat content equal to 19%) spiked with AA and AA- d_3 at the level of 200 and 1000 $\mu\text{g kg}^{-1}$ in the case of AA analysis, and 100 $\mu\text{g kg}^{-1}$ and 500 $\mu\text{g kg}^{-1}$ in the case of GE (expressed as glycidol moiety, according to EFSA [13]). Six replicates were prepared for each concentration level. Each sample was subjected to whole analytical procedure including fat extraction and transesterification (in case of GE), clean-up and derivatisation steps.

For AA obtained results showed good linearity ($r^2 > 0.996$) in the range 2–2000 $\mu\text{g kg}^{-1}$. LOD and LOQ, calculated based on the standard deviation of the response (S_y) of the curve and the slope of the calibration curve (S), according to the formula: $\text{LOD} = 3.3(S_y/S)$ and $\text{LOQ} = 10(S_y/S)$, were 3 $\mu\text{g kg}^{-1}$ and 9 $\mu\text{g kg}^{-1}$ respectively. The results of analyte recoveries (86.4% and 90.5%) for each spiking level with the RSD (relative standard deviation) lower than 6.1% (repeatability) and below 9% (within-laboratory reproducibility) confirmed the possibility of the use of modified QuEChERS concept for the determination of AA in analysed products.

The results for GE validation showed the linearity ($r^2 > 0.998$) in the range 0.006–1.43 mg kg^{-1} expressed as

glycidol moiety. LOD and LOQ, calculated as for AA, were equal to $3.1 \mu\text{g kg}^{-1}$ and $9.4 \mu\text{g kg}^{-1}$, respectively. Recovery ratios for both spiking levels were 79% and 82% with RSD not higher than 6.0 (repeatability) and 9.3% (within-laboratory reproducibility).

RESULTS AND DISCUSSION

3-MCPD CONTENT

The level of free and bound 3-MCPD

The results of the content of free 3-MCPD (Table 2) were within the values of $9.3\text{--}63.3 \mu\text{g kg}^{-1}$. Among the group of analysed products, the highest mean content of free 3-MCPD was noted for muesli samples ($33.3 \mu\text{g kg}^{-1}$), while the lowest for baby biscuits ($11.7 \mu\text{g kg}^{-1}$). Analysing the results obtained for the individual products, the highest content of free 3-MCPD was observed in the sample 4C (gluten free salty sticks, $63.3 \mu\text{g kg}^{-1}$). In the samples of 1C (breadsticks), 1E and 2E (peanuts), 3F (granola with fruits), 5H (rye flakes), 1K (gluten free biscuits), and 1M (baby biscuits) the level of free 3-MCPD was below the limit of quantification ($9.3 \mu\text{g kg}^{-1}$), while in the sample of classic corn puffs (3B), free 3-MCPD was not detected at all (the level below the limit of detection, $3.1 \mu\text{g kg}^{-1}$).

The levels of bound 3-MCPD were substantially higher (from $9.3 \mu\text{g kg}^{-1}$ to $1500 \mu\text{g kg}^{-1}$, expressed as free 3-MCPD, according to EFSA 2016). The highest average content of 3-MCPD esters in the analysed groups of products was observed for biscuits without sugar added ($599 \mu\text{g kg}^{-1}$), whereas the lowest for breakfast cereals ($50.2 \mu\text{g kg}^{-1}$). Taking into account the individual samples, the highest 3-MCPDE content was found in the sample 1I (biscuits with no sucrose added, $1500 \mu\text{g kg}^{-1}$) and lowest for sample 5A (tortilla chips, below the limit of quantification, $9.3 \mu\text{g kg}^{-1}$). The extremely high level of 3-MCPDE in the sample 1I can be explained by the presence of fructose, added as a sugar replacer. Reducing sugars upon heat treatment decompose with the generation of organic acids that lowers pH, which is a valuable factor contributing to formation of 3-MCPD [34].

The presence of glycidyl esters was reported only in four samples: 5A (tortilla chips), 2C (breadsticks for children), 2E (roasted and salted peanuts) and 2F (granola with nuts). The latter product contained the highest level of glycidyl esters ($28.8 \mu\text{g kg}^{-1}$, expressed as glycidol moiety).

The level of free and bound 3-MCPD in the examined products were also analysed regarding the content of fat, salt and sugar, present in the samples. No statistically significant correlation was found between the content of free 3-MCPD and the sample ingredients. In contrary, for 3-MCPD esters it has been

revealed that their levels were correlated with the fat content (correlation coefficient equal to 0.62). With a view to this correlation, we also investigated the origin of the fat present in the samples. In the products contained palm oil the 3-MCPD ester level was higher than $400 \mu\text{g kg}^{-1}$, even if the total fat content in the sample was not extremely high (below 18%; e.g. samples 1F, 3F, 3G, 5I, 3K, 4M, 2N). For comparison, in the samples with rapeseed oil only, the 3-MCPDE level was below $200 \mu\text{g kg}^{-1}$, although the overall fat content was high (more than 20%; e.g. samples 1B, 2B, 3B). Additionally, products containing butter (1J, 4J, 2M) were characterised by significantly lower level of 3-MCPD esters ($<88 \mu\text{g kg}^{-1}$). This confirms that the presence of palm oil in food products is largely responsible for the 3-MCPD esters formation.

Comparison with other studies

The results received in this study were compared to the data obtained in other surveys. The results of free 3-MCPD level determined in the investigated samples are generally in a good agreement with those from other studies.

The content of free 3-MCPD in potato chips reported by Chung et al. [5] ranged from $6 \mu\text{g kg}^{-1}$ to $11 \mu\text{g kg}^{-1}$, which was similar to the results obtained by Gawarska et al. [16] and Svejtkovska et al. [39] ($4.7\text{--}9.5 \mu\text{g kg}^{-1}$, and $15.4 \mu\text{g kg}^{-1}$, respectively). For corn puffs, the data were previously provided only by Gawarska et al. [16] who revealed the 3-MCPD level of $2.8\text{--}8.3 \mu\text{g kg}^{-1}$. The 3-MCPD content in crackers was at a similar level in the work performed by Ariseto et al. [2] ($20\text{--}30 \mu\text{g kg}^{-1}$), Chung et al. [5] ($17\text{--}22 \mu\text{g kg}^{-1}$), Crews et al. [10] ($14 \mu\text{g kg}^{-1}$), Starski [36] ($0\text{--}55 \mu\text{g kg}^{-1}$), Svejtkovska et al. [39] ($10.7 \mu\text{g kg}^{-1}$) and Vicente et al. [40] ($14\text{--}32 \mu\text{g kg}^{-1}$).

As far, breakfast cereals have been analyzed several times giving results much more diversified; Ariseto et al. [2], Leon et al. [23] and Vicente et al. [40] demonstrated the 3-MCPD content in the ranges $19\text{--}113 \mu\text{g kg}^{-1}$, $0.22\text{--}143 \mu\text{g kg}^{-1}$, $0\text{--}107 \mu\text{g kg}^{-1}$, respectively, while in the report provided by Chung et al. [4] the content was significantly lower ($9\text{--}23 \mu\text{g kg}^{-1}$), but much more comparable to our results. Granola samples were investigated only in the study conducted by Vicente et al. [40], providing results noticeably higher ($0\text{--}156 \mu\text{g kg}^{-1}$) than the results presented in this work.

In case of biscuits, Leon et al. [23] reported free 3-MCPD at the ranges of $0.22\text{--}103 \mu\text{g kg}^{-1}$, while the free 3-MCPD contents in the samples of biscuits from Polish market [16, 36] were lower and ranged from 13 to $58.8 \mu\text{g kg}^{-1}$. In a study performed by Kusters et al. [22] the biscuits present in retail market reached the free 3-MCPD level in the range of $8.5\text{--}40.5 \mu\text{g kg}^{-1}$. All these results are in good accordance with the data obtained in this research.

Table 2. The level of acrylamide, free 3-MCPD, 3-MCPD esters, and glycidyl esters detected in analysed samples (mean \pm SD)

	Contaminants' content [$\mu\text{g kg}^{-1}$]				Sample ingredients			
	Acrylamide	Free 3-MCPD	3-MCPD esters ^a	Glycidyl esters ^b	Fat [%]	NaCl ^c [%]	Sugar ^c [%]	Fat origin
Potato chips (n=5)								
1A	465 \pm 43	18.9 \pm 0.9	436 \pm 21	< 3.1	29.9 \pm 1.1	1.7	2.1	palm oil, sunflower oil
2A	764 \pm 62	14.4 \pm 1.1	604 \pm 16	< 3.1	32.6 \pm 1.5	1.9	0.9	palm oil
3A	946 \pm 23	11.2 \pm 1.9	522 \pm 23	< 3.1	29.5 \pm 1.5	1.0	1.0	vegetable oil
4A	797 \pm 37	18.8 \pm 0.5	595 \pm 11	< 3.1	20.1 \pm 1.1	1.9	2.2	rapeseed oil
5A ^d	321 \pm 15	12.2 \pm 0.9	< 9.3	9.5 \pm 0.5	23.1 \pm 1.0	0.7	1.2	palm oil
Corn puffs (n=4)								
1B	227 \pm 19	16.7 \pm 0.8	261 \pm 0	< 3.1	22.8 \pm 0.5	1.8	4.3	rapeseed oil
2B	308 \pm 20	11.3 \pm 1.6	267 \pm 6	< 3.1	20.2 \pm 0.5	1.6	4.6	rapeseed oil
3B	< 3.1	24.0 \pm 2.3	207 \pm 8	< 3.1	20.7 \pm 0.8	1.6	5.1	rapeseed oil
4B	884 \pm 42	11.2 \pm 0.6	45 \pm 2	< 3.1	13.8 \pm 0.8	2.0	2.0	sunflower oil
Sticks (n=5)								
1C	235 \pm 29	< 9.3	163 \pm 10	< 3.1	8.6 \pm 0.1	2.0	2.6	olive oil
2C	681 \pm 58	43.2 \pm 0.6	257 \pm 12	11.6 \pm 0.6	4.9 \pm 0.1	2.3	6.4	palm oil, coconut oil
3C	825 \pm 55	16.6 \pm 0.3	156 \pm 7	< 3.1	9.5 \pm 0.1	1.4	2.2	rapeseed oil
4C	998 \pm 16	63.3 \pm 2.6	25 \pm 1	< 3.1	5.9 \pm 0.1	3.3	0.2	rapeseed oil
5C	832 \pm 52	31.4 \pm 3.8	36 \pm 1	< 3.1	1.5 \pm 0.1	4.8	3.4	palm oil
Crackers (n=5)								
1D	345 \pm 23	35.5 \pm 2.2	592 \pm 24	< 3.1	21.8 \pm 1.0	2.3	5.7	palm oil, coconut oil
2D	538 \pm 35	11.1 \pm 1.8	748 \pm 28	< 3.1	19.1 \pm 0.9	1.5	8.5	palm oil, coconut oil
3D	887 \pm 81	16.4 \pm 2.1	434 \pm 20	< 3.1	14.4 \pm 0.7	1.4	7.6	palm oil, rapeseed oil
4D	789 \pm 34	29.0 \pm 3.5	112 \pm 5	< 3.1	14.3 \pm 0.7	5.0	5.9	palm oil
5D	853 \pm 52	< 3.1	361 \pm 16	< 3.1	14.9 \pm 0.6	3.0	1.0	palm oil
Peanuts (n=3)								
1E	345 \pm 22	< 9.3	251 \pm 3	< 3.1	26.9 \pm 0.5	3.3	5.2	palm oil, rapeseed oil
2E	290 \pm 10	< 9.3	422 \pm 13	< 9.4	44.9 \pm 0.8	0.8	7.8	palm oil, sunflower oil
3E	577 \pm 41	< 9.3	753 \pm 31	< 3.1	29.5 \pm 0.2	2.3	7.3	vegetable oil
Granola (n=3)								
1F	1003 \pm 56	12.5 \pm 0.6	406 \pm 14	< 3.1	11.8 \pm 0.6	0.3	22.0	palm oil
2F	950 \pm 116	27.1 \pm 1.4	206 \pm 3	28.8 \pm 1.5	17.3 \pm 0.5	0.5	19.0	palm oil
3F	612 \pm 30	< 9.3	513 \pm 26	< 3.1	11.2 \pm 0.5	0.5	18.0	palm oil
Muesli (n=3)								
1G	265 \pm 24	46.6 \pm 2.4	86 \pm 5	< 3.1	8.9 \pm 0.2	0.9	15.6	rapeseed oil, palm oil
2G	344 \pm 33	19.6 \pm 2.0	390 \pm 25	< 3.1	16.1 \pm 0.3	0.4	18.1	rapeseed oil, palm oil, cocoa fat, milk fat
3G	435 \pm 50	33.7 \pm 3.5	585 \pm 30	< 3.1	15.8 \pm 0.1	0.3	16.3	rapeseed oil, palm oil
Flakes (n=3)								
1H	370 \pm 20	16.4 \pm 0.8	74 \pm 4	< 3.1	2.7 \pm 0.1	0.7	22.6	
2H	477 \pm 27	25.0 \pm 0.5	39 \pm 2	< 3.1	1.1 \pm 0.1	1.0	15.0	
3H	512 \pm 31	20.8 \pm 0.6	55 \pm 3	< 3.1	0.9 \pm 0.1	2.1	6.8	
4H	269 \pm 12	18.8 \pm 3.1	78 \pm 3	< 3.1	1.4 \pm 0.1	1.2	4.8	
5H	816 \pm 49	< 9.3	26 \pm 1	< 3.1	1.3 \pm 0.1	1.1	8.6	
6H	565 \pm 65	13.3 \pm 0.4	42 \pm 3	< 3.1	1.1 \pm 0.1	0.8	1.4	
7H	733 \pm 22	26.8 \pm 1.4	38 \pm 3	< 3.1	0.5 \pm 0.1	1.9	9.1	
Sugar free biscuits (n=5)								
1I	504 \pm 32	33.1 \pm 2.0	1501 \pm 70	< 3.1	28.3 \pm 0.1	0.1	17.6	palm oil
2I	685 \pm 11	13.9 \pm 0.9	133 \pm 6	< 3.1	12.8 \pm 0.4	0.8	2.5	sunflower oil
3I	1188 \pm 60	38.1 \pm 2.5	245 \pm 13	< 3.1	22.3 \pm 0.1	0.7	9.0	palm oil, rapeseed oil

	Contaminants' content [$\mu\text{g kg}^{-1}$]				Sample ingredients			
	Acrylamide	Free 3-MCPD	3-MCPD esters ^a	Glycidyl esters ^b	Fat [%]	NaCl ^c [%]	Sugar ^c [%]	Fat origin
4I	933 \pm 47	9.8 \pm 0.2	612 \pm 21	< 3.1	22.4 \pm 0.1	0.4	0.5	palm oil, rapeseed oil
5I	1151 \pm 24	10.3 \pm 0.1	505 \pm 28	< 3.1	18.7 \pm 0.1	0.5	0.5	palm oil
Organic farming biscuits (n=5)								
1J	1352 \pm 3	15.0 \pm 0.3	72 \pm 2	< 3.1	14.3 \pm 0.3	0.2	20.3	butter
2J	526 \pm 21	13.3 \pm 0.4	59 \pm 2	< 3.1	11.8 \pm 0.8	1.0	25.0	butter
3J	927 \pm 23	17.0 \pm 1.2	495 \pm 15	< 3.1	12.2 \pm 0.2	0.5	16.6	coconut oil
4J	914 \pm 56	23.0 \pm 1.1	78 \pm 3	< 3.1	11.2 \pm 0.3	1.0	25.0	butter
5J	847 \pm 46	19.8 \pm 1.1	481 \pm 20	< 3.1	24.4 \pm 0.4	0.1	19.0	palm oil
Gluten free biscuits (n=4)								
1K	427 \pm 22	< 9.3	460 \pm 21	< 3.1	16.3 \pm 1.0	0.2	19.0	vegetable oil
2K	590 \pm 45	11.3 \pm 0.5	183 \pm 9	< 3.1	14.2 \pm 0.2	0.3	9.5	palm oil
3K	787 \pm 12	11.7 \pm 0.2	571 \pm 21	< 3.1	12.6 \pm 0.4	0.6	19.0	palm oil
4K	615 \pm 38	20.2 \pm 1.0	91 \pm 3	< 3.1	11.6 \pm 0.1	0.5	13.0	palm oil
Baby biscuits (n=6)								
1M	251 \pm 22	< 9.3	363 \pm 15	< 3.1	9.1 \pm 0.6	0.6	24.6	palm oil
2M	437 \pm 10	16.6 \pm 1.3	88 \pm 2	< 3.1	10.8 \pm 0.1	0.4	23.2	butter
3M	858 \pm 38	11.7 \pm 0.4	424 \pm 11	< 3.1	12.0 \pm 0.2	0.1	22.6	palm oil, sunflower oil
4M	758 \pm 14	10.1 \pm 0.7	443 \pm 20	< 3.1	10.6 \pm 0.7	0.7	17.0	palm oil
5M	195 \pm 20	10.1 \pm 0.6	246 \pm 18	< 3.1	10.8 \pm 0.1	0.7	17.0	palm oil
6M	201 \pm 56	14.8 \pm 0.5	137 \pm 4	< 3.1	10.7 \pm 1.1	0.4	22.0	coconut oil
Classic biscuits (n=5)								
1N	454 \pm 36	15.3 \pm 0.7	380 \pm 20	< 3.1	10.9 \pm 0.2	0.9	18.0	palm oil
2N	273 \pm 20	21.0 \pm 1.0	588 \pm 19	< 3.1	12.0 \pm 0.1	1.1	19.0	palm oil
3N	443 \pm 42	24.9 \pm 1.2	363 \pm 12	< 3.1	11.3 \pm 0.5	1.5	20.0	palm oil
4N	373 \pm 10	21.4 \pm 1.0	749 \pm 18	< 3.1	12.5 \pm 0.2	0.7	22.6	palm oil, soybean oil, sunflower oil, cotton oil
5N	544 \pm 41	18.1 \pm 1.3	870 \pm 14	< 3.1	20.7 \pm 0.1	1.5	16.8	palm oil

^aexpressed as 3-free 3-MCPD; ^bexpressed as glycidol moiety; ^clevels declared by manufacturers on the label;

^dtortilla chips;

n – number of samplers

< 3.1 – below the limit of detection (LOD) for GE;

< 9.4 – below the limit of quantification (LOQ) for GE;

< 3.1 – below the limit of detection (LOD) for 3-MCPD;

< 9.3 – below the limit of quantification (LOQ) for 3-MCPD

For 3-MCPD esters, the results were comparable as well. In the studies reported by *Arisseto et al.* [1] and *Chung et al.* [4] the 3-MCPDE content in potato chips varied from 110 $\mu\text{g kg}^{-1}$ to 810 $\mu\text{g kg}^{-1}$ and 22-660 $\mu\text{g kg}^{-1}$, respectively, while the data presented by *Svejkovska et al.* [39] were extremely high – the mean content of 3-MCPD esters was equal to 6100 $\mu\text{g kg}^{-1}$. The ester content in crackers was found to be at the level of 200-850 $\mu\text{g kg}^{-1}$ in the work carried out by *Chung et al.* [4], which is in line with our results. However, *Svejkovska et al.* [39] observed remarkably lower content of 3-MCPDE (140 $\mu\text{g kg}^{-1}$). The report presented by EFSA [13] revealed the 3-MCPDE content at the level of 123-137 $\mu\text{g kg}^{-1}$ for snacks in general, and 210-223 $\mu\text{g kg}^{-1}$ for potato chips. This is two times lower than the results obtained in this study.

For breakfast products, the level of bound 3-MCPD were examined only by *Chung et al.* [4],

who reported considerably low values (11-43 $\mu\text{g kg}^{-1}$). Referring the obtained results to the data included in EFSA report [13] it has been observed the same level of magnitude only in the case of flakes (19-33 $\mu\text{g kg}^{-1}$) in contrary to the results for muesli, for which EFSA report demonstrated much lower values (88-102 $\mu\text{g kg}^{-1}$) than those provided by this study.

In case of biscuits, *Kusters et al.* [22] disclosed the 3-MCPDE level in the range of 330-1520 $\mu\text{g kg}^{-1}$. Results of a study conducted in Hong Kong [4] showed that the level of 3-MCPDE in biscuit samples varied from 100 to 1140 $\mu\text{g kg}^{-1}$. These values are similar to those from this work. On the contrary, data obtained from the surveys carried out in European countries in 2009-2015 [13] provided lower levels of these contaminants (194-206 $\mu\text{g kg}^{-1}$ for total 3-MCPD), which is lower than the results received in this survey.

The data of GE occurrence in similar food commodities were presented only as far by EFSA [13], giving the GE levels in the range 12-59 $\mu\text{g kg}^{-1}$ for snacks in general and 16-85 $\mu\text{g kg}^{-1}$ for breakfast products. Regarding these values, our results are comparable in the case of samples of granola (2F) and slightly lower for sample 5A (tortilla chips).

Risk assessment

The risk assessment resulted from the exposure to total MCPD was calculated based on an average product consumption and the level of the compounds in the products. The assessment was performed for all population groups, up to 75 years old (infants, toddlers, other children, adolescents, adults, elderly, very elderly), using data available from the EFSA Comprehensive Food Consumption Database [12] and compared with Tolerable Daily Intake, established recently by EFSA at 0.8 $\mu\text{g kg}^{-1}$ bodyweight [13].

The results (Table 3) showed that the highest average daily intake was found for biscuits in "other children" group, while the lowest for breakfast

products ("elderly" and "very elderly"). In the group of toddlers TDI was exceeded mostly for the samples of snacks: potato chips (except of sample 5A), crackers (1D, 2D, 3D), peanuts (3E) but also for some biscuits (3K, 2N, 4N, 5N). Although most of these products are not usually consumed by toddlers, the problem is the occurrence of 3-MCPD esters in the sample 2D, which is intended for children, as it was declared by manufacturer. Within the group of other children, the exceedance of TDI was observed in the same snack samples as for toddlers, but additionally TDI was higher than 100% in case of the consumption of muesli (2G, 3G), and most of the biscuits samples (4I, 5I, 3J, 5J, 1K, 3M, 4M, and all classic biscuits). Particular attention should be paid to the fact, that the samples 3M and 4M, according to manufacturers, are produced and intended for children. For adolescents TDI was exceeded for two samples of potato chips (2A and 4A), crackers (1D, 2D), nuts (3E) and biscuits (1I, 4I, 2N, 4N and 5N). For other population groups, TDI higher than 100 % could be observed only in the case of the consumption of the sample 1I, that showed the highest content of 3-MCPD esters.

Table 3. Daily intakes of total 3-MCPD and acrylamide in different population groups

Daily intake ($\mu\text{g kg}^{-1}$ bodyweight)						
Food products	Toddlers (12-35 months); 13 kg*	Other children (1-9 years); 24 kg	Adolescents (10-17 years); 47 kg	Adults (18-64 years); 70 kg	Elderly (65-74 years); 73 kg	Very elderly (75 years and older); 66 kg
3-MCPD						
Snacks	0.05-1.63 (0.72)**	0.05-1.61 (0.68)	0.03-1.23 (0.44)	0.01-0.66 (0.22)	0-0.52 (0.16)	0-0.57 (0.14)
Breakfast products	0-0.24 (0.09)	0.04-1.31 (0.37)	0.03-0.56 (0.19)	0.02-0.37 (0.13)	0-0.06 (0.02)	0-0.05 (0.02)
Biscuits	0.11-2.36 (0.65)	0.15-3.21 (0.88)	0.10-2.09 (0.58)	0.05-1.08 (0.30)	0.05-1.07 (0.30)	0.05-1.15 (0.32)
Acrylamide						
Snacks	0-2.27 (1.13)	0-2.46 (1.10)	0-1.33 (0.66)	0-0.63 (0.34)	0-0.6 (0.27)	0-0.67 (0.26)
Breakfast products	0.53-2.06 (1.29)	0.29-1.49 (0.82)	0.20-0.91 (0.49)	0.15-0.61 (0.37)	0.16-0.52 (0.33)	0.14-0.41 (0.27)
Biscuits	0.3-2.08 (1.00)	0.41-2.83 (1.36)	0.27-1.84 (0.89)	0.14-0.95 (0.46)	0.14-0.95 (0.45)	0.15-1.02 (0.49)

* average body weight

** min-max (mean)

ACRYLAMIDE CONTENT

The level of AA in analysed samples

The content of acrylamide detected in analysed samples varied from 195 to 1352 $\mu\text{g kg}^{-1}$. The highest content was observed for the samples of organic biscuits (913 $\mu\text{g kg}^{-1}$), while the lowest content was found in muesli products (348 $\mu\text{g kg}^{-1}$). Considering

the individual products, the highest AA content was observed in the sample 1J (organic biscuits, 1352 $\mu\text{g kg}^{-1}$), while in the sample 3B (classic corn puffs), the level of AA was below the limit of detection (3 $\mu\text{g kg}^{-1}$).

Comparison with other studies

Comparing the results obtained with the indicative data from EU Regulation [7] (Table 4), it was found

that the AA content was higher for one sample of corn puffs (4B), almost all sticks and crackers (except the sample 1C and 1D), one sample of peanuts (3E), all granola and flake samples, muesli (3G), all samples of sugar free biscuits and organic biscuits, most gluten free biscuits and baby biscuits samples (with the exception for 1K and 5M), and, finally, for only one sample of classic biscuits (5N).

Table 4. Indicative acrylamide values based on the EFSA data from 2007-2012 [7]

Foodstuffs	Indicative value [$\mu\text{g kg}^{-1}$]
Potato crisps from fresh potatoes and potato dough	1000
Breakfast cereals:	
bran products and whole grain cereals	400
wheat and rye based products	300
maize, oat, spelt, barley and rice based products	200
Biscuits and wafers	500
Crackers with the exception of potato based crackers	500
Products similar to the other products in this category	500
Biscuits and rusks for infants and young children	200

Number of studies providing results for AA in different food commodities have been published in the literature since AA was first detected in food. The data from these surveys showed that the level of acrylamide was significantly differentiated in each group of analysed products. For potato chips, the highest AA level (up to $3647 \mu\text{g kg}^{-1}$) was observed by *Mojska et al.* [26], whereas the lowest in the work conducted by *Razia et al.* [31] ($29 \mu\text{g kg}^{-1}$). The level of AA in corn puffs was ranged from $59 \mu\text{g kg}^{-1}$ [28] to $3200 \mu\text{g kg}^{-1}$ [6]. Sticks, so far, were analysed by *Mojska et al.* [26, 27], and *Russo et al.* [32], showing the AA at the level of $62\text{-}879 \mu\text{g kg}^{-1}$ and $74\text{-}85 \mu\text{g kg}^{-1}$, respectively. For crackers the AA levels ranged from $15 \mu\text{g kg}^{-1}$ [24] to $3200 \mu\text{g kg}^{-1}$ [30]. Among breakfast products, the AA highest content was detected in a work realised by *Pacetti et al.* [29] (up to $2288 \mu\text{g kg}^{-1}$), and the lowest in the study carried out by *Mojska et al.* [26] (AA level starting from $11 \mu\text{g kg}^{-1}$). For biscuits, the AA contents varied from $10 \mu\text{g kg}^{-1}$ [24, 28] to $3200 \mu\text{g kg}^{-1}$ [30]. Among them, baby biscuits were analysed in five studies, giving the results from $25 \mu\text{g kg}^{-1}$ [3, 11] to $1217 \mu\text{g kg}^{-1}$ [6]. In principle, our results are comparable to the data presented above and place in the AA content ranges reported by other authors.

Risk assessment

Since any level of exposure to a genotoxic substance could potentially damage DNA and lead to cancer, EFSA's scientists conclude that they cannot set a tolerable daily intake (TDI) of acrylamide in food [14]. However, to assess human exposure on acrylamide a daily intake of AA was calculated based on an average consumption of examined food products and the AA level in investigated samples. The calculation was performed for the same population groups as for 3-MCPD.

In general, dietary exposure decreased with age for all analysed groups of food commodities (Table 3). Toddlers and other children showed the highest level of exposure ($1.13 \mu\text{g kg}^{-1}$ bw (body weight)/day for snacks, $1.27 \mu\text{g kg}^{-1}$ bw/day for breakfast cereals and $1.36 \mu\text{g kg}^{-1}$ bw/day for biscuits), which could be attributed mainly to low body weight of toddlers. On the contrary, the lowest average daily intake of acrylamide was noted for the very elderly group ($0.26 \mu\text{g kg}^{-1}$ bw/day snacks, $0.27 \mu\text{g kg}^{-1}$ bw/day breakfast products and $0.45 \mu\text{g kg}^{-1}$ bw/day for biscuits). Comparing the results of daily intake within the food products, the highest acrylamide intake was found for breakfast products (toddlers, $1.29 \mu\text{g kg}^{-1}$ bw/day), while for the rest of population groups, the daily intake showed the highest level in the case of consumption of biscuits ($0.45\text{-}1.36 \mu\text{g kg}^{-1}$ bw/day, from elderly to other children, respectively). The results are significantly higher (3-9 times) than the data obtained by *Zajac et al.* [42], and mainly arise from the high level of AA observed in our survey.

CONCLUSIONS

1. Based on the presented findings, it can be concluded that the consumption of popular snacks such as potato chips, crackers and biscuits may result in risk to human health as the effect of a high content of acrylamide or 3-MCPD in the products.
2. Another important outcome is a high level of these contaminants detected in some type of breakfast products, such as muesli or granola. As far, these commodities have been associated with a healthy lifestyle, but, however, the results showed that regular consumption of these products also might contribute to harmful effects to human body.
3. Finally, it should be underlined that some of the products targeted for children (biscuits, sticks, and crackers) also contained high amount of acrylamide and 3-MCPD. Therefore, consumption of these products should be restricted, especially in younger population groups.

Acknowledgements

This study was funded by the Ministry of Science and Higher Education of Republic of Poland within the statutory R & D activities (DS-3707/17/KTGik).

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Arisseto A.P., Marcolino P.F.C., Vicente E.: 3-Monochloropropane-1,2-diol fatty acid esters in commercial deep-fat fried foods. *Food Addit Contam A* 2015;32:1431-1435. DOI: 10.1080/19440049.2015.1071498.
2. Arisseto A.P., Vicente E., Furlani R.P.Z., Toledo M.C.: Estimate of dietary intake of chloropropanols (3-MCPD and 1,3-DCP) and health risk assessment. *Ciênc Tecnol Aliment Campinas* 2013;33(Supl. 1):125-133. DOI: 10.1590/S0101-20612013000500019.
3. Cengiz M.F., Pelin C., Gunduz B.: Acrylamide exposure among Turkish toddlers from selected cereal-based baby food samples. *Food Chem Toxicol* 2013;60:514-519. DOI: 10.1016/j.fct.2013.08.018.
4. Chung S.W.C., Chan B.T.P., Chung H.Y., Xiao Y., Ho Y.Y.: Occurrence of bound 3-monochloropropane-1,2-diol content in commonly consumed foods in Hong Kong analysed by enzymatic hydrolysis and GC-MS detection. *Food Addit Contam A* 2013;30:1248-1254. DOI: 10.1080/19440049.2013.800996.
5. Chung S.W.C., Kwong K.P., Yau J.C.W., Wong A.M.C., Xiao Y.: Chloropropanols levels in foodstuffs marketed in Hong Kong. *J Food Compos Anal* 2008;21:569-573.
6. Claeys W., De Meulenaer B., Huyghebaert A., Scippo M.-L., Hoet P., Matthys C.: Reassessment of the acrylamide risk: Belgium as a case-study. *Food Control* 2016;59:628-635. DOI: 10.1016/j.foodcont.2015.06.051.
7. Commission Recommendation No 2013/647 of 8 November 2013 on investigations into the levels of acrylamide in food. *Off J EU L* 12.11.2013.
8. Commission Recommendation No 2014/661 of 10 September 2014 on the monitoring of the presence of 2 and 3-monochloropropane-1,2-diol (2 and 3-MCPD), 2- and 3-MCPD fatty acid esters and glycidyl fatty acid esters in food. *Off J EU L* 12.09.2014.
9. Craft B.D., Chiodini A., Garst J., Granvogl M.: Fatty acid esters of monochloropropanediol (MCPD) and glycidyl in refined edible oils. *Food Addit Contam A* 2013;30(1):46-51. DOI: 10.1080/19440049.2012.709196.
10. Crews C., Hough P., Brereton P., Harvey D., Macarthur R., Matthews W.: Survey of 3-monochloropropane-1,2-diol (3-MCPD) in selected food groups, 1999-2000. *Food Addit Contam* 2002;19:22-27. DOI: 10.1080/026520300750038072.
11. Dias Soares C.M., Fernandes J.O.: MSPD Method to Determine Acrylamide in Food. *Food Anal Method* 2009;2:197-203. DOI: 10.1007/s12161-008-9060-1.
12. EFSA Comprehensive Food Consumption Database Available <https://www.efsa.europa.eu/en/food-consumption/comprehensive-database> (Accessed 01.12.2017).
13. EFSA, European Food Safety Authority, Panel on Contaminants in the Food Chain (CONTAM): Risks for human health related to the presence of 3- and 2-monochloropropanediol (MCPD), and their fatty acid esters, and glycidyl fatty acid esters in food. *EFSA Journal* 2016;4(5):4426-4585.
14. EFSA, European Food Safety Authority, Panel on Contaminants in the Food Chain (CONTAM): Scientific opinion on acrylamide in food. *EFSA Journal* 2015;13(6):4104-4425.
15. Freudenstein A., Weking J., Matthaus B.: Influence of precursors on the formation of 3-MCPD and glycidyl esters in a model oil under simulated deodorization conditions. *Eur J Lipid Sci Technol* 2013;115:286-294. DOI: 10.1002/ejlt.201200226.
16. Gawarska H., Sawilska-Rautenstrauch D., Starski A., Karłowski K.: Occurrence of 3-monochloropropane-1,2-diol (3-MCPD) in food products. *Rocz Panstw Zakł Hig* 2009;60:213-216.
17. Hamlet C.G., Sadd P.A., Gray D.A.: Influence of composition, moisture, pH and temperature on the formation and decay kinetics of monochloropropanediols in wheat flour dough. *Eur Food Res Technol* 2003;216:122-128. DOI: 10.1007/s00217-002-0621-z.
18. IARC, International Agency for Research on Cancer: Acrylamide. In: *Monographs on the Evaluation of Carcinogenic Risks to Humans. Some industrial chemicals*. Lyon, IARC 1994;60:389-434.
19. IARC, International Agency for Research on Cancer: Glycidol. In: *Monographs on the Evaluation of Carcinogenic Risks to Humans. Some industrial chemicals*. Lyon, IARC 2000;77:469-489.
20. IARC, International Agency for Research on Cancer: 3-Monochloro-1,2-propanediol. In: *Monographs on the Evaluation of Carcinogenic Risks to Humans. Some chemicals present in industrial and consumer products, food and drinking-water*. Lyon: IARC 2012;101:349-374.
21. Kowalska D., Gruczyńska E., Tarnowska K.: Estrzy chloropropanoli, chloropropanodiolu i glicydolu – termicznie indukowane procesy zanieczyszczenia żywności [Esters of chloropropanols, chloropropanediols and glycidol – thermally induced process contaminants of foods]. *Probl Hig Epidemiol* 2017;98(1):9-16 (in Polish).
22. Kusters M., Bimber U., Ossenbruggen A., Reeser S., Gallitzendorfer R., Gerhartz M.: Rapid and Simple Micromethod for the Simultaneous Determination of 3-MCPD and 3-MCPD Esters in Different Foodstuffs. *J Agric Food Chem* 2010;58:6570-6577. DOI: 10.1021/jf100416w.
23. Leon N., Yusa V., Pardo O., Pastor A.: Determination of 3-MCPD by GC-MS/MS with PTV-LV injector used for a survey of Spanish foodstuffs. *Talanta* 2008;75:824-831. DOI: 10.1016/j.talanta.2007.12.028.

24. *Mesias M., Morales F.J.*: Acrylamide in Bakery Products. In: *Gokmen V.* ed. Acrylamide in Food. Cambridge, Academic Press, 2016.
25. *Mogol B.A., Gokmen V.*: Thermal process contaminants: acrylamide, chloropropanols and furan. *Curr Opin Food Sci* 2016;7:86–92. DOI: 10.1016/j.cofs.2016.01.005.
26. *Mojska H., Gielecińska I., Ołtarzewski M., Szponar L.*: Akryloamid w żywności – ocena narażenia populacji polskiej [Acrylamide exposure from foods of the Polish population]. *Bromat Chem Toksykol* 2009; XLII:436–441 (in Polish).
27. *Mojska H., Gielecińska I., Stoś K., Jarosz M.*: Zawartość akryloamidu w żywności w Polsce w świetle aktualnych zaleceń Unii Europejskiej [Acrylamide content in food in Poland in the light of current EU recommendations]. *Probl Hig Epidemiol* 2011; 92:625–628 (in Polish).
28. *Olmez H., Tuncay F., Ozcan N., Demirel S.*: A survey of acrylamide levels in foods from the Turkish market. *J Food Compos Anal* 2008;21:564–568. DOI:10.1016/j.jfca.2008.04.011.
29. *Pacetti D., Gil E., Frega N.G., Álvarez L., Dueñas P., Garzón A., Lucci P.*: Acrylamide levels in selected Colombian foods. *Food Addit Contam B* 2015;8:99–105. DOI: 10.1080/19393210.2014.995236.
30. *Rachwał D., Nebesny E.*: Redukcja zawartości akrylamidu w produktach spożywczych [Reduction of acrylamide content in food products] *Bromat Chem Toksykol* 2012; XLV:219–227 (in Polish).
31. *Razia S., Bertrand M., Klaus V., Meinolf G.L.*: Investigation of acrylamide levels in branded biscuits, cakes and potato chips commonly consumed in Pakistan. *International Food Research Journal* 2016;23(5):2187–2192.
32. *Russo M.V., Avino P., Centola A., Notardonato I., Cinelli G.*: Rapid and simple determination of acrylamide in conventional cereal-based foods and potato chips through conversion to 3-[bis(trifluoroethoxy)amino]-3-oxopropyl trifluoroacetate by gas chromatography coupled with electron capture and ion trap mass spectrometry detectors. *Food Chem* 2014;146:204–211. DOI: 10.1016/j.foodchem.2013.09.050.
33. *Sadowska-Rociek A., Cieřlik E., Florkiewicz A.*: Formation of free and bound 3-monochloropropane-1,2-diol in fat-rich cereal model systems: the impact of flour composition. *Chem Pap* 2017, in press. DOI: 10.1007/s11696-017-0302-9.
34. *Sadowska-Rociek A., Cieřlik E., Sieja K.*: Mitigation role of erythritol and xylitol in the formation of 3-monochloropropane-1,2-diol and its esters in glycerol and shortbread model systems. *Eur Food Res Technol* 2017;11:2055–2063. DOI: 10.1007/s00217-017-2916-0.
35. *Sadowska-Rociek A., Cieřlik E., Sieja K.*: Simultaneous sample preparation method for determination of 3-monochloropropane-1,2-diol and polycyclic aromatic hydrocarbons in different foodstuffs. *Food Anal Method* 2016;9(10):2906–2916. DOI: 10.1007/s12161-016-0486-6.
36. *Starski A., Jedra M., Gawarska H., Postupolski J.*: Assessing exposure to 3-MCPD from bakery products based on monitoring studies undertaken throughout Poland. *Rocz Panstw Zakł Hig* 2013;64(4):277–83.
37. *Surma M., Sadowska-Rociek A., Cieřlik E., Sznajder-Katarzyńska K.*: Optimization of QuEChERS sample preparation method for acrylamide level determination in coffee and coffee substitutes. *Microchem J* 2017;131:98–102. DOI: 10.1039/C6AY00931J.
38. *Svejkovská B., Doležal M., Velíšek J.*: Formation and decomposition of 3-chloropropane-1,2-diol esters in models simulating processed foods. *Czech J Food Sci* 2006;24:17–179.
39. *Svejkovská B., Novotný O., Divinová V., Reblova Z., Doležal M., Velíšek J.*: Esters of 3-chloropropane-1,2-diol in foodstuffs. *Czech J Food Sci* 2004;22:190–196.
40. *Vicente E., Ariseto A.P., Furlani R.P.Z., Monteiro V., Gonçalves L.M. Pereira A.L.D., Toledo M.C.F.T.*: Levels of 3-monochloropropane-1,2-diol (3-MCPD) in selected processed foods from the Brazilian market. *Food Res Int* 2015;77:310–314. DOI: 10.1016/j.foodres.2015.03.035.
41. *Wenzl T., Lachenmeier D.W., Gökmen V.*: Analysis of heat-induced contaminants (acrylamide, chloropropanols and furan) in carbohydrate-rich food. *Anal Bioanal Chem* 2007;389:119–137. DOI: 10.1007/s00216-007-1459-9.
42. *Zajac J., Bojar I., Helbin J., Kolarzyk E., Potocki A., Strzemecka J., Owoc A.*: Dietary acrylamide exposure in chosen population of South Poland. *Ann Agric Environ Med* 2013;20(2):351–355.

Received: 14.12.2017

Accepted: 16.03.2018

THE INFLUENCE OF PRESCHOOL CHILDREN'S DIETS ON THE RISK OF LIFESTYLE DISEASES. A PILOT STUDY

Małgorzata Kostecka

University of Life Science, Faculty of Food Science and Biotechnology,
Department of Chemistry, Lublin, Poland

ABSTRACT

Background. A healthy diet in early life not only contributes to physical and intellectual development, but it can also reduce the risk of disease in adulthood. There is growing evidence to indicate that childhood diets are highly correlated with health in adult years. Eating habits formed in childhood persist in later life.

Objective. The objective of this study was to evaluate the diets of preschool children aged 3 to 6 years and to identify statistical correlations between dietary factors and the risk of lifestyle diseases.

Material and methods. The described survey was conducted based on the paper and pencil interviewing method. The study was conducted on 380 children from Lublin and Świętokrzyskie regions. The risk of lifestyle diseases in the studied population was evaluated based on the answers to 17 selected questions. The questionnaires were processed statistically in SPSS and Statistica programs.

Results. Eating irregular meals increased the risk of lifestyle diseases, and the lower the number of meals per day, the greater the relevant risk ($p=0.002$). Children who did not eat regular breakfasts or afternoon teas and ate sweet and salty snacks were at significantly higher risk of lifestyle diseases. Consumption of milk and dairy product was an important predictor of lifestyle diseases. Children who did not drink milk every day were at significantly higher risk of developing lifestyle diseases than their peers who drank milk at least once a day ($p<0.0001$).

Conclusions. Eating habits formed in childhood can contribute to the risk of lifestyle diseases in adulthood. Particularly dangerous are nutritional habits leading to overweight and obesity. Both children and parents require nutritional education to develop healthy eating habits.

Key words: *lifestyle disease, preschool children, nutrition*

STRESZCZENIE

Wprowadzenie. Właściwa dieta w pierwszych latach życia człowieka nie tylko wpływa na prawidłowy rozwój fizyczny i intelektualny, ale może być również jednym z ważniejszych czynników powodujących obniżenie ryzyka rozwoju chorób w wieku dojrzałym. Istnieje coraz więcej dowodów na ścisły związek pomiędzy odżywianiem w okresie dzieciństwa, a zdrowiem człowieka dojrzałego.

Cel. Celem badań była ocena żywienia dzieci w wieku przedszkolnym, w wieku od 3 do 6 lat oraz próba poszukiwania statystycznych zależności pomiędzy wskazanymi w literaturze elementami sposobu żywienia, a ryzykiem zachorowania na choroby cywilizacyjne.

Materiały i metody. Badania przeprowadzono za pomocą autorskiego kwestionariusza ankiety wśród 380 dzieci z województwa lubelskiego i świętokrzyskiego. Ryzyko wystąpienia chorób cywilizacyjnych wśród badanych dzieci oceniono na podstawie 17 wybranych pytań ankiety. Wypełnione kwestionariusze poddano analizie statystycznej za pomocą programów komputerowych SPSS i Statistica 10.

Wyniki. Nieprawidłowy rozkład posiłków w ciągu dnia był czynnikiem zwiększającym ryzyko wystąpienia chorób cywilizacyjnych, stwierdzono, że im mniejsza liczba posiłków w ciągu dnia tym oceniane ryzyko jest wyższe ($p=0,002$). Istotnie wyższym ryzykiem wystąpienia chorób cywilizacyjnych obarczone były dzieci, które nie jadły regularnie śniadań oraz podwieczorku oraz te, które pojadały słodkie lub słone przekąski ($p<0,05$). Bardzo ważnym czynnikiem ryzyka okazało się niskie spożycie mleka i jego przetworów, dzieci spożywające mleko rzadziej niż raz dziennie miały istotnie statystycznie wyższe ryzyko rozwoju chorób cywilizacyjnych niż rówieśnicy pijący mleko przynajmniej raz w ciągu dnia ($p<0,0001$).

Wnioski. Zachowania i nawyki żywieniowe w okresie dzieciństwa mogą być czynnikiem ryzyka zachorowania na choroby cywilizacyjne w przyszłości. Szczególnie niebezpieczne są zachowania żywieniowe prowadzące do rozwoju nadwagi i otyłości. Konieczna jest edukacja żywieniowa zarówno rodziców jak i dzieci mająca na celu wprowadzenie prozdrowotnych nawyków żywieniowych.

Słowa kluczowe: *choroby cywilizacyjne, dzieci przedszkolne, żywienie*

Corresponding author: Małgorzata Kostecka, University of Life Science, Faculty of Food Science and Biotechnology, Department of Chemistry, Akademicka street 15, 20-950, Lublin, Poland, phone: +48 81 445 68 46, e-mail: julka-portal@wp.pl

INTRODUCTION

A healthy diet in early life not only contributes to physical and intellectual development, but it can also reduce the risk of disease in adulthood. There is growing evidence to indicate that childhood diets are highly correlated with health in adult years. Eating habits formed in childhood persist in later life. Unhealthy diet, stress, sedentary lifestyle, substance abuse and environmental pollution are the main causes of lifestyle diseases. Children grow and develop rapidly during preschool years. Preschoolers are at high risk of nutritional deficiencies, which is why their nutrient intake should closely match nutrient recommendations in different stages of physiological development.

Preschoolers should eat 4-5 meals per day at intervals not exceeding 3-4 hours. A child's diet should be varied and well-balanced. The inclusion of various food products in a diet will guarantee that a child's nutritional needs are adequately met. Children eating a varied diet will also be able to develop a liking for different types of foods [7].

An unbalanced diet can disrupt physical growth and development, weaken immunity and contribute to insufficient or excessive body weight. The recommended daily calcium dose for preschoolers is estimated at 800 mg. Diets deficient in calcium lead to rickets in early childhood and loss in bone density and mass in later life [13,18].

Lifestyle diseases originate in early childhood, and they are caused by a sedentary lifestyle and unhealthy eating habits. Overweight and obese individuals are more frequently diagnosed with diseases such as type 2 diabetes, hypertension, bile duct stones, gastroesophageal reflux and asthma [11].

The objective of this study was to evaluate the diets of preschool children aged 3 to 6 years and to identify statistical correlations between dietary factors and the risk of lifestyle diseases.

MATERIAL AND METHODS

The described survey was conducted based on the paper and pencil interviewing method. The analytical tool was an anonymous questionnaire developed by the authors. The questionnaire was composed of 35 questions, including 28 close-ended or multiple choice questions and 7 open-ended questions. The questions addressed the surveyed children's diets, health status, anthropometric and sociodemographic data, gender, age and family size. The respondents were asked to describe the children's diets in the past month and the eating habits in the family home. The questions addressed eating habits on both school and non-school days.

The study was conducted in kindergartens between September 2016 and November 2016 on 380 children

from Lublin and Świętokrzyskie regions. The inclusion criteria were the participants' age, absence of chronic diseases or diseases that require an elimination diet. A total of 320 correctly completed questionnaires were returned by the children's parents. The studied population consisted of 51.2% of girls and 48.8% of boys.

The participants' nutritional status was evaluated based on anthropometric measurements of height to the nearest 0.1 cm and body weight to the nearest 0.1 kg. The participants' nutritional status was evaluated based on anthropometric measurements. The results were used to calculate the body mass index (BMI) and develop a percentile chart adjusted for the participants' gender and age, based on the recommendations of the Institute of the Mother and Child in Warsaw. BMI values between the 5th and 85th percentile on the chart represented the normal weight range. Values below the 5th percentile denoted underweight subjects, values above the 85th percentile and below the 95th percentile denoted overweight subjects, and values above the 95th percentile denoted obese subjects [3].

The risk of lifestyle diseases in the studied population was evaluated based on the answers to 17 selected questions (Table 1) about for example: regular meals, consumption of milk, fruits, fish and snacks. Behaviors and attitudes that contribute to lifestyle diseases scored 1 point, and parents could score maximum 17 points for the above questions. The results were expressed in percentage terms to indicate the risk of lifestyle diseases on a scale of 0 to 100%. The higher the result, the greater the associated risk in the surveyed population.

The questionnaires were processed statistically in SPSS and Statistica programs. Differences between mean values were determined with the use of the χ^2 test, *Mann-Whitney U* test and the *Kruskal-Wallis* test at a significance level of $p < 0.05$.

Description of the surveyed population

In the studied population of preschoolers, 31.25% children were aged 3-4 years, and 68.75% were aged 5-6 years. The average body weight was determined at 20.46 ± 3.89 kg, and it ranged from 14 kg to 35 kg. The average body weight of younger children was significantly lower than the average body weight of older subjects.

The average height was determined at 115.86 ± 7.65 cm in the range of 90 cm to 132 cm. Children aged 5-6 years were significantly taller than children aged 3-4 years, and the observed differences represented normal age-related variations in height.

Body mass index values ranged from 9.91 to 27.16 (Table 2). Based on BMI values, more than 1/3 of children aged 4-5 years were classified as underweight, whereas children aged 3-4 years were significantly more often overweight ($p = 0.0002$).

Table 1. Risk of lifestyle diseases – answer key

Question number	4	6	7	9	12	13	15	16	18	20	21	23	24	25	26	27	32
Response	overweight or obese	b	b	a	b	d	b	a	a	b	a	b	d	b	a	a	b

Table 2. Description of the surveyed population

		Age				Total		p
		3 - 4 years		5 - 6 years		N	%	
		n	%	n	%			
Gender	Female	62	62	102	46.4	164	51.25	0.0666
	Male	38	38	118	53.6	156	48.75	
Body weight [kg]		18.68±3.41		21.26±3.84		20.46±3.89		0.0001
Height [cm]		110.34±5.6		118.37±7.14		115.86±7.65		<0.0001
BMI [kg/m ²]		15.32±2.32		15.20±2.72		15.24±2.60		0.4671
BMI	underweight	19	19	74	33.6	93	29	0.3200
	normal weight	46	46	100	45.5	146	45.6	
	overweight	29	29	36	16.4	65	20.3	
	obese	6	6	10	4.5	16	5	
Family members	2	0	0	6	2.7	6	1.9	0.1138
	3	42	42	54	24.5	96	30	
	4	46	46	128	58.2	174	54.4	
	5 and more	12	12	32	14.5	44	13.8	
Financial status	very high	18	18	28	12.7	46	14.4	0.3242
	high	54	54	146	66.4	200	62.5	
	average	28	28	46	20.9	74	23.1	
	low	0	0	0	0.0	0	0.0	

RESULTS

The majority of the parents (60.0%) claimed that their children consumed 4-5 meals per day, and only every tenth child ate less than 3 meals per day (Table 3). Significant differences between the children's age and the number of meals per day were not observed ($p=0.6286$). Meal frequency was not correlated with age ($p=0.4133$), and only 38.1% of children ate meals at regular times throughout the day.

Table 3. Age and regular meals

Regular meals		Age				p
		3 - 4 years		5 - 6 years		
		n	%	n	%	
Breakfast	no	34	34.0	42	19.1	0.0400
	yes	66	66.0	178	80.9	
Second breakfast	no	62	62.0	146	66.4	0.5917
	yes	38	38.0	74	33.6	
Lunch	no	20	20.0	40	18.2	0.7848
	yes	80	80.0	180	81.8	
Afternoon tea	no	74	74.0	144	65.5	0.2823
	yes	26	26.0	76	34.5	
Dinner	no	28	28.0	82	37.3	0.2524
	yes	72	72.0	138	62.7	

An evaluation of the surveyed children's appetite revealed that 5- to 6-year-olds were significantly more eager (71.8%) to eat, but only the foods that they enjoyed, than 3- to 4-year-olds (42.0%), whereas a significantly higher number of children in the group

of 3- to 4-year olds had very good appetite or were fussy eaters ($p=0.0032$).

According to 70.6% of the parents, their children enjoyed eating in the school cafeteria, and this group of respondents did not differ significantly in age ($p=0.5274$). In the surveyed population, 64.4% of children ate breakfast at home, whereas every 6 child did not eat breakfast at home or ate it sporadically. Children aged 3-4 years were more prevalent in the latter group ($p=0.0425$). On non-school days, all children ate breakfast, whereas only every fourth child aged 4-5 years and every other younger child ate second breakfast. Breakfast consumption was significantly differentiated by age ($p=0.001$).

More than 1/4 of the respondents declared that children ate fruit and vegetables 2-3 times a day, 40.6% respondents consumed fruit and vegetables once a day, whereas more than 20% of children ate fruit and vegetables 2 to 3 times a week. Five- to 6-year-olds were significantly more (47.3%) likely to eat fruit and vegetables once a day than 3- to 4-year-olds, most of whom ate fruit and vegetables once a week or less often ($p=0.0241$). The children's favorite fruits were bananas and apples in all age groups, tangerines in the group of 4- to 5-year olds, and kiwis in the group of 3- to 4-year olds ($p=0.0023$).

According to the parents, 63.1% ($N=202$) of the surveyed children consumed milk and dairy beverages every day. Children drank pure milk (65.8%), flavored milk (24.3%) and plant milk (9.9%). Flavored milk was more frequently consumed by 4- to 5-year olds

($p=0.002$). In the studied population, 36.9% of the respondents did not drink milk or dairy beverages daily due to the children's or the parents' dislike for such products or intolerance. None of the evaluated children were allergic to cow's milk proteins. Significant differences in daily consumption of milk and dairy beverages were not observed between age groups.

Based on the collected data, 68.1% of children ate cheese, yogurt and other dairy products on a daily basis. Daily consumption of dairy products did not differ significantly between age groups. Children had a preference for homogenized cheese and sweetened yogurt, and age was not a differentiating factor. Only 18.8% of the respondents ate plain yogurt, and this product was significantly more popular among 3- to 4-year olds ($p=0.0005$). The most popular types of cheese were hard cheese, semi-skimmed cottage cheese and granulated cottage cheese. The least popular cheeses were full-fat cheese and ricotta-type cheeses. Children ate cheese and dairy products during every meal, excluding lunch, mostly during breakfast, afternoon tea and dinner.

Most parents ($N=143$, 89.4%) declared that their children snacked between meals. Only 10.6% ($N=17$) of the respondents gave the opposite answer. In the studied population, 86.0% of 3- to 4-year-olds and 90.9% of 5- to 6-year-olds snacked between meals. The differences between age groups were not statistically significant ($p=0.3503$). Children most often snacked on sweets (60.1%, $p=0.0034$) and least often on raw vegetables or salads (3.5%, $p=0.0012$). Most children had a preference for sweet snacks ($p=0.0023$), but the preferred types of snacks did not differ significantly between age groups. The frequency of daily snacking was correlated with age (36.4% of 5- to 6-year-olds vs. 14% of 3- to 4-year-olds). According to questionnaire data, 56.3% of the surveyed parents made attempts to limit or control the number of snacks consumed by their children.

Fruit juice and soft drinks were consumed by 68.8% of preschoolers, in particular younger children ($p=0.0148$). Every sixth child drank more than 500 ml of juice daily, and overweight children were significantly more prevalent in this group ($p=0.0012$). The vast majority of parents (71.8%) served juice 2-3 times a week, and average juice consumption was determined at 1050 ± 234 ml per week. Only 11.25% of parents served freshly squeezed fruit juice, whereas 9.5% diluted juice with an equal amount of water ($p=0.003$). According to 58.8% of the respondents, their children drank still mineral water every day, and the number of older children was significantly higher in this group ($p=0.0106$). Children were significantly more likely to drink water in kindergarten ($p=0.0012$), whereas juice consumption was significantly higher during afternoon tea or between meals at home ($p=0.01$).

The vast majority of children eagerly participated in physical activities in kindergarten (83.1%), and 74.3%

of the surveyed parents declared that their children also participated in extracurricular sports. The most popular extracurricular activities were swimming (45 minutes per week), playing with peers (120 minutes per week on average) and ballet (45 minutes per week). Five- to 6-year-olds were significantly more likely to participate in extracurricular activities than 3- to 4-year-olds ($p=0.0113$).

The parents were also asked about the perceived need to modify their children's diets (Figure 1). According to 55.6% of the respondents, the child's diet should be improved, whereas 22.5% of the parents recognized the need for improvement in the eating habits of the entire family. A significant difference was observed only for vegetables, where the parents of older children were hoping to introduce more vegetables to the diet ($p=0.0281$). The remaining responses did not differ significantly between age groups.

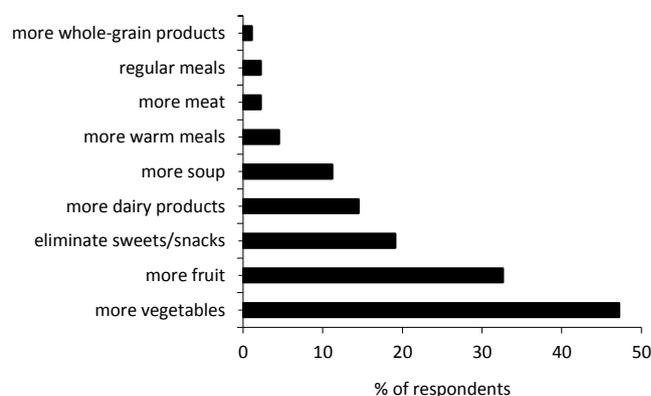


Figure 1. Possible improvements in the child's diet

The average risk of lifestyle diseases was determined at $30.26\pm 10.63\%$ ($p=0.002$) in the range of 5.88% to 52.94%. In 50% of the surveyed population, the risk of lifestyle diseases did not exceed 29.41%. In more than 1/4 of the surveyed children, the relevant risk was estimated at 35.29% (Figure 2).

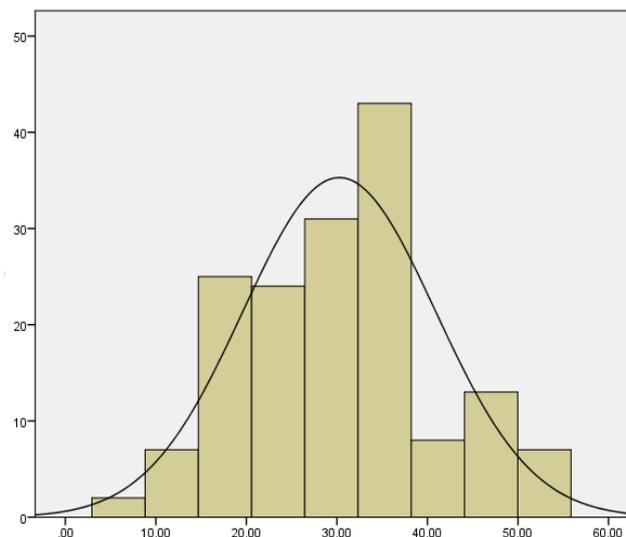


Figure 2. Risk of lifestyle diseases in the studied population.

The risk of lifestyle diseases was higher among boys than girls, but the noted difference was not significant ($p=0.3870$). Age was not a differentiating factor either ($p=0.5327$). An analysis of the results revealed the highest risk of lifestyle diseases in children from families with 5 or more members ($p=0.0457$) and in families with average financial status ($p=0.0324$).

Eating irregular meals increased the risk of lifestyle diseases, and the lower the number of meals per day, the greater the relevant risk ($p=0.002$).

Children who did not eat regular breakfasts or afternoon teas were at significantly higher risk of lifestyle diseases, and these findings were correlated with the number of meals consumed per day (Table 4).

Table 4. Regular meals and the risk of lifestyle diseases

Regular meals		Risk of lifestyle diseases	
		Mean	SD
Breakfast	no	35.14	11.07
	yes	28.74	10.07
p		0.0036	
Second breakfast	no	29.98	11.31
	yes	30.78	9.32
p		0.4868	
Lunch	no	26.67	8.13
	yes	31.09	10.99
p		0.0589	
Afternoon tea	no	32.00	10.66
	yes	26.53	9.66
p		0.0030	
Dinner	no	31.87	11.36
	yes	29.41	10.19
p		0.2570	

The results also indicate that children who were poor and fussy eaters were at significantly higher risk of lifestyle diseases than eager eaters ($p=0.0186$). Significant differences in the risk of lifestyle diseases were not observed between children who were and were not eager to eat in the school cafeteria ($p=0.607$).

Consumption of milk and dairy product was an important predictor of lifestyle diseases. Children who did not drink milk every day were at significantly higher risk of developing lifestyle diseases than their peers who drank milk at least once a day ($p<0.0001$).

An analysis of preschoolers' snacking habits revealed that sweet and salty snacks also significantly contributed to the risk of lifestyle diseases (Table 5).

Table 5. Snacking and the risk of lifestyle diseases

Snack		Risk of lifestyle diseases	
		Mean	SD
Sweets	no	27.76	10.65
	yes	32.15	11.00
p		0.0228	
Sandwiches	no	30.48	11.29
	yes	29.76	9.18
p		0.9646	
Fruit	no	31.55	11.07
	yes	28.81	10.64
p		0.0847	
Vegetables/salads	no	30.39	11.18
	yes	30.59	6.44
p		0.8493	
Salty snacks	no	24.97	7.31
	yes	29.27	8.99
p		0.01783	
Sweetened yogurt	no	24.48	10.52
	yes	32.41	11.01
p		0.0010	
Crisps	no	29.12	11.69
	yes	33.47	8.67
p		0.0184	
Other	no	30.03	10.97
	yes	32.82	11.49
p		0.4477	

DISCUSSION

In child nutrition, regular eating is as important as a well-balanced diet. In this study, 60% of the surveyed children ate 4-5 meals a day, which is consistent with dietary recommendations for this age group. In the work of *Stankiewicz et al.* [18], a similar percentage of respondents ate 4-5 meals a day, but only 38% of children consumed meals regularly throughout the day. Children should eat breakfast at home before going to kindergarten. Many parents are convinced that children do not need to eat breakfast at home because this meal is served in kindergarten. However, breakfast is served only at 8:30 a.m., whereas most students arrive at kindergarten already before 7:30 a.m. A prolonged interval between dinner and breakfast can lead to hypoglycemia and low levels of physical and mental activity in the morning hours [15].

The family's socioeconomic status and the educational attainment of the parents, in particular the

mothers, significantly influence the family's eating habits, including the tendency to eat regular breakfasts and higher consumption of vegetables, fruit, fish and whole-grain products which decrease the risk of lifestyle diseases [17].

A statistical analysis of the results noted in this study revealed that children from families with very high financial status were significantly more likely to eat breakfast at home ($p=0.001$) and consumed whole-grain products ($p=0.0045$) and vegetables ($p=0.034$) more often than their peers from families with average financial status.

An Irish study of children aged 1-4 years demonstrated that vegetables and fruit are the main sources of dietary fiber, vitamin C and *beta*-carotene in the diet, but they cater to only 35-50% of the requirements for these nutrients in preschoolers' diets [12]. The economic factor often plays roles in the amount of fresh fruits and vegetables consumed by children [1]. Vegetables contain compounds with antioxidant properties, and they can prevent cardiovascular diseases [2]. Diets that are abundant in calcium-rich food products such as milk and dairy products promote bone formation in children and prevent osteoporosis in later life. In our study, milk consumption was significantly higher among children who ate breakfast at home ($p=0.0021$) and children who had siblings ($p=0.0047$). In a study by *Newerli-Guz* and *Kulwikowska*, kindergarten children consumed more milk and dairy products than the respondents surveyed in our study. In the cited study, only 13.7% of children consumed milk and dairy products less than once daily [11].

Salty snacks increase the intake of dietary sodium and contribute to the risk of lifestyle diseases, in particular obesity, cardiovascular diseases and hypertension [5]. In our study, the consumption of salty snacks was higher among 5- to 6-year-olds and children who had siblings ($p=0.023$).

Frequent snacking has a negative influence on regular eating patterns and disrupts physiological mechanisms of hunger and satiety. According to *Kelishadi* et al. (2017), snacking disrupts regular eating and the frequency of meal consumption [4]. In our study, children who snacked on salty foods and sweetened yogurt were less likely to eat afternoon tea ($p=0.001$), and children who snacked on sweets at least once a day were significantly more likely to eat irregular meals at different time intervals ($p=0.023$).

The results of this study indicate that more than 60% of parents approve of sweet snacking, and similar findings were reported by *Platta* and *Martul* [14]. *Kozłowska-Wojciechowska* also found that 85% of kindergarten children from Warsaw and the Region of Mazowsze enjoyed salty snacks (crisps, etc.), according to *Kozioł-Kozakowska*, 91% of children from Kraków area consumed salty snacks such as crisps and crackers [8,9]. In a study by *Kolarzyk* et al. [6], sweets were

the most frequent snack among children with normal weight as well as children who were overweight and obese. Excessive consumption of sweets has never been directly correlated with obesity, but prolonged consumption of high-energy foods that exceed the daily recommended caloric intake can contribute to weight gain [19]. In addition to sweets such as cookies, candy bars and lollipops, significant amounts of sugar are found in fruit juice and soft drinks whose consumption has increased considerably in recent years. Research has demonstrated that daily consumption of large amounts of juice and soft drinks can significantly increase daily calorie intake, but it does not directly affect the BMI of kindergarten children [12]. A study analyzing juice consumption among 2-year-olds in the United States demonstrated that daily consumption of 100% juice can increase BMI at the age of 2 to 4 years [16]. In the surveyed population, more than 2/3 of children drank juice, mostly sweetened carrot, orange and multifruit nectars ($p=0.0023$). High juice consumption was significantly correlated with lower milk intake. Children who drank milk at least once a day drank significantly less juice ($p=0.001$).

Physical activity contributes to healthy growth and development from the earliest age, and it minimizes the risk of lifestyle diseases in later life [10]. Physical activity is vital for healthy physical, cognitive, emotional and social development in early life. Special emphasis should be placed on the interactions between physical activity and motor skills, as well as on physical activities that promote healthy weight gain [20].

In our study, 74.3% of the surveyed children participated in physical activities in kindergarten as well as in extracurricular sports. According to recommendations, preschoolers should participate in at least 60 minutes of active play daily. In our study, the physical activity levels of the surveyed children were not correlated with gender or family size. The only exception was noted in children from families with average financial status which were less likely to participate in organized sports outside kindergarten ($p=0.001$).

CONCLUSIONS

1. Eating habits formed in childhood can contribute to the risk of lifestyle diseases in adulthood.
2. Children who eat breakfast at home have healthier eating habits.
3. Age and gender did not influence snacking behaviors which were relatively similar in the entire surveyed population.
4. Both children and parents require nutritional education to develop healthy eating habits.

Conflict of interest

The Author declare no conflict of interest.

REFERENCES

1. *Carty S.A., Mainvil L.A., Coveney J.D.*: Exploring family home food environments: Household resources needed to utilise weekly deliveries of free fruits and vegetables. *Nutr Diet* 2017;74(2):138-146. doi: 10.1111/1747-0080.12296.
2. *Czerwiecki L.*: Contemporary view of plant antioxidants role in prevention of civilization diseases. *Rocz Państw Zakł Hig.* 2009;60(3):201-216.
3. *Jodkowska M., Woynarowska B., Oblacińska A.*: Screening test for detecting physical developmental disorders in school children and adolescents. *Instytut Matki i Dziecka* 2007 (in Polish).
4. *Kelishadi R., Mozafarian N., Qorbani M., Motlagh M.E., Safiri S., Ardalan G., Keikha M., Rezaei F., Heshmat R.*: Is snack consumption associated with meal skipping in children and adolescents? The CASPIAN-IV study. *Eat Weight Disord* 2017 doi: 10.1007/s40519-017-0370-4 [Epub ahead of print].
5. *Klunklin S., Channoonthuan K.*: Snack consumption in normal and undernourished preschool children in North-eastern Thailand. *J Med Assoc Thai* 2006;89(5):706-713.
6. *Kolarzyk E., Janik A., Kwiatkowski J.*: Dietary habits of pre-school children. *Probl Hig Epidemiol* 2008; 89(4):527-532 (in Polish).
7. *Kostecka M.*: Proper Nutrition of preschool children as an essential element of prevention of lifestyle diseases. *Piel Zdr Publ* 2013;3(3):257-263 (in Polish).
8. *Kozioł-Kozakowska A., Piórecka B., Żwirska J., Jagielski P., Schlegel-Zawadzka M.*: Assessment of the eating habits of pre-school children attending kindergartens in the region of Krakow, including socioeconomic characteristics. *Probl Hig Epid* 2007;88(4):422-427 (in Polish).
9. *Kozłowska-Wojciechowska M., Makarewicz-Wujec M.*: Nutritional behavior of pre-school children. *Rocz Państw Zakł Hig* 2005;56(2):165-169.
10. *Lindsay A.C., Greaney M.L., Wallington S.F., Mesa T., Salas C.F.*: A review of early influences on physical activity and sedentary behaviors of preschool-age children in high-income countries. *J Spec Pediatr Nurs* 2017 doi: 10.1111/jspn.12182. [Epub ahead of print].
11. *Newerli-Guz J., Kulwikowska K.*: Zachowania żywieniowe i preferencje dzieci w wieku przedszkolnym. [Nutritional habits and preferences of pre-school children]. *Zeszyty Naukowe Akademii Morskiej w Gdyni* 2014; 86:80-89 (in Polish).
12. *O'Connor L., Walton J., Flynn A.*: Fruit and vegetable intakes, sources and contribution to total diet in very young children (1-4 years): the Irish National Pre-School Nutrition Survey. *Br J Nutr* 2016;115(12):2196-2202. doi: 10.1017/S0007114516001422.
13. *Orkus A., Włodarczyk A.*: Evaluation of preschool children's diets based on 10-day menus. *Nauki Inżynierskie i Technologie* 2014;1(12):72-81 (in Polish).
14. *Platta A., Martul A.*: Assessment of parents' knowledge about the effects of abnormal nutritional behavior on the development of simple obesity in children. *Bramat Chem Toksykol* 2015; XLV(3):1087-1091 (in Polish).
15. *Sadowska J., Krzymuska A.*: Evaluation of complementing the nursery school food ration by the parents of preschool children. *Bromat Chem Toksykol* 2010; XLIII(2):203-211(in Polish).
16. *Shefferly A., Scharf R.J., DeBoer M.D.*: Longitudinal evaluation of 100% fruit juice consumption on BMI status in 2–5-year-old children. *Pediatric obesity* 2016;11(3):221-227.
17. *Sotos-Prieto M., Santos-Beneit G., Pocock S., Redondo J., Fuster V., Peñalvo J.L.*: Parental and self-reported dietary and physical activity habits in pre-school children and their socio-economic determinants. *Public Health Nutr* 2015;18(2):275-285. doi: 10.1017/S1368980014000330.
18. *Stankiewicz M., Pęgiel-Kamrat J., Zarzeźna-Baran M., Jankowski M., Łysia-Szydłowska W., Pieszko-Klejnowska M.*: Nutritional habits amongs nursery-school children in parent's opinion. *Probl Hig Epidemiol* 2006; 87(4): 119 (in Polish).
19. *Strabala A., Bawa S., Wojciechowska M., Weker H.*: Energy value of daily diets and macronutrient intake by obese and normal-weight pre-school children. *Bromat Chem Toksykol* 2009;XLII(3):747-753 (in Polish).
20. *Timmons B.W., Naylor P.J., Pfeiffer K.A.*: Physical activity for preschool children-how much and how? *Can J Public Health* 2007;98(2):122-134.

Received: 21.09.2017

Accepted: 19.02.2018

FOOD AVERSIONS AND DIETARY PREFERENCES IN PRE-SCHOOL CHILDREN FROM OLSZTYN

Joanna Ciborska, Jan Kłobukowski, Iwona Pierzchała

University of Warmia and Mazury in Olsztyn, Faculty of Food Science,
Human Nutrition Department, Olsztyn, Poland

ABSTRACT

Background. The nutrition of pre-school children often does not follow the recommendations, and qualitatively and quantitatively limited selection of products in the diet shapes an attitude of aversion towards new products and dishes. The risk of deficiencies in many important nutrients emerges, particularly in vitamins and mineral components, which can affect the psychophysical development of the child and have an impact on nutritional status and health disorders in adulthood.

Objective. Study of dietary preferences in pre-school children and identify possible food aversions.

Material and methods. Nutritional preferences of pre-school children in Olsztyn were examined using a questionnaire prepared in a graphic form, presenting images of 40 food products classified into 5 groups, and the acceptance level and knowledge of the product was established.

Results. The values of *Cole's* index proving the proper nutritional status of pre-school children were obtained for about 87% of the examined group, excessive nutrition was observed in more than 4% of the examined group, about 2% of the group demonstrated obesity and mild malnutrition was observed in about 7% of the examined children. A high acceptance rate of sweets and fast-food products by children was observed. A high degree of preference for milk was recorded, as well as traditional and cognitive aversion for kefir. In the group of fruit and vegetables, both a high degree of preference and aversions to all indicated vegetables and fruit were observed. Taste determined the results, with high acceptance for the sweet taste and rejection or a neutral attitude towards sour and bitter products

Conclusions. Food aversions, by reducing the intake of food products, can result in nutritional deficiencies, affecting the psychosomatic development and cognitive abilities of the child. Traditional and cognitive food aversions was observed towards kefir, cheeses and most of vegetables. A high level of preference was observed in relation towards sweet and fast food products and a low acceptance level for selected vegetables, fruits and dairy products.

Key words: dietary preferences, pre-school children, food aversions

STRESZCZENIE

Wprowadzenie. Żywnienie dzieci przedszkolnych często nie odpowiada zaleceniom, ograniczony ilościowo i jakościowo dobór produktów w diecie kształtuje postawę niechęci wobec nowych produktów i potraw. Pojawia się ryzyko niedoborów wielu ważnych substancji odżywczych, głównie witamin i składników mineralnych, które rzutować mogą na rozwój psychofizyczny dziecka i wpływać na stan odżywienia i zaburzenia zdrowia w dorosłości.

Cel. Badanie preferencji żywieniowych dzieci przedszkolnych i określenie możliwych awersji pokarmowych.

Material i metody. Preferencje żywieniowe dzieci przedszkolnych badano z zastosowaniem kwestionariusza opracowanego w formie graficznej, przedstawiającego obrazy 40. produktów spożywczych podzielonych na 5 grup i określano stopień akceptacji oraz znajomość produktu.

Wyniki. Wartości wskaźnika *Cole'a*, świadczące o prawidłowym stanie odżywienia dzieci przedszkolnych, uzyskano dla blisko 87% badanej grupy, nadmierne odżywienie wykazano u ponad 4% badanych, około 2% grupy charakteryzowała otyłość a u około 7% badanych dzieci zaobserwowano nieznaczne niedożywienie. Zaobserwowano wysoką akceptację słodczy i produktów typu fast-food wśród badanych dzieci. Zanotowano wysoki stopień preferencji dla mleka i awersję tradycyjną i poznawczą do kefiru. W grupie owoców i warzyw zaobserwowano zarówno wysoki stopień preferencji jak i awersje do wszystkich wskazanych warzyw i owoców. O wyniku decydował smak, charakterystyczna była wysoka akceptacja dla smaku słodkiego i odrzucanie lub obojętny stosunek do produktów kwaśnych i gorzkich.

Wnioski. Awersje pokarmowe poprzez ograniczenie spożycia produktów spożywczych mogą skutkować niedoborami pokarmowymi, wpływając na rozwój psychosomatyczny i możliwości poznawcze dziecka. Awersje tradycyjne i poznawcze zaobserwowano względem kefiru, serów oraz większości warzyw. Wysoki poziom preferencji zaobserwowano w relacji do produktów słodkich i żywności typu 'fast-food', a niski poziom akceptacji dla wybranych warzyw, owoców i produktów nabiałowych.

Słowa kluczowe: preferencje żywieniowe, dzieci przedszkolne, awersje pokarmowe

Corresponding author: Joanna Ciborska, University of Warmia and Mazury in Olsztyn, Faculty of Food Science, Human Nutrition Department, 10-957 Olsztyn, Pl. Cieszyński 1, Poland, tel. +48 89 5234994, e-mail: joanna.ciborska@uwm.edu.pl

INTRODUCTION

Human nutrition is an environmental factor which affects the development of health (defined in its somatic, social, psychical and emotional aspects) to a significant degree. Although the importance of developing proper dietary habits is commonly acknowledged, this relation is usually transposed to the food/nutrition – somatic health dependence. Multiple behaviours towards food and nutrition are developed in the emotional sphere, being the result of attitudes, customs and nutritional habits demonstrated by persons in the nearest circle. One of the important objectives in child development is to promote proper dietary habits, which will certainly constitute one of the pillars of health at each subsequent stage of his or her life.

Dietary attitudes and behaviours are clearly dependent on dietary preferences, which have been defined as “general predispositions towards specific food, regardless of the situation in which this food is consumed” [11] and are characterized in terms of food names using the degree of like or dislike, specified as a consumer’s acceptance to a given food sample. Many studies indicate that the diet of children aged 2-7 years quite frequently does not correspond to nutritional recommendations and can be monotonous – children consume the same products, selected from the food pyramid area, developing an attitude of aversion towards new products and dishes [5]. The risk of deficiency of several very important nutrients emerges, mainly as regards vitamins and mineral components which can affect the psychophysical development of the child and subsequently, the health of the adult [9, 10].

MATERIAL AND METHODS

The research was carried out with participation of pre-school, four-, five- and six-year-old children, from randomly selected kindergarten in the area of the city of Olsztyn, in Poland. The children’s parents were invited to take part in the study. The experiment was carried out in June 2011 and a total number of 45 children participated in the study, including 19 four-year-olds, 14 five-year-olds and 12 six-year-old children. The study of potential dietary preferences or aversions was based on two questionnaires [8]:

(1). A questionnaire in a graphic form, addressed to children, presenting images of 40 food products divided into five groups (Table 1): dairy products, vegetables, fruits, sweets, fast food products; the degree of product acceptance was expressed by showing an emoticon defining the acceptance degree and the familiarity with the product (Figure 1);



Figure 1. An emoticon defining the acceptance degree and the familiarity with the product

Table 1. Food products to which food preferences of children were examined

Group	Food products
Sweets	candies, chocolate bar, muesli bar, pastry (cakes, sweet rolls, donuts), ice-creams, jellies, sweet beverages (Fanta, Pepsi, Cola), chewing gum
Dairy products	milk, rennet cheeses, cottage cheeses, yoghurt, kefir;
Vegetables	cucumber, tomato, potato, parsnip, carrot broccoli, cauliflower, lettuce, pepper, radish, onion
Fruits	apple, pear, cherry, plum, grapes, banana, orange, lemon, kiwi;
Fast-food products	hamburger, hot-dog, grilled cheese baguette, chips, pizza, crisps, puff snacks;

(2). A survey questionnaire addressed to parents of the examined pre-school children; the questions concerned the same groups of products about the acceptance of which the children were asked, but the questionnaire made it possible to provide answers in a broader context, by introducing the scale, taking into account the following answers: likes (rank 1), dislikes (rank – 2), neutral (rank - 3), has never eaten (rank 4), does not eat following the doctor’s advice (rank 5).

Data concerning anthropometric parameters of children – their body weight and height – were obtained from the parents of the examined children. This information made it possible to specify selected indicators evaluating the nutritional status of children – the analysis of centile distributions according to WHO and determine *Cole’s* index for the percentage evaluation of BMI (Body Mass Index) in relation to the ideal BMI, corresponding to the 50th centile for the age and sex. *Cole’s* index specified in the 90%-110% range was assumed as the value proving the correct nutritional status [3].

BMI index was calculated according to the formula: $BMI = \text{body mass (kg)} / \text{height}^2 \text{ (m)}$

Formula for calculating *Cole’s* index = $(\text{patient’s BMI} / \text{standard BMI}) \times 100\%$ [3].

Classification of the nutritional status was achieved using *Cole’s* index as a criterion:

- < 75% - severe malnutrition (depletion), 75- 85% - malnutrition, 85-90% - mild malnutrition
- 90-110% - norm, 110 -119% - excessive nutrition, $\geq 120\%$ obesity [3].

Characteristics of the examined group

The research was carried out on a group of 45 children aged 4-6 years. 51% (23 persons) of the examined group were girls, 49% – boys (22 persons) (Table 2).

Table 2. The structure of the examined group

Child's age (years)	Girls		Boys		Total group	
	n	%	n	%	n	%
4	11	58	8	42	19	100
5	6	43	8	57	14	100
6	6	50	6	50	12	100
Total	23	51	22	49	45	100

Based on the data concerning the body weight and height of children (mean values for the examined group are presented in Table 3), BMI was calculated, *Cole's* index was established and nutritional status classification was performed.

Table 3. Body weight and height of the examined children (mean values)

Child's age (years)	Girls				Boys			
	body weight (kg)		body height (m)		body weight (kg)		body height (m)	
	X	SD	X	SD	X	SD	X	SD
4	16.1	1.86	1.0	0.030	16.5	0.61	1.0	0.008
5	17.6	0.81	1.1	0.007	17.5	0.93	1.05	0.009
6	20.0	0.95	1.2	0.004	20.0	1.15	1.1	0.020

RESULTS AND DISCUSSION

The nutritional status of the examined group of children, evaluated on the basis of *Cole's* index, was described as good. For a small percentage of children, overweight or obesity was found (about 4% and about 2%, respectively) and about 7% of children demonstrated mild malnutrition.

A high degree of food preference towards sweets was observed. Within each age group under study, products of this group are liked or very much liked. A high acceptance rate was also noted for fast-food products and the degree of preference towards products or dishes increased with the age of the children participating in the study. A high preference towards milk (accepted by approx. 80% of the group under study) and rennet cheeses as well as towards selected vegetables most typical of Polish cuisine (cucumber, tomato, carrot, and lettuce) was noted. Fruits were defined in the area of high food preferences. The accepted fruits are primarily those included in a child's menu already in the early stages of development as an element of juices, puree juices, snacks or desserts, mainly bananas, apples, pears, grapes and oranges.

Traditional and cognitive aversions were observed within all age groups of the children under study; 4-year olds exhibited aversions towards the greatest number of products. A tendency towards cognitive aversions is triggered by fermented dairy products, mainly kefir. Vegetables are another group of products associated with a wide range of aversions; cognitive and traditional aversions towards cruciferous and root vegetables as well as those with unique taste. Taste was also significant in defining food aversions towards fruits. The fruits most often indicated as not accepted were sour fruits (cherries, lemons, kiwifruits, and plums). Traditional aversions towards fruits being frequently included in children's diets, such as apples and pears, were noted. As regards the group of fast-food products, aversions towards products such as grilled cheese baguette, hot-dogs and hamburger were demonstrated, and for commonly accepted sweets, cognitive and traditional aversions towards chocolate bars and muesli bars were observed. Moreover, traditional aversions towards pastry products, and cognitive aversions towards sweet beverages were noted.

The acceptance of a product or dish and the decision to eat it depends on many factors. Particular importance is given to individual dietary preferences, resulting from previous nutritional experiences, taste preferences as well as from aesthetics, consistency and smell of the given food product [7]. Two types of aversion have been distinguished: traditional and cognitive aversion. Traditional aversion usually emerges as a result of negative experiences with a product or a dish, which can be connected to discomfort from the alimentary tract or a lack of acceptance of the appearance, consistency or smell. Cognitive aversion is a complex process, consisting in disliking and rejecting products and dishes without tasting them.

Sweets

In the group of the examined children, a high acceptance rate was observed for sweets (Table 4). The inclination to consume sweets results both from innate preferences for sweet taste as well as from dietary habits developed in later periods. A similar high position of sweets in the preference ranking was observed by *Kolarzyk et al.* [8], emphasizing that the highest level of acceptance for sweets was observed among underweight children and children with proper body weight, while overweight and obese children ranked sweets in third place in their preferences. In the studies, the highest preference rates were revealed by children in relation to jellies, candies and ice-cream. Five- and six-year-old children demonstrated a high acceptance of pastry and, in relation to this group of products, cognitive aversions were observed in the group of four-year-old children.

It should be noted that there were traditional aversions in the group of four- and six-year-old children for sweet Pepsi-, Fanta- and Cola-type beverages. For this group of products, the highest percentage of the examined children with cognitive aversions were the group of five-year-old children, and such a declaration was confirmed in the interview with parents, who chose the answer “has never eaten, does not know what it tastes like” for products such as: sweet beverages, but also chewing gums and pastry. The awareness of the effect of the glucose-fructose syrup used in the production of sweet beverages on lipid balance disorders, risk of obesity, atherosclerosis and ischemic heart disease, was not the subject of educational activities under the research [1]. Nevertheless, the dietary approaches of parents are satisfactory. The highest intake of candies, chocolate bars, pastry, ice-cream and sweet beverages was observed for children with proper body weight and for underweight children. A relatively low percentage of the examined children demonstrated a neutral attitude towards sweets. In the group of four-year old children, it was about 30% of those surveyed; among five-year-olds it was about 14%, and about 17% in the group of six-year-old children. No impact of the sex of children was observed on their choice and scale of preferences.

Dairy products

Milk is the product preferred by the majority of the examined children (Table 4). Four-year-olds ranked this product high in their preference scale (more than 84% of the group), as well as five-year-olds (100% of the group) and six-year-old children (about 84% of the group). As results from the study conducted by *Kozioł-Kozakowska et al.* [9] with a group of over 300 children aged 2 to 7, milk was consumed every day in the amount of 1-2 glasses a day; it was also observed that dairy products were often chosen for snacking. Other studies [2] also revealed a high consumption and acceptance rate for milk and milk-based products. In the author’s own research, yoghurts were recorded high in the preference

ranking. Aversions were observed towards other dairy products. The strongest traditional and cognitive aversion was observed in relation to kefir. The taste and smell characteristics of kefir were not accepted by 42% of four-year olds, almost 30% of five-year-olds and 25% of six-year-old children, but almost 67% of six-year-old children declared that they had never tried, and did not want to try, and “did not like” the product. An equally clear cognitive aversion towards kefir as well as towards cottage and rennet cheeses was observed in the group of five-year old children. According to the answers provided by the parents of the children, rennet cheeses, cottage cheeses and kefirs were products that children do not like or do not know/have never eaten. The sex of the surveyed children was not a differentiating factor. The research carried out by *Kolarzyk et al.* [8] demonstrated that a low level of dairy acceptance was typical for the groups of children with excessive body and too low body weight, which can indicate an important relation between the supply of milk and its products in a diet and maintaining proper body weight. The answers provided by children were similar to those chosen by their parents. None of the children had to reduce or eliminate dairy products from their diet following medical recommendations.

Vegetables

Multiple studies emphasize that preferences towards substances with sweet taste and aversions towards bitter and sour substances is the effect of adaptation of the human body to living conditions. These preferences start to take shape in the foetal development period and sensitivity to various tastes affects dietary preferences in later periods of life. Additionally, the significance of genetic conditions was emphasized, particularly with regard to sensitivity to the bitter taste, which can significantly affect the degree of acceptance of new tastes in products [9, 12]. The highest degree of acceptance for vegetables was observed in the group of six-year-old children. Dietary preferences start to develop intensively in the pre-school period and the dynamics of those

Table 4. Food preferences and dietary aversions, in relation to sweets and dairy products

Child's age (years)	Food preferences	Dietary aversions	
		traditional	cognitive
Group / food products			
4	<ul style="list-style-type: none"> sweets/jellies, candies, ice-creams dairy products/milk, yoghurt 	<ul style="list-style-type: none"> sweets/ sweet beverages (Fanta, Pepsi, Cola) dairy products /kefir, rennet cheeses 	<ul style="list-style-type: none"> sweets/ chocolate bar, sweet beverages (Fanta, Pepsi, Cola) dairy products /kefir, cottage cheeses
5	<ul style="list-style-type: none"> sweets/jellies, ice-creams, pastry dairy products/milk, yoghurt 	<ul style="list-style-type: none"> sweets/ chocolate bar, sweet beverages (Fanta, Pepsi, Cola) dairy products /kefir, cottage cheeses 	<ul style="list-style-type: none"> sweets/ sweet beverages (Fanta, Pepsi, Cola) chewing gum dairy products /kefir, cottage cheeses, rennet cheeses
6	<ul style="list-style-type: none"> sweets/jellies pastry, sweet beverages (Fanta, Pepsi, Cola) products/milk, yoghurt, rennet cheeses 	<ul style="list-style-type: none"> sweets/ sweet beverages (Fanta, Pepsi, Cola) dairy products /kefir 	<ul style="list-style-type: none"> sweets / muesli bar dairy products /kefir, cottage cheeses

changes was observed in the study. The younger children most often did not know, and had never eaten, broccoli or cauliflower, but the same was true for pepper, onion, parsnip, carrot, lettuce and radish (Table 5). The highest degree of acceptance was observed for such vegetables as cucumber, carrot, tomato, potato and, for a half of the four-year olds, also lettuce and radish. Traditional aversion was recorded with reference to such vegetables as parsnip and cauliflower (over 40% of the examined group) and pepper, onion and radish (37%-42% of the group). In the group of older children, the amount of accepted vegetables increases and, at the same time, aversions of the traditional type are observed with regard to all presented vegetables. Children also demonstrate cognitive aversion, rejecting such vegetables as tomato (about 36% of the five-year old), radish, pepper, onion (about 29% of five-year-old children), parsnip, onion and cauliflower (more than 14% of the examined five-year-olds), although they have never eaten those vegetables. Six-year-old children in the definitely high rate accepted all vegetables demonstrated. Traditional aversions were observed mainly with reference to cauliflower (25-42% of the examined group), while cognitive aversion was also related to the consumption of cauliflower and parsnip. Those products are definitely more often accepted by boys. Openness to taste in children decreases after the twelfth month of life, therefore the possible occurrence of cognitive aversions is typical, particularly for the period between the second and sixth years of life. It might be assumed that introduction of new tastes to the diet by the carers and the creation of new flavour combinations can make it possible to increase the taste preferences of children, which is particularly important for increasing the consumption of vegetables [5, 14]. The degree of product acceptance demonstrated by the children and

the degree of acceptance of those products indicated by parents differed. In the parents' opinion, the diet of their children included a great majority of the vegetables indicated, and those vegetables were accepted by the children, although six-year-olds declared traditional and cognitive aversion and a reduced preference towards the vegetables in question.

Fruits

The dietary patterns in early childhood are related to the introduction of fruits and juices made of easily digestible, non-allergic fruits to the child's diet. This unquestionably affects the dietary preferences of pre-schoolers and is particularly visible in the youngest children. Four-year-old children like fruit, indicating bananas, grapes, pears and apples as particularly liked (Table 5). Other fruits of preference included oranges, kiwis, lemons, cherries and plums, introduced to the child's diet in a later stage. Fruits of this last group are also most often indicated as unknown, not previously consumed. Five- and six-year-old children demonstrate a high and diversified degree of fruit acceptance. In those groups, aversions of the traditional type were observed in relation to almost every fruit indicated, while a determining aspect is generally the taste, the consistence and, sometimes, the smell of the fruit. Cognitive aversions were also recorded; such relations were observed towards seasonal fruits, mainly sour cherries and plums, neutral reactions of children were additionally observed towards well-known and accepted fruits - apples, pears, but also in relation to kiwi and lemons. Declarations of parents and children as regards fruit preferences were similar, with a negative relation demonstrated by children most often towards sour cherries, plums, kiwi as well as apples and pears.

Table 5. Food preferences and dietary aversions to vegetables, fruits and fast-food products

Child's age (years)	Food preferences	Dietary aversions	
		traditional Group / food products	cognitive
4	<ul style="list-style-type: none"> vegetables/cucumber carrot, tomato, potato fruits/ banana, grapes, pear, apple fast- food/chips, pizza 	<ul style="list-style-type: none"> vegetables/ parsnip, cauliflower, pepper, onion, radish fruits/ plum, cherry fast- food/grilled cheese baguette 	<ul style="list-style-type: none"> vegetables/broccoli cauliflower, onion, pepper fruits/ lemon, kiwi, plum, cherry fast- food/hot-dog, grilled cheese baguette, hamburger, crisps
5	<ul style="list-style-type: none"> vegetables / cucumber carrot, potato fruits/ orange, apple fast- food/ chips, crisps 	<ul style="list-style-type: none"> vegetables/parsnip, broccoli fruits/ lemon, plum fast- food/hot-dog, grilled cheese baguette 	<ul style="list-style-type: none"> vegetables / tomato, radish, pepper, onion fruits/ plum, cherry fast -food/ hamburger, grilled cheese baguette, puff snacks
6	<ul style="list-style-type: none"> vegetables/ carrot, pepper, cucumber, tomato, onion fruits/ banana, grapes fast- food/ chips, crisps, pizza 	<ul style="list-style-type: none"> vegetables/ broccoli, cauliflower, parsnip fruits/ lemon, kiwi, plum fast- food/ grilled cheese baguette, hamburger 	<ul style="list-style-type: none"> vegetables/ cauliflower, parsnip fruits/ cherry, plum, lemon fast food/hot-dog, hamburger, grilled cheese baguette

Fast food

Fast food includes food products commonly regarded as unhealthy. Therefore, they should not make up an element of the child's diet and such recommendations in educational programmes are addressed to parents and educators. However, a high preference level was found for this type of food (Table 5). It was observed that each product in this group was liked by more than 50% of the examined sample. If the salty or umami taste, typical for fast-food products, is known, the acceptance of products from this group also increases. The most-liked products included chips and pizza, and the highest dislike was declared by children towards puffy snacks. Among four-year olds, cognitive aversions were recorded towards hot-dogs, grilled cheese baguettes, hamburgers and crisps. Overweight children did not consume (or significantly reduced the intake of) products from this group and sex was not a factor determining the choice of the product. About 7% of the examined five-year olds demonstrated cognitive aversions towards hamburgers, grilled cheese baguettes, pizza and puffy snacks. Six-year-old children definitely showed the highest preference for chips and crisps. This group also included children who have never eaten and do not know the taste of hot-dogs (42% of the group), hamburgers (25%), grilled cheese baguettes (about 17%) and chips (over 8%). A small share (about 8%) of six-year-old children were neutral towards fast-food products. The youngest children had a negative relation most often towards crisps and grilled cheese baguettes, while in the older groups these products most often included puffy snacks and hot-dogs. The point of view of the parents on preferences concerning this product group did not differ from children's declarations. The observed emotional, behavioural or interventional selective consumption of products or dishes, without body weight loss, is generally perceived as a standard behaviour of children, while early detection of problems related to improper dietary habits and preferences can prevent the development of many health disorders in further stages of child development [4, 6, 7, 15].

It was observed that children at pre-school age chose a product they knew when confronted with the group of products differing in taste. Therefore, they often preferred products with a sweet taste, which is known and accepted. In the examined group of pre-school children, fast-food was preferred to a significant degree. The study did not demonstrate any differences in preferences depending on sex. The role of the dietary attitudes of parents and carers must be also emphasized. Introduction of new tastes to the diet by the carers and the creation of new flavour combinations can make it possible to increase the taste

preferences of children. Dietary education of parents, carers and children is a necessary element in building proper attitudes and dietary behaviours, because food aversions can contribute to reduced consumption of food products and result in nutritional deficiencies, having an impact on the psychosomatic development and cognitive abilities of the child.

CONCLUSIONS

1. A high level of preference was observed in relation towards sweet and fast food products and a low acceptance level for selected vegetables, fruits and dairy products.
2. Traditional and cognitive food aversions was observed towards kefir, cheeses and the most of vegetables.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Bray GA.: Fructose and Risk of Cardiometabolic disease. *Curr Atheroscler Rep.* 2012; 14:570-578.
2. Chalcarz W, Merkiel S, Hodyr Z.: Food behaviour in preschool children from Pabianice. *New Medicine* 1/2009; 7-12.
3. Charzewska J, Chabros E, Pachocka L.: Ocena stanu odżywienia (w:) *Praktyczny poradnik dietetyki.* (Red.) Jarosz M., Instytut Żywności i Żywienia, Warszawa, 2010; 117-129.
4. Damsbo-Svendsen M, Frøst MB, Olsen A.: A review of instruments developer to measure food neophobia. *Appetite.* 2017; 113:358-367.
5. De Cosmi V, Scaglioni S, Agostini C.: Early Taste Experience and Late Food Choices. *Nutrients.* 2017; 9,107; doi:10.3390/nu9020107.
6. Equit M, Palmke M, Becker N, Moritz A-M, Becker S, von Gotrad A.: Eating problems in young children- a population-based study. *Acta Peditrica.* 2013;102:149-155.
7. Harris G.: Development of taste and food preferences in children. *Current Opinion in Clinica Nutrition and Metabolic Care.* 2008; 11:315-319.
8. Kolarzyk E, Janik A, Kwiatkowski J.: Zwyczaje żywieniowe dzieci w wieku przedszkolnym. *Probl Hig Epidemiol.* 2008; 89(4): 527-532.
9. Kozioł-Kozakowska A, Piórecka B.: Neofobia żywieniowa i jej uwarunkowania i konsekwencje zdrowotne. *Standardy Medyczne/Pediatrics.* 2013; T.1: 6-6.
10. Orkusz A, Włodarczyk A.: Ocena żywienia dzieci w przedszkolu na podstawie dekadowych jadłospisów. *Nauki Inżynierskie i Technologie.* 2014; 1(12):72-81.
11. Pilska M, Jeżewska-Zychowicz M.: *Psychologia żywienia. Wybrane zagadnienia.* Warszawa: Wydawnictwo SGGW; 2008; 53.

12. *Revedy C, Chesnel F, Schlich P, Köster EP, Lange C.*: Effect of sensory education on willingness to taste novel food in children. *Appetite*. 2008; 51(1):156-165.
13. *Russel CG, Worsley A.*: Why don't like that? And can I do anything about it? The nature and correlates of parents' attributions and self-efficacy beliefs about preschool children's food preferences. *Appetite*. 2013; 66:34-43.
14. *Sochacka-Tatara E, Jacek R, Sowa A, Musiał A.*: Ocena sposobu żywienia dzieci w wieku przedszkolnym. *Probl Hig Epidemiol*. 2008; 89(3): 389-394.
15. *Ventura AK, Worobey J.*: Early Influences on the Development of Food Review Preferences. *Current Biology*. 2013; 23, R401-R408.

Received: 12.10.2017

Accepted: 20.02.2018

ANALYSIS OF THE CHOICE OF FOOD PRODUCTS AND THE ENERGY VALUE OF DIETS OF FEMALE MIDDLE- AND LONG-DISTANCE RUNNERS, DEPENDING ON THE SELF-ASSESSMENT OF THEIR NUTRITIONAL HABITS

Dominika Głabska, Marta Jusińska

Warsaw University of Life Sciences-SGGW, Faculty of Human Nutrition and Consumer Sciences,
Chair of Dietetics, Department of Dietetics, Warsaw, Poland

ABSTRACT

Background. Properly balanced diet is especially important in the case of young athletes, as it influences not only their physical development, but also influences results obtained during trainings and competitions.

Objective. The aim of the study was to assess the choice of food products and the energy value of diets of female middle- and long-distance runners, depending on the self-assessment of their nutritional habits.

Material and methods. The study was conducted in the group of 40 female middle- and long-distance runners, aged 15-25, who declared average diet (n=15, 37.5%) or outstanding diet (n=25, 62.5%). Participants conducted three-day dietary record of the consumed dishes and drunk beverages, that was based on the self-reported data. The choice of products, the energy value of diets as well as macronutrients intake were compared depending on the self-assessment of the nutritional habits.

Results. Runners declaring outstanding diet were characterized by significantly lower intake of dairy beverages, than runners declaring average diet (p=0.0459), but simultaneously, by higher intake of mushrooms (p=0.0453). No difference of energy value of diets was stated between groups of runners depending on the self-assessment of their nutritional habits. Runners declaring outstanding diet were characterized by significantly lower intake of lactose, than runners declaring average diet (p=0.0119), but simultaneously, by higher intake of cholesterol (p=0.0307).

Conclusions. The female middle- and long-distance runners analysed in the presented study do not assess the quality of their diet reliably, so they probably do not have the sufficient nutritional knowledge. There is a need to implement nutritional education among professional runners and their coaches, in order to improve the quality of diet of professional runners and, as a results maybe also to improve their sport results.

Key words: *female runners, young women, diet, energy value, choice of food products*

STRESZCZENIE

Wprowadzenie. Prawidłowo zbilansowana dieta jest szczególnie istotna w przypadku młodych sportowców, jako że wpływa nie tylko na ich rozwój fizyczny, ale także na ich wyniki osiągnięte na treningach, czy zawodach.

Cel. Celem badań była analiza wyboru produktów spożywczych oraz wartości energetycznej diety młodych biegaczek średnio- i długodystansowych, w zależności od ich samooceny sposobu żywienia.

Material i metody. Badanie przeprowadzono w grupie 40 biegaczek średnio- i długodystansowych, w wieku 15-25 lat, które deklarowały przeciętny sposób żywienia (n=15, 37,5%) lub dobry sposób żywienia (n=25, 62,5%). Uczestniczki wykonały 3-dniowe bieżące notowanie spożycia. Dobór produktów, wartość energetyczna diety oraz spożycie makroskładników zostały porównane w grupach zależnych od samooceny sposobu żywienia.

Wyniki. Biegaczki deklaruujące dobry sposób żywienia charakteryzowały się istotnie niższym spożyciem napojów mlecznych, niż te deklaruujące przeciętny sposób żywienia (p=0,0459), ale równocześnie charakteryzowały się wyższym spożyciem grzybów (p=0,0453). Między porównywanymi grupami zależnymi od samooceny sposobu żywienia nie obserwowano różnic wartości energetycznej diety. Biegaczki deklaruujące dobry sposób żywienia charakteryzowały się istotnie niższym spożyciem laktozy, niż te deklaruujące przeciętny sposób żywienia (p=0,0119), ale równocześnie charakteryzowały się wyższym spożyciem cholesterolu (p=0,0307).

Wnioski. Biegaczki średnio- i długo-dystansowe z analizowanej grupy nie oceniają jakości swojej diety w sposób rzetelny, co sugeruje, że prawdopodobnie nie mają one dostatecznej wiedzy żywieniowej. Istnieje zatem potrzeba edukacji żywieniowej wśród profesjonalnych biegaczy i ich trenerów, która miałaby na celu poprawę jakości diet tych biegaczy, co w konsekwencji może także wpłynąć na poprawę ich wyników sportowych.

Słowa kluczowe: *biegaczki, młode kobiety, dieta, spożycie, wartość energetyczna, wybór produktów spożywczych*

Corresponding author: Dominika Głabska, Chair of Dietetics, Department of Dietetics, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences-SGGW, Nowoursynowska Street 159c, 02-776 Warsaw, Poland, phone: +48 22 5937126, fax: +48 22 5937018, e-mail: dominika_glabska@sggw.pl

INTRODUCTION

Properly balanced diet is especially important in the case of young athletes [27]. It influences not only their physical development, but also results obtained during trainings and competitions [33]. It is indicated, that the choice of products consumed in specific meals may be crucial, as meals being high in fat may cause the delay of gastric emptying and, as a result may contribute to worse sport performance [11]. Moreover, in the case of the morning trainings, it is necessary to plan the early-morning snack before it and a regular breakfast after – in order to provide sufficient energy and carbohydrates intake [21].

In the case of male athletes no risk of insufficient intake is commonly stated [10], but in the case of women, the intake is often too low [18]. It is associated with higher intake in the case of male, than in the case of female, that results *inter alia* from decreased consumption due to desire to lose weight, that is common in the case of female athletes [17]. It is observed even in the case of teen athletes, as dietary restrictions are more common in the case of girl athletes, than boy athletes [7], while girl athletes are characterized by worse nutritional habits than boys [31] and they are indicated as a risk group of eating disorders development [28].

On the one hand, low intake observed in the female athletes is associated with common under-reporting [6]. However, on the other hand, even if energy value of diet is on the recommended level, the diet is often not properly balanced and the intake of micronutrients is too low [8, 15]. Common supplements applying causes, that the symptoms of deficiencies are not observed [3], but in Poland supplements are applied mainly by male athletes [14]. However, the excessive use of supplements is other problem in the nutrition of athletes, as they apply supplements without consultation with a sport nutrition specialist and without understanding the possible risk of too high intake of nutrients [22].

Taking into account the insufficient nutritional knowledge, the need of education is commonly emphasized [26], as it may allow to obtain the positive dietary changes [1]. However, unless the athletes are aware of the need for the diet improvement, as they perceive their nutritional habits as satisfying, the education may not be sufficient.

The aim of the study was to assess the choice of food products and the energy value of diets of female middle- and long-distance runners, depending on the self-assessment of their nutritional habits.

MATERIAL AND METHODS

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and it was approved by the Bioethical Commission of the National Food and Nutrition Institute in Warsaw (No. 0701/2015).

The invitation to participate in the study, as well as information about inclusion criteria were distributed among young female middle- and long-distance runners, practicing in 20 Polish sport running clubs. The middle- and long-distance runners were not divided into two groups, due to the fact, that because of the characteristics of the training, female athletes in Poland participate both in middle- and long-distance running competitions.

Inclusion criteria were: women, taking part in the national middle- and long-distance running competitions, not being pregnant and during lactation, without any chronic diseases diagnosed, written informed consent to participate. The number of 40 individuals, aged 15-25 years, that were meeting the inclusion criteria, volunteered to participate in the study.

Participants were asked to fill out the questionnaire, answering questions associated with *inter alia* their training and self-assessment of their nutritional habits. They were able to indicate, that their diet is: extremely outstanding (very good nutritional habits), outstanding (good nutritional habits), average (neither good nor bad nutritional habits), unsatisfactory (bad nutritional habits), extremely unsatisfactory (very bad nutritional habits). In the analysed group of 40 athletes, 15 (37.5%) declared average diet and 25 (62.5%) declared outstanding diet. The declared self-assessment of their nutritional habits was the basis of the further analysis.

Participants conducted three-day dietary record of the consumed dishes and drunk beverages, that was based on the self-reported data. The record was to be conducted, using a structured format, during three typical random not following days (2 weekdays and 1 weekend day). To provide reliable estimates of food intake, the additional questions about name of the meal, time and location of consumption, meal ingredients and weight of serving (while weighted using kitchen scale) or size of serving (while estimated using standard household measures) was placed in the structured format, as is commonly applied [25]. Participants were instructed on the principles of conducting the dietary record, as well as on the necessity of accurate and scrupulous recording of all food products consumed and beverages drunk. Afterwards, the serving sizes were verified by a dietitian using the Polish food model booklet [32].

The typical daily energy and nutritional value of diets were assessed using the Polish dietician software “Dietetyk 2” (National Food and Nutrition Institute, 2001) and the Polish base of the nutritional value of the products [20]. The typical daily intake of food products were calculated, while the following groups were taken into account: dairy products (dairy beverages, cottage cheese, rennet cheese), eggs, meat and meat products, fish products, fats (butter, cream, oils, margarine), plant products (vegetables, legumes, fruits, potatoes), bread and other cereals, sugar, jam and honey, beverages (tea, coffee, alcoholic beverages, sweetened beverages), nuts

and seeds, mushrooms, sweets (chocolate sweets, cakes and cookies).

The obtained data are presented as means \pm standard deviations (SD) with minimum, maximum and median values. The normality of distribution was verified using the *Shapiro-Wilk* test. To compare the intake between groups declaring various self-assessment of their nutritional habits, the *t-Student* test (for parametric distribution) and *U Mann-Whitney* test (for non-parametric distribution) were applied. The level of significance $p \leq 0.05$ was accepted, while the level of significance $p \leq 0.1$ was indicated as close to statistical significance. The statistical analysis was carried out using the Statistica software version 8.0 (StatSoft Inc).

RESULTS

The body mass of the recruited female individuals was 53.54 ± 5.90 kg (34-67 kg) and their Body Mass Index (BMI) was 19.44 ± 1.33 kg/m² (16.55-21.67 kg/m²), while 25% of individuals was characterized by BMI lower than 18.5 kg/m², and BMI was higher than 25 kg/m² for none of the recruited female middle- and long-distance runner.

Runner declared, that they have trainings 5-7 times a week, while 10% declared 5 times a week, 40% – 6 times a week, and 50% – 7 times a week. The typical training duration in the analysed group was 2 hours. The recruited female middle- and long-distance runners practiced running for 3-12 years, while mean duration of practicing running was 5.78 ± 2.31 years.

The daily intakes of products in diets of female runners characterized by various self-assessment of their nutritional habits are presented in Table 1. The comparison of choices of products revealed, that runners declaring outstanding diet were characterized by significantly lower intake of dairy beverages, than runners declaring average diet ($p=0.0459$), but simultaneously, by higher intake of mushrooms ($p=0.0453$).

The intakes of products in diets of female runners characterized by various self-assessment of their nutritional habits, recalculated per 1000 kcal of diet, are presented in Table 2. The comparison of choices of products revealed, similarly as for daily intakes, higher intake of mushrooms ($p=0.0454$) in diets of runners declaring outstanding diet, than for runners declaring average diet. However, the previously observed difference of dairy beverages intake was only close to statistical significance ($p=0.0645$).

The energy values of diets and macronutrients daily intakes in diets of female runners characterized by various self-assessment of their nutritional habits are presented in Table 3. No difference of energy value of diets was observed. The comparison of daily intake revealed, that runners declaring outstanding diet were characterized by significantly lower intake of lactose, than runners

declaring average diet ($p=0.0119$), but simultaneously, by higher intake of cholesterol ($p=0.0307$).

The macronutrients intakes in diets of female runners characterized by various self-assessment of their nutritional habits, recalculated per 1000 kcal of diet, are presented in Table 4. The comparison of daily intake revealed, similarly as for daily intakes, lower intake of lactose ($p=0.0204$) in diets of runners declaring outstanding diet, than for runners declaring average diet. However, the previously observed difference of cholesterol intake was only close to statistical significance ($p=0.0883$).

DISCUSSION

The lack of nutritional knowledge is commonly indicated for athletes. However, especially important is the fact, that insufficient nutritional knowledge may be accompanied by insufficient nutritional intake. In the systematic review of *Heaney et al.* [16], it was indicated, that there may be a positive correlation between nutritional knowledge and dietary intake, but due to the lack of valid instruments to assess the knowledge, it is hard to conclude.

In this own study, the nutritional knowledge was not assessed directly, but the fact that respondents were asked to conduct self-assessment of their diet, allows to interpret if their nutritional knowledge is sufficient, or not. It must be supposed, that individuals declaring good nutritional habits are characterized by better nutritional value of diet, than others, and only in such situation it may be interpreted, that their nutritional knowledge is sufficient and self-assessment of dietary habits is reliable. It results from the fact, that in general, the association between nutritional knowledge, dietary habits and self-assessment of them is expected [19].

The association was observed in the study of *Hoogenboom et al.* [18] in the group of female collegiate swimmers, that in the simple true/ false test of nutritional knowledge scored 72%, while simultaneously majority of analysed group (96%) did not meet the recommended intake of macronutrients. It should be indicated, that while the simple true/ false test is applied, the assessed knowledge may be overestimated, due to the possibility of guessing among two potentially correct answers, so the conclusion, that swimmers did not know 28% of important nutritional information [18] may had been underestimated. Similarly, in the Polish study conducted in a group of teen athletes, it was observed, that a number of respondents was characterized by low level of nutritional knowledge, while the simple true/ false test was applied to assess, and low level of nutritional knowledge was related to the improper nutritional behaviors [13].

Table 1. Comparison of the choice of products in diets of female runners characterized by various self-assessment of their nutritional habits – the daily intakes presented for groups [g]

	Runners declaring average diet; n=15		Runners declaring outstanding diet; n=25		p-value**
	Mean±SD	Median (min.- max.)	Mean±SD	Median (min.- max.)	
Dairy beverages	270.0±93.1	250.0 (100.0-450.0)	192.0±127.0	200.0 (0.0-450.0)	0.0459
Cottage cheese	29.3±33.3	30.0* (0.0-100.0)	33.0±34.2	30.0* (0.0-100.0)	0.7915
Rennet cheese	15.3±15.2	15.0* (0.0-45.0)	15.6±12.4	20.0* (0.0-35.0)	0.9313
Eggs	16.1±22.0	0.0* (0.0-60.0)	24.8±25.8	20.0* (0.0-80.0)	0.1863
Meat	86.7±45.5	90.0 (0.0-160.0)	105.8±35.0	110.0 (40.0-180.0)	0.1431
Meat products	29.0±17.9	30.0 (0.0-60.0)	31.2±13.0	30.0* (15.0-60.0)	0.7326
Fish products	22.7±32.2	0.0* (0.0-90.0)	19.8±26.0	0.0* (0.0-80.0)	0.9876
Butter	2.5±4.5	0.0* (0.0-15.0)	4.2±5.6	0.0* (0.0-15.0)	0.4790
Cream	7.0±12.9	0.0* (0.0-45.0)	7.0±9.0	0.0* (0.0-25.0)	0.5910
Vegetables	247.3±86.7	260.0 (100.0-400.0)	229.4±75.4	220.0 (90.0-380.0)	0.4955
Legumes	10.7±23.7	0.0* (0.0-80.0)	12.2±16.8	0.0* (0.0-50.0)	0.3218
Fruits	305.0±135.1	265.0 (80.0-550.0)	286.0±80.0	295.0 (60.0-410.0)	0.5784
Potatoes	36.7±59.8	0.0* (0.0-150.0)	47.2±53.0	40.0* (0.0-190.0)	0.2754
Bread	108.0±64.3	100.0 (0.0-200.0)	117.4±50.7	120.0 (0.0-210.0)	0.6110
Other cereals	144.7±67.8	150.0 (40.0-250.0)	120.6±55.6	110.0* (40.0-210.0)	0.3070
Oils	5.5±5.0	5.0 (0.0-15.0)	6.6±4.4	6.0* (0.0-20.0)	0.4892
Margarine	2.3±3.5	0.0* (0.0-10.0)	2.2±3.6	0.0* (0.0-10.0)	0.9063
Sugar	3.7±5.8	0.0* (0.0-15.0)	5.1±6.0	5.0* (0.0-20.0)	0.3893
Jam and honey	11.0±15.3	0.0* (0.0-45.0)	12.4±11.3	10.0* (0.0-40.0)	0.3590
Tea	466.7±230.4	300.0* (200.0-750.0)	442.0±280.9	500.0* (0.0-750.0)	0.7210
Coffee	146.7±179.7	100.0* (0.0-500.0)	162.0±170.9	200.0* (0.0-500.0)	0.8252
Alcoholic beverages	0.0±0.0	0.0* (0.0-0.0)	16.6±46.9	0.0* (0.0-165.0)	0.1784
Sweetened beverages	186.7±184.6	150.0* (0.0-500.0)	182.0±199.9	200.0* (0.0-500.0)	0.9069
Nuts and seeds	10.7±14.4	0.0* (0.0-40.0)	7.0±8.8	7.0* (0.0-30.0)	0.9522
Mushrooms	0.0	0.0* (0.0-0.0)	6.0±9.4	0.0* (0.0-25.0)	0.0453
Chocolate sweets	24.0±29.4	0.0* (0.0-100.0)	25.6±17.9	30.0 (0.0-55.0)	0.4265
Cakes and cookies	43.0±41.0	50.0* (0.0-100.0)	38.8±33.8	35.0* (0.0-115.0)	0.7975

* - non-parametric distribution (verified using *Shapiro-Wilk* test; $p \leq 0.05$)

** - compared using *t-Student* test (parametric distribution) or *U Mann-Whitney* test (non-parametric distribution)

In the study of *Frederick & Hawkins* [12] conducted in groups of women characterized by various physical activity level – college-aged dancers, members of a college track team, nonathletic college women and postmenopausal women, it was stated, that the number of servings of high-calcium food products consumed was significantly correlated with nutritional knowledge level, as well as with attitude scores. However, in the same study it was indicated, that nutritional knowledge level and attitude scores were not correlated [12]. It may explain the fact, that in some studies the nutritional knowledge and nutritional intake are not associated, as it may result from the influence of attitude on the nutritional intake, that in some groups may be stronger, than the influence of nutritional knowledge.

In the presented own study, the nutritional knowledge of middle- and long-distance female runners must be assessed as insufficient. The self-assessed level of their nutritional habits was not reliable, as both choice of

products in diets and nutritional value of diets were similar in the sub-groups of runners declaring outstanding diet and declaring average diet. Taking it into account, it must be concluded, that either runners declaring outstanding diet overestimated their nutritional habits, or runners declaring average diet underestimated their nutritional habits.

Among the studies indicating, that the risk of diet-related deficits may be independent from the nutritional knowledge, there is a study conducted in the group of young female athletes, assessed as susceptible and not susceptible to the Female Athlete Triad Syndrome (disordered eating, amenorrhea and osteoporosis combined observed in young female athletes due to dietary restrictions), in which the similar level of nutritional knowledge was observed [29]. The presented results indicate, that the nutritional education would be not enough to reduce the risk of Female Athlete Triad Syndrome, as the risk of the syndrome is independent from the nutritional knowledge. The results of own study indicate also, that declared nutritional knowledge or

Table 2. Comparison of the choice of products in diets of female runners characterized by various self-assessment of their nutritional habits, while recalculated per 1000 kcal of diet – the intakes per 1000 kcal presented for groups [g/ 1000 kcal]

	Runners declaring average diet; n=15		Runners declaring outstanding diet; n=25		p-value**
	Mean±SD	Median (min.-max.)	Mean±SD	Median (min.-max.)	
Dairy beverages	142.9±65.3	127.2 (44.7-298.3)	101.2±67.8	91.5 (0.0-229.8)	0.0645
Cottage cheese	15.4±17.9	14.9* (0.0-56.9)	17.5±18.2	16.2* (90.0-53.3)	0.7807
Rennet cheese	8.2±8.7	6.0* (0.0-25.0)	8.1±6.5	10.7* (0.0-18.5)	0.8416
Eggs	7.2±11.0	0.0* (0.0-35.5)	13.0±13.1	11.2* (0.0-42.7)	0.1553
Meat	45.8±29.8	40.2 (0.0-119.3)	55.3±19.1	59.3 (16.1-96.0)	0.2273
Meat products	14.6±8.7	13.2 (0.0-32.4)	16.6±8.3	13.7* (8.1-42.2)	0.7568
Fish products	11.2±16.2	0.0* (0.0-44.6)	10.5±14.4	0.0* (0.0-56.3)	0.9012
Butter	1.3±2.3	0.0* (0.0-6.6)	2.2±2.9	0.0* (0.0-7.9)	0.4999
Cream	3.8±7.2	0.0* (0.0-25.6)	3.5±4.6	0.0* (0.0-13.4)	0.6587
Vegetables	126.3±45.5	133.6 (43.6-240.5)	119.4±38.4	112.0 (41.3-193.3)	0.6102
Legumes	4.74±10.51	0.0* (0.0-35.2)	6.5±9.2	0.0* (0.0-28.1)	0.3828
Fruits	156.5±71.8	156.9 (44.4-285.9)	148.2±40.2	147.0 (32.1-210.4)	0.6394
Potatoes	19.6±31.9	0.0* (0.0-85.4)	24.2±27.8	20.2* (0.0-101.4)	0.3244
Bread	58.7±40.5	59.2 (0.0-134.2)	59.8±24.8	57.8 (0.0-101.5)	0.9119
Other cereals	78.1±42.2	87.1 (15.9-143.3)	64.3±33.3	55.5 (20.4-147.7)	0.2592
Oils	2.8±3.0	2.1* (0.0-11.2)	3.6±2.8	3.2* (0.0-14.1)	0.3538
Margarine	1.3±1.9	0.0* (0.0-5.1)	1.1±1.9	0.0* (0.0-5.4)	0.8667
Sugar	2.1±3.6	0.0* (0.0-11.2)	2.7±3.2	2.3* (0.0-10.5)	0.4264
Jam and honey	5.6±7.7	0.0* (0.0-23.1)	6.5±6.1	5.0* (0.0-21.1)	0.4240
Tea	241.9±123.2	214.6 (79.6-435.7)	229.6±149.4	255.2 (0.0-450.9)	0.7896
Coffee	76.1±91.8	59.2* (0.0-277.3)	81.3±86.6	96.4* (0.0-262.6)	0.7807
Alcoholic beverages	0.0±0.0	0.0* (0.0-0.0)	8.2±23.2	0.0* (0.0-84.2)	0.1784
Sweetened beverages	95.3±89.9	84.8* (0.0-269.7)	98.5±111.7	96.4* (0.0-292.4)	0.9768
Nuts and seeds	6.0±8.0	0.0* (0.0-19.8)	3.6±4.7	3.4* (0.0-17.2)	0.9168
Mushrooms	0.0±0.0	0.0* (0.0-0.0)	2.1±4.2	0.0* (0.0-13.5)	0.0454
Chocolate sweets	11.3±13.1	11.0* (0.0-39.8)	13.6±9.7	14.1 (0.0-29.2)	0.3013
Cakes and cookies	24.3±24.9	22.0* (0.0-67.1)	19.9±17.0	18.5* (0.0-61.4)	0.7330

*- non-parametric distribution (verified using *Shapiro-Wilk* test; $p \leq 0.05$)

** - compared using *t-Student* test (parametric distribution) or *U Mann-Whitney* test (non-parametric distribution)

nutritional habits of female athletes must be also verified, in order to assess the level properly.

As the frequency of Female Athlete Triad Syndrome and of elements of Female Athlete Triad Syndrome, among female athletes, is high [24], the possibility to overcome the trend of high frequency would be of a great value. However, it must be indicated that the main reason of the syndrome is the excessive dieting [30]. It may be associated with disordered eating and, while contributes to low body mass, it may cause also oligomenorrhea or amenorrhea and low bone mineral density, as other elements of Female Athlete Triad Syndrome [2].

In the analysed group of young female runners, the body mass of majority of analysed group was proper, as only 25% of individuals was characterized by BMI lower than 18.5 kg/ m². However, in the case of athletes that have planned intensive trainings (2 hours each day and even 7 times a week), a high share of muscle mass may

be observed and fat mass share may be low. As a result, a proper body mass of majority of analysed women does not eliminate the risk of Female Athlete Triad Syndrome.

As in the presented study, the diet of young female middle- and long-distance runners was analysed, it also must be assessed taking into account the risk of development of Female Athlete Triad Syndrome. The energy value of diet did not differ between groups of runners declaring outstanding diet and declaring average diet (while it was analysed both in kcal and kcal per kg of body mass), so it may be indicated, that in the groups compared in own study, level of satisfying energy needs was similar, while similar level of under-reporting in groups was assumed. The similar level of protein, fat and carbohydrates in diet was also observed, as it also did not differ between groups declaring outstanding diet and declaring average diet (while it was analysed both in g and g per kg of body mass).

Table 3. Comparison of the energy value and macronutrients intakes in diets of female runners characterized by various self-assessment of their nutritional habits – the daily intakes presented for groups

	Runners declaring average diet; n=15		Runners declaring outstanding diet; n=25		p-value**
	Mean±SD	Median (min.- max.)	Mean±SD	Median (min.- max.)	
Energy value [kcal]	1986.2±333.6	1945.8 (1340.8-2510.9)	1934.3±224.4	1896.1 (1421.9-2490.6)	0.5590
Energy value [kcal/ kg of body mass]	37.63±4.56	38.45 (30.05-44.07)	35.66±4.67	35.79 (25.17-47.81)	0.2009
Total protein [g]	82.4±14.6	85.4 (58.6-111.2)	84.1±14.8	83.5 (51.8-122.7)	0.7236
Total protein [g/ kg of body mass]	1.58±0.29	1.64 (0.98-1.99)	1.56±0.35	1.47 (0.88-2.48)	0.8832
Animal protein [g]	51.6±13.8	52.0 (29.2-83.0)	52.6±14.2	50.5 (24.5-84.3)	0.8377
Plant protein [g]	31.0±4.9	31.1 (22.1-40.2)	30.9±6.1	30.0 (21.0-48.5)	0.9354
Energy from protein [%]	16.5±2.8	16.2 (12.8-22.6)	17.7±5.1	16.5* (12.0-37.3)	0.5025
Total fat [g]	66.8±17.8	63.1 (44.1-94.6)	70.2±14.2	70.1 (39.5-92.7)	0.5114
Total fat [g/ kg of body mass]	1.26±0.29	1.21 (0.79-1.66)	1.29±0.25	1.26 (0.81-1.74)	0.7859
Saturated fatty acids [g]	26.8±9.2	24.6* (14.5-38.1)	25.2±7.4	25.6 (10.4-36.8)	0.5668
Monounsaturated fatty acids [g]	26.7±6.7	25.6 (17.5-36.1)	25.9±6.1	24.5 (14.5-39.4)	0.7026
Polyunsaturated fatty acids [g]	12.1±4.0	12.0 (7.1-21.8)	13.8±7.5	12.0* (5.0-43.7)	0.5388
Cholesterol [mg]	226.6±65.5	248.6 (103.4-328.9)	322.6±157.1	276.9 (105.0-666.3)	0.0307
Energy from fat [%]	29.3±3.7	29.1 (22.9-34.5)	31.1±5.7	32.3 (18.7-40.9)	0.2661
Total carbohydrates [g]	287.9±53.4	304.5 (171.4-370.3)	269.5±50.8	259.7 (138.3-363.6)	0.2841
Total carbohydrates [g/ kg of body mass]	5.43±0.68	5.44 (4.23-6.61)	4.97±0.97	4.92 (2.45-6.99)	0.1131
Sucrose [g]	58.6±20.9	60.9 (12.5-85.5)	51.0±16.2	49.0 (21.2-88.8)	0.2032
Lactose [g]	19.6±7.8	17.0* (11.5-34.3)	13.5±6.5	12.7 (3.4-30.3)	0.0119
Starch [g]	137.9±31.6	138.7 (83.3-191.9)	133.5±34.5	129.1 (76.7-211.8)	0.6890
Fiber [g]	27.0±6.3	26.9 (12.8-39.3)	26.0±4.2	25.7 (17.8-36.1)	0.5235
Energy from carbohydrates [%]	54.2±4.4	53.2 (48.3-63.5)	51.1±5.8	51.4 (40.7-63.6)	0.0923

*- non-parametric distribution (verified using *Shapiro-Wilk* test; $p \leq 0.05$)

** - compared using *t-Student* test (parametric distribution) or *U Mann-Whitney* test (non-parametric distribution)

However, among observed differences between groups, the differences of dairy beverages intake and of lactose intake must be indicated. Difference of lactose intake must be interpreted as a consequence of the difference of dairy beverages intake, but except from dairy beverages intake and lower lactose intake in the group declaring outstanding diet, the calcium deficiency risk may be also supposed.

The typical intake of dairy beverages in a group of runners declaring outstanding diet was 192±127 g and it varied from 0 g to 450 g. At the same time, in a group of runners declaring average diet, it was 270±92 g and it varied from 100 g to 450 g. It may be stated, that not only lower general dairy beverages intake was stated in a group of runners declaring outstanding diet, but also, some of them did not consume dairy beverages at all.

The intake observed in the assessed group may be compared with the recommendations for athletes practicing at least 5 hours a week, as in the assessed group of female middle- and long-distance runners such per week duration of trainings was observed. The Swiss Food Pyramid for Athletes [5] indicates, that in the case of such training duration, the basic pyramid provides enough calcium and protein, so the additional servings of milk and dairy products are not needed. However, the recommended intake according to the

basic pyramid – Food Pyramid of the Swiss Society for Nutrition [34] is significantly higher, than observed in the assessed group. According to the Food Pyramid of the Swiss Society for Nutrition, 1 serving of meat, fish, eggs, cheese or other source of protein should be consumed each day and in addition, 3 servings of milk or dairy products should be consumed each day, while 1 serving counterparts 200 g of milk. In such situation, the daily intake of dairy product should at least counterpart 600 g of milk. At the same time, in the assessed group, the daily intake of both cottage cheese (median of 30 g in both groups) and rennet cheese (median of 15 g in runners declaring average diet and 20 g in runners declaring outstanding diet) was also too low to contribute to the sufficient intake of dairy products.

The main observed differences between compared groups were associated with intake of dairy beverages and cholesterol, as the intake of mushrooms is the minor issue. In the case of cholesterol, important is the fact, that the higher intake was observed in the group of runners declaring outstanding diet (323±157 mg), than in a group of runners declaring average diet (227±65 mg), while it is well known, that cholesterol intake is perceived as a factor, that may contribute to cardiovascular diseases risk [4].

Table 4. Comparison of the macronutrients intakes in diets of female runners characterized by various self-assessment of their nutritional habits, while recalculated per 1000 kcal of diet – the intakes per 1000 kcal presented for groups

	Runners declaring average diet; n=15		Runners declaring outstanding diet; n=25		p-value**
	Mean±SD	Median (min.- max.)	Mean±SD	Median (min.- max.)	
Total protein [g/1000 kcal]	41.9±6.9	40.3 (31.6-56.3)	43.9±8.6	41.7 (29.6-62.5)	0.4591
Animal protein [g/1000 kcal]	26.2±6.5	25.2 (15.0-39.8)	27.4±7.5	25.5 (14.0-40.1)	0.6157
Plant protein [g/1000 kcal]	15.9±3.0	15.1 (12.3-23.6)	16.0±3.2	15.6* (12.0-25.9)	0.9221
Total fat [g/1000 kcal]	33.2±4.2	33.4 (25.8-38.9)	36.5±7.9	36.6 (21.1-60.5)	0.1144
Saturated fatty acids [g/1000 kcal]	13.5±4.1	12.2 (8.4-22.3)	13.0±3.6	13.7 (5.6-19.7)	0.7354
Monounsaturated fatty acids [g/1000 kcal]	13.5±2.7	13.0 (9.8-20.3)	13.4±3.0	12.6 (7.6-21.0)	0.9882
Polyunsaturated fatty acids [g/1000 kcal]	6.1±1.5	5.8 (3.9-9.3)	7.4±5.4	5.8* (2.9-30.7)	0.6957
Cholesterol [mg/ 1000 kcal]	114.1±27.5	117.8 (53.1-147.3)	170.5±90.5	143.3* (55.1-400.6)	0.0883
Total carbohydrates [g/1000 kcal]	144.8±13.1	140.1 (127.9-166.9)	138.7±17.5	138.6 (97.3-181.7)	0.2688
Sucrose [g/1000 kcal]	29.1±9.6	30.6 (9.3-47.4)	26.4±8.3	25.5 (14.9-49.1)	0.3531
Lactose [g/ 1000 kcal]	10.0±4.2	9.2* (5.5-19.2)	7.2±3.8	6.7* (1.6-17.2)	0.0204
Starch [g/1000 kcal]	69.8±13.6	69.2 (47.4-95.1)	68.8±15.3	67.9 (42.3-107.2)	0.8553
Fiber [g/ 1000 kcal]	13.6±2.7	13.1 (9.6-19.1)	13.5±2.4	13.3 (9.4-18.1)	0.9110

*- non-parametric distribution (verified using *Shapiro-Wilk* test; $p \leq 0.05$)

** - compared using *t-Student* test (parametric distribution) or *U Mann-Whitney* test (non-parametric distribution)

As a result, it may be indicated, that group of runners declaring outstanding diet was actually characterized by not better, but worse diet, than runners declaring average diet, so the issue of worse diet accompanied by higher assessment of own diet must be emphasized. The result observed for dairy beverages are in contradiction to the previously mentioned results of the study of *Frederick & Hawkins* [12] observed for high-calcium food products, as in the compared studies the higher intake of similar groups of products was associated either with higher or with lower nutritional knowledge level.

However, the issue of the self-assessment of nutritional knowledge appears, as the assessed runners may had overestimated their actual level of knowledge. Moreover, the lower dairy beverages intake in the case of individuals assessing their own diet as outstanding may be associated with common misunderstanding of the lactose-intolerance issue and false perceiving lactose as a harmful factor, that is indicated for ages in Western countries [23]. Both indicated above potential reasons of the observed situation, emphasize the need for the nutritional education in the group of professional runners and their coaches.

Moreover, it must be indicated, that in the study of *Czaja et al.* [9], while the nutritional habits of Polish middle- and long-distance runners were analysed over ten years ago, the similar observations were indicated, as it was stated, that a diet of runners was not properly balanced and not properly planned for athletes. In the indicated study it was also concluded, that properly planned education is essential [9], but now, it must be emphasized, that ten years after, the observations are similar.

CONCLUSIONS

1. The female middle- and long-distance runners analysed in the presented study do not assess the quality of their diet reliably, so they probably do not have the sufficient nutritional knowledge.
2. There is a need to implement nutritional education among professional runners and their coaches, in order to improve the quality of diet of professional runners and, as a results maybe also to improve their sport results.

Conflict of interest

The authors declare not conflict of interest.

REFERENCES

1. *Abood D.A., Black D.R., Birnbaum R.D.*: Nutrition education intervention for college female athletes. *J Nutr Educ Behav.* 2004;36(3):135-137.
2. *Barrack M.T., Ackerman K.E., Gibbs J.C.*: Update on the female athlete triad. *Curr Rev Musculoskelet Med.* 2013;6(2):195-204. doi: 10.1007/s12178-013-9168-9.
3. *Beals K.A., Manore M.M.*: Nutritional status of female athletes with subclinical eating disorders. *J Am Diet Assoc.* 1998;98(4):419-425.
4. *Berger S., Raman G., Vishwanathan R., Jacques P.F., Johnson E.J.*: Dietary cholesterol and cardiovascular disease: a systematic review and meta-analysis. *Am J Clin Nutr.* 2015;102(2):276-294. doi: 10.3945/ajcn.114.100305.
5. *Burke L.M.*: A Food Pyramid for Swiss Athletes. *Int J Sport Nutr Exerc Metab.* 2008;18:430-437.
6. *Caccialanza R., Cameletti B., Cavallaro G.*: Nutritional intake of young Italian high-level soccer players: Under-reporting is the essential outcome. *J Sports Sci Med.* 2007;6(4):538-542.
7. *Chalcarz W., Radzimirska-Graczyk M.*: Jakościowy sposób żywienia dzieci i młodzieży uprawiających szermierkę. Cz. II. Przerwy między posiłkami, charakterystyka dojadania [Nutritional habits in children and adolescents practicing fencing. Part II. Characteristics of eating between meals]. *Rocz Panstw Zakl Hig* 2010;61(1):71-74 (in Polish).
8. *Clark M., Reed D.B., Crouse S.F., Armstrong R.B.*: Pre- and post-season dietary intake, body composition, and performance indices of NCAA division I female soccer players. *Int J Sport Nutr Exerc Metab.* 2003;13(3):303-319.
9. *Czaja J., Lebedzińska A., Szefer P.*: Sposób żywienia i suplementacji diety reprezentantów Polski w biegach średnio- i długodystansowych w latach 2004-2005 [Eating habits and diet supplementation of Polish middle- and long-distance representative runners in years 2004-2005]. *Rocz Panstw Zakl Hig.* 2008;59(1):67-74 (in Polish).
10. *Daneshvar P., Hariri M., Ghiasvand R., Askari G., Darvishi L., Iraj B., Mashhadi N.S.*: Dietary behaviors and nutritional assessment of young male Isfahani wrestlers. *Int J Prev Med.* 2013;4(Suppl 1):S48-S52.
11. Dietitians of Canada, the American Dietetic Association, and the American College of Sports Medicine Joint position statement: Nutrition and athletic performance. *Can J Diet Pract Res.* 2000;61(14):176-192.
12. *Frederick L., Hawkins S.T.*: A comparison of nutrition knowledge and attitudes, dietary practices, and bone densities of postmenopausal women, female college athletes, and nonathletic college women. *J Am Diet Assoc.* 1992;92(3):299-305.
13. *Gacek M.*: Wiedza i zachowania żywieniowe młodzieży uprawiającej sport w Szkole Mistrzostwa Sportowego w Krakowie [Knowledge and nutritional behaviours among the youth practising sports at School of Sports Championship in Cracov]. *Rocz Panstw Zakl Hig.* 2007;58(4):641-648 (in Polish).
14. *Gacek M.*: Zwyczaje żywieniowe grupy osób wyczynowo uprawiających siatkówkę [Eating habits of a group of professional volleyball players]. *Rocz Panstw Zakl Hig.* 2011;62(1):77-82 (in Polish).
15. *Garrido G., Webster A.L., Chamorro M.*: Nutritional adequacy of different menu settings in elite Spanish adolescent soccer players. *Int J Sport Nutr Exerc Metab.* 2007;17(5):421-432.
16. *Heaney S., O'Connor H., Michael S., Gifford J., Naughton G.*: Nutrition knowledge in athletes: a systematic review. *Int J Sport Nutr Exerc Metab.* 2011;21(3):248-261.
17. *Hinton P.S., Sanford T.C., Davidson M.M., Yakushko O.F., Beck N.C.*: Nutrient intakes and dietary behaviors of male and female collegiate athletes. *Int J Sport Nutr Exerc Metab.* 2004;14(4):389-405.
18. *Hoogenboom B.J., Morris J., Morris C., Schaefer K.*: Nutritional knowledge and eating behaviors of female, collegiate swimmers. *N Am J Sports Phys Ther.* 2009;4(3):139-148.
19. *Jezewska-Zychowicz M., Guzek D.*: Associations between adult perception of body weight, diet, preparing meals and dietary patterns. *Rocz Panstw Zakl Hig.* 2017;68(4):381-387.
20. *Kunachowicz H., Nadolna J., Przygoda B., Iwanow K.*: Tabele składu i wartości odżywczej żywności [Food composition tables]. Warsaw, PZWL, 2005 (in Polish).
21. *Litt A.*: Fuel for young athletes: Essential foods and fluids for future champions. Windsor, Human Kinetics; 2004.
22. *Maughan R.J., Depiesse F., Geyer H.*: The use of dietary supplements by athletes. *J Sports Sci.* 2007;25(Suppl.1):S103-S113.
23. *McBean L.D., Miller G.D.*: Allaying fears and fallacies about lactose intolerance. *J Am Diet Assoc.* 1998;98(6):671-676.
24. *Nazem T.G., Ackerman K.E.*: The Female Athlete Triad. *Sports Health.* 2012;4(4):302-311. doi: 10.1177/1941738112439685.
25. *Ortega R.M., Pérez-Rodrigo C., López-Sobaler A.M.*: Dietary assessment methods: Dietary records. *Nutr Hosp.* 2015;31:38-45.
26. *Pilis K., Michalski C., Zych M., Pilis A., Jelonek J., Kaczmarzyk A., Pilis W.*: A nutritional evaluation of dietary behaviour in various professional sports. *Rocz Panstw Zakl Hig.* 2014;65(3):227-234.
27. *Purcell L.K.* Sport nutrition for young athletes. *Paediatr Child Health.* 2013;18(4):200-202.
28. *Radzimirska-Graczyk M., Chalcarz W.*: Jakościowy sposób żywienia dzieci i młodzieży uprawiających szermierkę. Część I. spożywanie posiłków [Nutritional habits in children and adolescents practicing fencing. Part 1. Meal consumption]. *Rocz Panstw Zakl Hig* 2009;60(4):385-388 (in Polish).
29. *Raymond-Barker P., Petroczi A., Quested E.*: Assessment of nutritional knowledge in female athletes susceptible to the Female Athlete Triad syndrome. *J Occup Med Toxicol.* 2007;2:10. doi: 10.1186/1745-6673-2-10.
30. *Sundgot-Borgen J., Torstveit M.K.*: Aspects of disordered eating continuum in elite high-intensity sports. *Scand J Med Sci Sports.* 2010;20(Suppl.2):112-121. doi: 10.1111/j.1600-0838.2010.01190.x.

31. *Szeja N., Szczepańska E., Janion K., Szymkiewicz A., Lenard B., Dudzik I., Koldon A.*: Selected eating behaviours of girls and boys attending sport-oriented classes. *Rocz Panstw Zakl Hig* 2017;68(1):83-90.
32. *Szponar L., Wolnicka K., Rychlik E.*: Album fotografii produktów i potraw [Album of photographs of food products and dishes], Warsaw, Institute of Food and Nutrition, 2000 (in Polish).
33. *Volek J.S., Forsythe C.E., Kraemer W.J.*: Nutritional aspects of women strength athletes. *Br J Sports Med.* 2006;40(9):742-748.
34. *Walter P., Infanger E., Mühlemann P.*: Food pyramid of the Swiss Society for Nutrition. *Ann Nutr Metab.* 2007;51(suppl 2):15-20. doi: 10.1159/000103562.

Received: 10.10.2017

Accepted: 13.02.2018

ANALYSIS OF NUTRITION AND NUTRITIONAL STATUS OF HAEMODIALYSIS PATIENTS

Anna Bogacka, Anna Sobczak-Czynsz, Elżbieta Kucharska, Małgorzata Madaj, Katarzyna Stucka

West Pomeranian University of Technology in Szczecin, Faculty of Food Sciences and Fisheries Department of the Fundamentals of Human Nutrition, Szczecin, Poland

ABSTRACT

Background. Chronic kidney disease (CKD) is a common disease of civilization where nutrition is part of the treatment. Diet therapy is difficult as it is necessary to control the intake of: energy, protein and minerals – Na, K, Ca and P in the daily food rations (DFR).

Objective. The aim of the study was to assess the nutritional status and diets of haemodialysis (HD) patients.

Material and methods. The study involved 141 haemodialysis patients, at the average age of 65.9. The patients were divided into groups taking into consideration their sex and diagnosis for diabetes. The information on the diets were collected using a 7-day dietary recall. In the DFRs the amount of energy and 22 nutrients were calculated. Obtained results were compared with requirements for HD patients.

Results. Appropriate nutritional status (measured with BMI) was reported for majority of women (70.6%) and almost half of men, however, excessive weight was recognized in every third female patient and more than half male patients, and type I obesity was noted in 7.8% of men. The analysis of the results showed that diets of all examined patients were deficient in energy and protein (except women with diabetes), whereas the consumption of fat was appropriate in both groups of women. The recommendations with respect to the amount of cholesterol were met but dietary fibre was too low. Intake of vitamins B₁, D, C, folates and Ca and Mg was lower and intake of vitamin B₁₂ was higher than recommended.

Conclusions. Assessment of the coverage of the demand on nutrients in HD patients should not be based on the analysis of their nutritional status (BMI) only but also on the analysis of diets, especially in case of diabetes.

Key words: *chronic kidney disease, haemodialysis, nutrition, nutritional status*

STRESZCZENIE

Wprowadzenie. Przewlekła niewydolność nerek jest częstą chorobą cywilizacyjną, w której żywienie jest składową procesa leczenia. Dietoterapia jest trudna, ze względu na konieczność kontrolowania energii i spożycia białka oraz składników mineralnych (Na, K, Ca and P) w całodziennych racjach pokarmowych (CRP)

Cel badań. Celem badań była ocena stanu odżywienia i sposobu żywienia hemodializowanych (HD) pacjentów.

Material i metody. W badaniach wzięło udział 141 hemodializowanych pacjentów w wieku średnio 65,9 lat, których podzielono na grupy uwzględniając płeć i obecność cukrzycy. Dane na temat sposobu żywienia zebrano metodą bieżącego notowania z 7 dni. W całodzienniej racji pokarmowej wyliczono zawartość energii oraz 22 składników diety. Uzyskane wartości porównano z normami dla HD pacjentów.

Wyniki. Prawidłowe BMI stwierdzono u większości kobiet (70,6%) i niespełna połowy mężczyzn, natomiast u co trzeciej pacjentki i ponad połowy pacjentów rozpoznano nadwagę oraz otyłość I stopnia u 7,8% mężczyzn. Analiza wyników wykazała, że sposób żywienia wszystkich badanych był nieodpowiedni pod względem ilości energii, białka w dietach (wyjątek kobiety z cukrzycą), natomiast spożycie tłuszczu było prawidłowe w obu grupach kobiet. Spełniono zalecenia odnośnie ilości cholesterolu, natomiast błonnika w dietach było za mało. U wszystkich badanych wykazano niższą od zaleceń podaż witamin: B₁, D, C, folianów oraz Ca i Mg; nadmierną witaminę B₁₂.

Wnioski. W ocenie pokrycia zapotrzebowania na składniki diety u HD osób należałoby badać nie tylko stan odżywienia, lecz również sposób żywienia, szczególnie w przebiegu cukrzycy.

Słowa kluczowe: *przewlekła niewydolność nerek, hemodializa, żywienie, stan odżywienia*

Corresponding author: Anna Bogacka, Department of Fundamentals of Human Nutrition, Faculty of Food Sciences and Fisheries, West Pomeranian University of Technology in Szczecin, Papieża Pawła VI 3, 71-459 Szczecin, tel. +48 914496519, fax. +48 914496516, e-mail: anna.bogacka@zut.edu.pl

INTRODUCTION

In recent years, in Poland and throughout the world, an increased incidence of chronic kidney disease (CKD) caused by diabetes and hypertension has been observed. The number of people requiring renal replacement therapy is growing. According to the data from the reports of voivodeship nephrology consultants in Poland at the end of 2012, there were 18626 dialysed people (haemodialysis and peritoneal dialysis) and at the end of 2013 – 19420 people. These data indicate the increase by 794 patients [49].

The data of the International Diabetes Federation (IDF) published on 14th of November 2013 showed that 382 million people in the world suffer from diabetes. The prevalence of diabetes is constantly rising. IDF estimates that by 2035 the number of people with diabetes will rise to 592 million [15]. In many countries, including Poland, diabetes is the cause of serious complications leading to disability. Due to kidney failure in the course of diabetes more than 3.5 thousand patients are permanently included in the programs of persistent dialysis treatment. Half of those patients suffer from coronary artery disease and 2/3 of deaths of diabetics are caused by cardio-vascular complications [18].

In the last decade, many research studies have reported the existence of the relationship between protein-energy malnutrition and the increase of morbidity and mortality in the group of dialysed patients [41, 44]. Disorders accompanying uremic toxemia may, along with progressing impairment of kidneys function, affect nutritional status of the patients. In advanced kidney failure there are tendencies for negative nitrogen balance and loss of muscle mass, which in consequence can lead to cachexia.

The aetiology of malnutrition in chronic kidney failure is complex. Bad nutritional status can be attributed to diet restrictions in pre-dialysis period, appetite loss and increased catabolism in dialysis period [31]. Not adhering to dietetic recommendations contributes to low consumption of nutrients, including vitamins, bioelements and energy. Diet intended for dialysis patients is often unaccepted due to its limitations. Moreover, social factors affect the development of malnutrition in this group of patients. The necessity of dialyses forces the patients to resign from work. In consequence, financial restrictions affect the choice of a diet. Reduced absorption of food in patients is observed during the days when dialyses are performed. The patients miss healthy and nutritious meal due to the visit in hospital for dialysis.

Appropriate nutrition is crucial for the health and is important part of the treatment in chronic kidney disease, which causes many metabolic disturbances. One of the qualities of a proper diet is to maintain optimal body weight.

Nutritional mistakes made by dialysis patients may contribute to deterioration of the health. Education and monitoring of the diets and nutritional status of the patients might help to point out the irregularities and enable to correct them, and thus would contribute to improvement in health and quality of life during the treatment.

The goal of this study was to assess the nutritional status and analyse daily food rations of haemodialysis patients.

MATERIAL AND METHODS

The study involved 141 haemodialysis patients treated in several dialysis stations of West Pomeranian Voivodeship. The patients were divided into groups taking into consideration their sex and diagnosis for diabetes: I group – 36 W (66.5 ± 12.1 years old), II group – 15 W with diabetes (69 ± 9.6 years old), III group – 61 M (60.2 ± 10.7 years old), IV group – 29 M with diabetes (68.0 ± 10.2 years old).

The patients were haemodialyzed regularly for at least 3 months (3-18 months). The average time of dialysis treatment was 13 months. All the patients were dialyzed for 3-5 hours three times a week using Fresenius dialysis machine (Homburg, Germany) with polysulfone-based dialysers.

The nutritional status was determined for all the patients based on the body mass index (BMI). It was calculated considering dry body weight (after dialysis). BMI results were interpreted using WHO classification. The range 18.5-24.9 was considered as proper [47].

The assessment of the content of energy and nutrients in daily food rations (DFR) was based on weekly menus noted on ongoing basis by the patients on the days with and without dialysis on an especially prepared questionnaire. 987 menus were analysed using Aliant software (Anmarsoft) based on “Tables of components and nutritional value of food products” [29]. The results were compared with current standards for HD patients considering the recommendations for a diet for diabetics [13, 19]. The size of food ratio was determined using “Photo album of products and dishes” [43]. Diet supplements were not considered in nutritional assessment.

Normality of the analysed variables were tested with the *Kolmogorov-Smirnov Chi-squared* tests at the level of $p < 0.05$. Since the distributions varied from normality, to compare the values of analysed parameters within the given sex between the subgroups with and without diabetes, a nonparametric *Mann-Whitney U* test was used. The level of statistical significance was $p < 0.05$. The analyses were performed using Statistica 12 (StatSoft Inc.).

RESULTS AND DISCUSSION

Malnutrition is the most common nutritional disorder during dialysis therapy. Table 1 presents the

percentage of examined patients fitting into selected ranges of BMI, an index assessing the nutritional status of patients from particular groups.

Table 1. Percentage of patients with proper and improper body mass index (BMI)

BMI [kg/m ²]	Women (n=51)		Men (n=90)	
	No diabetes	With diabetes	No diabetes	With diabetes
< 18.5	0	0	0	0
18.5 – 24.99	49	21.6	22.2	18.9
25 – 29.99	21.6	7.8	45.6	5.5
30 – 34.99	0	0	0	7.8

In the group of examined patients, 70.6% of women had proper body weight (without diabetes n=25 and with diabetes n=11), as well as 41.1% of men (without diabetes n=20 and with diabetes n=17). Excessive body weight was noted in 29.4% of women (without diabetes n=11 and with diabetes n=4) and type I obesity was observed only in case of 7 men with diabetes.

Other authors in their studies observed initial BMI between 20 and 25 kg/m² in majority of the patients [32, 37], and also below 20 kg/m² in case of some of them [30, 39]. The review of the literature presented the results of studies indicating systematic body weight loss in chronically haemodialysis patients [40]. Numerous reports confirm that BMI below 25 kg/m² is a risk factor of increased mortality in this group of patients [12, 14, 20]. Moreover, Park et al. showed increased survival of dialysis patients with excessive weight (BMI 25-30) or obese (BMI>30) [33].

Appropriate amount of energy in a diet should be provided to maintain desirable body mass of the patients and to limit the process of gluconeogenesis and prevent protein catabolism. Adequate intake of protein is crucial to keep proper nutritional status. Moreover, meals should be small in volume and quantity and they should be consumed at regular intervals during the day. As shown by Cotton, too high one-time supply of protein in case of patients with CKD may lead to accumulation of ammonia in blood (hyperammonaemia) [8].

In this study, the average intake of energy, basic nutrients and vitamins and minerals was compared between the patients with CKD and diabetes and those with CKD without diabetes (Tables 2-5).

An insufficient supply of calories and protein was determined in DFRs of most of the patients participating in this study. The average energy load of DFR in both groups of women was lower than recommended, despite excessive body weight, and it was, on average: 1436.1 ± 434.2 kcal/day in group of women without diabetes (75.4% of the norm) and 1533.5 ± 515.5 kcal/day in group of women with diabetes (89.0% of the norm). The average energy load in DFR in male group was also lower than recommended and amounted to 1461.7

± 512.5 kcal/day in the group of men without diabetes and 1660.5 ± 61.8 kcal/day in the group of men with diabetes. The supply of energy differed significantly between male groups. In this work the energy from glucose contained in dialysis fluid was not considered, but it can amount to 30% of energetic demand.

Proper consumption of protein was only observed in female group with diabetes. The demand for protein in this group was realized in 95.2%, whereas in the group of women without diabetes - in 77.8%. The highest intake of protein was noted in the group of men with diabetes (62.5 ± 24.2 g/day) and it was significantly higher than in the group of men without diabetes (53.9 ± 21.3 g/day).

The prevalence of protein-energy deficiencies in diets of dialysis patients was confirmed in many Polish [22, 28, 46] and foreign studies [1, 7, 16]. However, *Chazot et al.*, based on 5-year observations of the diets of HD patients aged above 60 reported that the intake of energy and protein was at recommended level [6]. The results of another research performed in 2017 did not confirm the results of *Chazot et al.* It was shown that the consumption of energy and protein by HD patients was lower than recommended [20].

The average consumption of fat in DFRs of examined female patients (both groups) was in accordance with the recommendations and amounted to 69.7 ± 11.0 g/day in group of women without diabetes (105.6% of the norm) and 60.9 ± 25.6 g/day in group of women with diabetes (101.5% of the norm). The average content of fat in men's diets was similar to that of women's, however, due to higher demand, the requirement was not sufficiently met (in 69.9% and 89.5%). Moreover, the differences in fat intake in men's diets were statistically significant. High consumption of this component in haemodialysis patients was noted in studies by *Arslan et al.* [2] and *Kardasz and Ostrowska* [22]. High-fat diet containing saturated fatty acids is one of the causes of atherosclerotic changes in vessels, including those in kidneys, which in turn increase the risk of MIA (malnutrition-inflammation-atherosclerosis) syndrome.

The average content of cholesterol in patients' diets was in accordance with the recommendations (<300 mg/day). The consumption for this component in women's diets was at a similar level (242.6 ± 82.3 mg without diabetes and 234.0 ± 131.4 mg with diabetes), whereas in group of men without diabetes (185.6 ± 171.5) mg the intake was significantly lower than in group of men with diabetes (266.3 ± 170.6 mg). Among examined patients there were people who exceeded upper limit of recommended intake. These were 4 women without diabetes (11.1%), 4 women with diabetes (26.7%), 10 men without diabetes (16.4%) and 6 men with diabetes (20.7%). In those patients, high consumption of cholesterol might have contributed to high level of LDL in blood, which could affect the development of cardiovascular diseases [2].

Table 2. Energetic value and content of basic nutrients in DFRs of haemodialysis patients

Component	Indexes	Women		Men	
		No diabetes	With diabetes	No diabetes	With diabetes
Energy [kcal/day]	average \pm SD	1436.1 \pm 434.2	1533.5 \pm 515.5	1461.7 \pm 512.5*	1660.5 \pm 61.8*
	min. - max.	242.6 – 2410.0	437.3 – 3075.6	598.7 – 3149.5	217.8 – 4161.7
	% of norm	75.4	89.0	55.0	72.0
Protein [g/day]	average \pm SD	50.2 \pm 16.2	55.5 \pm 21.2	53.9 \pm 21.3*	62.5 \pm 24.2*
	min. - max.	10.2 – 100.6	12 – 118.7	20.2 – 136.1	3.6 – 169.7
	% of norm	77.8	95.2	59.9	80
Fat [g/day]	average \pm SD	69.7 \pm 11.0*	60.9 \pm 25.6*	60.1 \pm 27.2*	68.0 \pm 34.7*
	min. - max.	45.9 – 97.5	8.6 – 155.1	12.5 – 159.6	1.8 – 207.3
	% of norm	105.6	101.5	69.9	89.5
Carbohydrates [g/day]	average \pm SD	298.7 \pm 104.5*	208.1 \pm 78.5*	213.7 \pm 86.0	218.1 \pm 86.2
	min. - max.	53.8 – 530.7	69.9 – 460.4	59.8 – 503.1	54.3 – 497.5
	% of norm	100.6	70.1	68.9	70.4
Cholesterol [mg/day]	average \pm SD	242.6 \pm 82.3	234.0 \pm 131.4	185.6 \pm 171.5*	266.3 \pm 170.6*
	min. - max.	132.1 – 438.8	28.1 – 957.1	0 – 972.7	0 – 867.1
Fibre [g/day]	average \pm SD	12.8 \pm 4.7*	18.2 \pm 6.3*	13.0 \pm 5.1*	19.6 \pm 6.6*
	min. - max.	3.2 – 24.6	5.5 – 37.9	4.7 – 30.8	9.1 – 40.5
	% of norm	42.7	60.7	43.3	65.3

*significance of differences $p < 0,05$

Recommended intake of carbohydrates is no lower than 130 g. Such amount ensures proper function of central nervous system and erythrocytes. In this study, a proper intake of carbohydrates was observed in both groups of women and men (at the average level of 253.4 g in women and 215.9 g in men). The average content of carbohydrates in diets of women with and without diabetes differed significantly. Among the examined patients there were 35 people (9W without diabetes, 3W with diabetes, 15M without diabetes, 8M with diabetes) who consumed less than 130 g of carbohydrates. Insufficient consumption of total carbohydrates in chronic dialysis patients was also reported by other authors [22, 36]. In case of insufficient amount of carbohydrates in a diet the metabolism of fats is incomplete. It promotes the accumulation of ketones and, in consequence, the development of metabolic acidosis. Acidosis increases anorexia, reduces the synthesis of albumins, increases the release of cortisol and enhances protein catabolism, thus intensifying malnutrition and muscle mass loss [27, 48].

Analysis of the menus showed low consumption of dietary fibre in all groups of examined patients, regardless of their sex. Significantly lower intake of dietary fibre was noted in groups of patients without diabetes (on average 12.9 ± 4.9 g/day) in comparison to patients with diabetes (on average 18.9 ± 6.5 g/day). These results are similar to that of others [22, 37].

Insufficient consumption of the majority of main nutrients resulted in the fact that the structure of energy from macronutrients in examined diets was inappropriate (Table 3). There was too little share of energy coming from carbohydrates and proteins and the average percentage of energy from fats exceeded recommendations. The results were confirmed by other authors [22, 32, 36]. Other results were obtained by dos Santos et al., who observed proper intake of energy from carbohydrates and fats [11].

Table 3. The structure of consumed energy in examined groups of patients

Source of energy	Women		Men	
	No diabetes	With diabetes	No diabetes	With diabetes
protein	14	14.5	14.8	15.1
fat	43.7*	35.7*	37	36.9
carbohydrates	42.3*	49.8*	48.2	48

*significance of differences with $p < 0.05$

In patients' DFRs the contents of almost all analysed mineral compounds were low, except sodium in group of men without diabetes, potassium, iron and copper in dialysis patients with diabetes, and zinc in women with diabetes (Table 4).

Table 4. Average content of selected mineral elements in DFRs of haemodialysis patients

Element	indexes	Women		Men	
		No diabetes	With diabetes	No diabetes	With diabetes
Sodium [mg/day]	average \pm SD	1605.7 \pm 609.2*	1445.7 \pm 694.6*	1978.4 \pm 866.6*	1643.9 \pm 943.1*
	min. - max.	172.6 - 3755.2	333.5 - 4168.7	407.9 - 4949.6	180.0 - 5977.6
	% of norm	74.7	67.2	92.0	76.5
Potassium [mg/day]	average \pm SD	1734.2 \pm 755.8*	2578.9 \pm 940.9*	1690.1 \pm 671.9*	2661.6 \pm 900.1*
	min. - max.	428.1 - 5082.1	592.3 - 4821.5	587.6 - 4016.9	946.6 - 6274.3
	% of norm	77.1	114.6	75.1	118.3
Phosphorus [mg/day]	average \pm SD	771.1 \pm 265.4*	884.2 \pm 318.7*	787.9 \pm 321.0*	960.7 \pm 359.4*
	min. - max.	158 - 1409.8	223.1 - 2091.1	262.9 - 1859.1	109.8 - 2026.8
	% of norm	64.3	73.7	65.7	80.0
Calcium [mg/day]	average \pm SD	373.8 \pm 199.6	431.2 \pm 308.4	214.8 \pm 221.3*	394.6 \pm 257.8*
	min. - max.	40.9 - 1268.1	59.3 - 2243.5	41.2 - 1357.1	95.4 - 1503.7
	% of norm	29.9	34.5	17.2	31.6
Iron [mg/day]	average \pm SD	6.6 \pm 2.5*	8.8 \pm 3.5*	7.3 \pm 3.1*	9.1 \pm 3.8*
	min. - max.	1.6 - 13.2	3.3 - 22.9	2.8 - 19.7	2.3 - 32.2
	% of norm	66.0	88.0	73.0	91.0
Magnesium [mg/day]	average \pm SD	176.6 \pm 77.7*	217.9 \pm 76*	172.3 \pm 78.8*	215.8 \pm 82.3*
	min. - max.	30.8 - 444.9	67.9 - 436	54.2 - 463.4	61.2 - 523.9
	% of norm	55.2	68.1	41	51.4
Zinc [mg/day]	average \pm SD	6.1 \pm 2.2*	7.3 \pm 2.7*	6.8 \pm 2.4*	8.2 \pm 3.0*
	min. - max.	1.4 - 12.5	2.3 - 16.2	2.9 - 14.2	1.3 - 20.2
	% of norm	76.3	91.3	61.8	74.5
Copper [mg/day]	average \pm SD	0.7 \pm 0.3*	0.9 \pm 0.3*	0.7 \pm 0.3*	1.0 \pm 0.3*
	min. - max.	0.1 - 1.7	0.3 - 1.7	0.2 - 1.5	0.4 - 2.1
	% of norm	77.8	100.0	77.8	111.1

*significance of differences with $p < 0.05$

The intake of sodium in group of men without diabetes fully covered daily demand. The realization of the norm at the average level of 72.8% in other groups may be regarded as sufficient. Statistical analysis showed significantly lower sodium content in diets of people with diabetes in comparison to diets of people without diabetes. Healthy kidneys participate in water-electrolyte balance regulation. In chronic kidney disease the excretion of sodium is disrupted, thus is it necessary to limit its intake with the diet. Moreover, excessive amount of sodium can strengthen already existing sodium-related hypertension and contribute to formation of oedema due to accumulation of water in tissues. In this study, in the DFRs an appropriate or lower than recommended amount of sodium was noted, although potential additional salting of meals was not considered. There are various data reported in the literature. The intake of sodium exceeding recommended amounts was observed by Jin Woo and *Nam-Ho* [20]. On the other hand, diets analysed by *Bataille* et al. and *Bossola* et al. contained lower than recommended amounts of this element [3, 5].

Taking into consideration the necessity for haemodialysis patients to limit potassium, the

consumption at the level of 1700 mg/day by patients without diabetes can be regarded as proper. The amount of this element was significantly lower in diets of examined patients without diabetes than in those of patients with diabetes. The average consumption of potassium in DFR of patients with diabetes was higher than recommended and amounted to 2578.9 \pm 940.9 mg/day in group of women and 2661.6 \pm 900.1 mg/day in group of men. Haemodialysis patients have a tendency for hyperkalaemia, which is one of the most important issues. Reduction in the consumption of potassium is usually achieved by limiting or excluding fruits and vegetables from DFR. It is suggested to reduce the consumption of one large portion per day to two portions of cooked fruits without juice or two small portions of vegetables and salads [35]. Other authors recommend decreasing the intake of potassium by entire elimination of fruits and vegetables from daily menus [34]. Own studies showed that patients without diabetes usually completely resigned from these groups of products in diet, thus the intake of potassium was 1700 mg/day. Such radical limitations may contribute to deficiencies in vitamins, minerals and bioflavonoids, so they are not a good solution.

The results of the study indicate low content of calcium in the diets. The amount of calcium in DFRs of women was on average 402.5 mg, and in case of men – 304.7 mg, versus the recommended 1000 – 1500 mg/day. The lowest intake was noted in group of men without diabetes (214.8 mg) and it was significantly lower than the amount of this element in diets of men with diabetes (394.6 mg). Similar low intake of calcium was reported by *Bossola et al.* [5] and *Sanlier and Demircioglu* [37]. Higher consumption of this bioelement than in this study was observed by *Jin Woo and Nam-Ho* [20]. Those levels, however, did not exceed recommended daily intake. That was probably caused by reduced consumption of protein with the diet (hence its small intake). Similar relations were observed by other authors [5, 7, 37].

The consumption of phosphorus was lower than suggested by diet recommendations for haemodialysis patients and was, on average, 827.7 mg in female group and 874.3 mg in male group. There were significant differences in phosphorus intake between the patients with and without diabetes. Results obtained by other authors vary. Appropriate or only slightly higher than recommended intake of phosphorus in patients' diets was observed by *Kardasz et al.* [24], whereas *Cupisti et al.* [9] reported its low intake. Hyperphosphatemia is a challenge for the professionals taking care of a patient due to its role in pathogenesis of hyperparathyroidism and calcification. The most common cause is excessive intake of potassium, which is mainly supplied by products rich in protein. However, reduction of protein intake as a method to decrease hyperphosphatemia cannot be recommended for most patients, due to the necessity of replenishing the losses of amino acids and proteins during dialysis. Because phosphorus is ubiquitous in food and diet restrictions are of little effect, there are medications used to bind phosphates in alimentary tract. Moreover, it was shown that hyperphosphatemia decreases with age. It is explained on one hand by worse nutritional status of the patient and on the other hand by more systematic intake of medications binding phosphates in alimentary tract [34].

Despite intensive research on the mechanisms of phosphates absorption from digestive tract and on searching for new drugs, the basic measure against hyperphosphatemia is still to follow diet recommendations. Disrupted balance between parathormone and the levels of calcium, phosphorus and vitamin D is the main cause of vascular calcification and higher risk of death. It should be stressed that avoiding foods containing very large amounts of phosphorus, such as dairy foods, some drinks, meat products, peanuts and products containing baking powder, is still an important therapeutic method for haemodialysis patients [38].

The content of magnesium in food ratios of patients was low and did not exceed 62% of recommended amount in female groups and 60% in male groups. It was shown that the average magnesium intake with

diets in patients without diabetes was significantly lower than in case of patients with diabetes, regardless of sex. The main source of magnesium in average food ratio of Poles are grain products, milk and milk products and potatoes. Patients with chronic kidney disease often resigned from these diet components due to the presence of phosphorus and potassium. Studies on nutrition among healthy people report that the intake of magnesium is much lower than recommended. In this study, in DFRs of HD patients an insufficient content of magnesium was also observed. Similar low intake of this element was noted by other authors [9, 37].

Zinc plays a key role in maintaining proper nutritional status in dialysis patients. Deficiency of zinc in blood may be displayed by the loss of appetite, taste disturbances, growth inhibition or slower wound healing. *Kardasz et al.* observed lower concentration of zinc in blood plasma of dialysis patients than in healthy people. They attributed it to low intake of the bioelement with the diet and increasing renal failure [24]. In this study, too small amount of Zn in DFRs of almost all groups of patients was also observed, except women with diabetes. The average consumption of zinc by dialysis patients without diabetes was significantly lower than by patients with diabetes. Daily average intake of this element in men was 7.5 ± 2.7 mg and in women – 6.7 ± 2.5 mg. Comparable too low intake of zinc was reported by other authors [5, 37, 45].

Copper is a component of many enzymes. Appropriate level of this bioelement in a body is maintained through adequate absorption from alimentary tract and its amount contained in food ratio. Copper with zinc are components of superoxide dismutase, which has antioxidative activity. Both elements thus indirectly participate in sweeping free radicals away. Their insufficient intake with a diet can be the cause of reduced activity of SOD. In this study the consumption of copper in haemodialysis patients with diabetes was assessed as proper, but in case of patients without diabetes it was significantly lower (80% of the norm). Similar results were obtained by *Cupisti et al.* [9], whereas in the study of *Szpanowska-Wohn et al.* the consumption of copper was particularly low – not reaching 40% of recommended value [42].

Similar to the works of other authors, here it was shown that the consumption of iron in DFR was low [5, 24, 26]. Proper intake of this element was noted in group of men with diabetes (91% of the norm). Diets of patients with diabetes contained significantly more iron than diets of patients without diabetes. Too low amount of iron in diets of haemodialysis patients with additional insufficient intake of folic acid and vitamin B₁₂ may be one of the cause of anaemia in this group of patients. People treated with dialysis lose iron due to bleeding from the digestive tract, giving blood samples for frequent blood tests or due to haemodialysis itself. Iron losses are estimated to ca. 3 g per year [21].

Table 5. Average content of vitamins in DFRs of examined haemodialysis patients

Component	indexes	Women		Men	
		No diabetes	With diabetes	No diabetes	With diabetes
vitamin A [µg/day]	average ± SD	665.4 ± 686.8	960.8 ± 1503.8	633.5 ± 852.9*	870.4 ± 735.2*
	min. - max.	57.3 - 5853.5	146.2 - 11908.8	46.7 - 8235.5	36.4 - 3978.8
	% of norm	95.1	137.3	70.4	96.7
vitamin D [µg/day]	average ± SD	2.8 ± 2.1*	2.0 ± 2.0*	3.2 ± 2.1*	3.5 ± 5.4*
	min. - max.	0.8 - 18.7	0.1 - 14.3	0.2 - 18.4	0 - 46.3
	% of norm	18.7	13.3	21.3	23.3
vitamin E [mg/day]	average ± SD	9.4 ± 4.2*	6.2 ± 3.4*	9.6 ± 4.7*	7.0 ± 4.5*
	min. - max.	1.3 - 21.5	1.6 - 20.0	1.0 - 26.1	0.6 - 29.9
	% of norm	117.5	77.5	96.0	70.0
vitamin B1 [mg/day]	average ± SD	0.7 ± 0.3*	0.8 ± 0.3*	0.8 ± 0.3*	1.0 ± 0.4*
	min. - max.	0.1 - 1.6	0.2 - 2.1	0.3 - 2.2	0.2 - 2.4
	% of norm	63.6	72.7	61.5	76.9
vitamin B2 [mg/day]	average ± SD	0.9 ± 0.4*	1.1 ± 0.6*	0.9 ± 0.4*	1.1 ± 0.5*
	min. - max.	0.2 - 2.1	0.2 - 4.4	0.3 - 3.1	0.2 - 3.1
	% of norm	81.8	100.0	69.2	100.0
vitamin B6 [mg/day]	average ± SD	1.1 ± 0.5*	1.5 ± 0.6*	1.2 ± 0.5*	1.7 ± 0.7*
	min. - max.	0.3 - 3.4	0.4 - 3.0	0.4 - 3.2	0.4 - 4.2
	% of norm	73.3	100.0	70.6	100.0
vitamin B12 [µg/day]	average ± SD	2.7 ± 4.0	3.0 ± 5.8	2.9 ± 4.9	3.5 ± 4.7
	min. - max.	0.1 - 26.7	0.1 - 48.5	0.3 - 50.0	0 - 31
	% of norm	112.5	125.0	120.8	145.8
Folates [µg/day]	average ± SD	107.9 ± 44.5*	158.3 ± 94*	102.0 ± 46.8*	144.7 ± 55.7*
	min. - max.	20.5 - 339.5	47.5 - 748.5	32.3 - 340.4	47.0 - 310.0
	% of norm	26.9	39.6	25.5	36.2
vitamin C [mg/day]	average ± SD	29.1 ± 28.3*	54.1 ± 36.0*	21.0 ± 20.8*	42.7 ± 26.9*
	min. - max.	0 - 149.3	0.5 - 198.0	0 - 105.3	8.9 - 119.6
	% of norm	38.8	72.1	23.3	47.4

*significance of differences with $p < 0.05$

Anaemia is a significant problem in the group of patients with CKD treated with repeated haemodialysis. Obtaining and maintaining proper levels of iron in a body is a key factor to produce and keep target level of haemoglobin in blood. Therefore, intravenous and oral administration of iron is used to treat anaemia [21]. Moreover, proper iron stores are essential to receive maximal advantages from using erythropoietin.

Haemodialysis patients are susceptible to deficiencies in water soluble vitamins, especially vitamin C, folic acid and B vitamins. Table 5 presents the average content of selected vitamins in DFR of haemodialysis patients.

Low content of water soluble vitamins was noted in analysed menus. Only in case of vitamin B₁₂ the consumption covered daily demand of women and men, and did not statistically differ between the groups. The demand for vitamins B₂ and B₆ was also covered in

patients with diabetes. Average content of vitamin B₁ in DFR of haemodialysis patients without diabetes was significantly lower than in case of patients with diabetes and amounted to, respectively, W 0.7 ± 0.3 mg/day and M 0.8 ± 0.3 mg/day. and W 0.7 ± 0.3 mg/day and M 1.0 ± 0.4 mg/day. Insufficient consumption of thiamine among haemodialysis patients was shown in other studies [7, 25]. *Cupisti* et al. observed higher by ca. 10% intake of vitamin B₁ in diet of haemodialysis patients in comparison with the control group (healthy people). In the same study it was noted that both haemodialysis and healthy people consumed meals with proper content of riboflavin [9]. In this study it was shown that patients with diabetes consumed significantly higher amounts of vitamins B₂ and B₆ than the groups without diabetes. For patients with diabetes, the average content of these vitamins in diets met the requirements in 100%. The average consumption of these two vitamins in groups without diabetes was

within 70-80% of the norm. Inadequate fulfilment of the recommendations was shown by *Cho* et al. [7] and *Jankowska* et al. [17]. Here, high intake of vitamin B₁₂ with diets of examined people confirms the results obtained by *Kardasz* et al. [23]. However, *Jankowska* et al. [17] and *Alshatwi* et al. [1] in their studies observed low intake of this vitamin in haemodialysis patients, which can increase the risk of megaloblastic anaemia.

Analysis of menus revealed very low intake of folates and vitamin C in all the patients. The average content of both these vitamins was significantly higher in groups with diabetes than in people without diabetes, regardless of the sex. The requirement for folates in groups without diabetes was met at the level of 25%, whereas in case of patients with diabetes – in almost 40%. Moderate hyperhomocysteinaemia is often observed among dialysis patients. It is a risk of cardiovascular diseases and relates to, among others, low concentration of B vitamins and folic acid in blood plasma. The studies performed by *Delfino* et al. proved that oral supplementation with folic acid (10 mg/day for 2 years) reduces the concentration of homocysteine by almost 70% [10]. *Bayes* et al. used folic acid at that dose three times a week. Besides decreasing the level of homocysteine by 44% he also achieved the reduction in malondialdehyde (MDA) by 40% [4]. The results suggest that folic acid has an indirect antioxidative activity by decreasing peroxidative activity of homocysteine, which leads to reduced oxidative stress. The highest intake of vitamin C was observed in HD women with diabetes (54.1 ± 36.0 mg/day, which met the recommendations in 72.1%).

Proper level of fat soluble vitamins: E and A, in a diet is important due to their antioxidative role in the organism. In this study it was shown that the intake of these vitamins met the requirements in most of examined groups. The average intake of vitamin A in group of men was significantly higher for patients with diabetes than those without. DFRs of haemodialysis patients without diabetes contained significantly higher levels of tocopherol than diets of patients with diabetes, regardless of the sex. Similar results were obtained by other authors [7, 37]. However, some authors reported reduced content of vitamin E [17] and vitamin A [5, 25] in the diets.

Due to the role of vitamin D in the regulation of calcium-phosphorus balance it should be supplied at proper amounts in DFR, especially in dialysis patients. Numerous studies confirm lower than recommended intake of vitamin D in the group of haemodialysis patients [3, 17, 37].

CONCLUSIONS

1. The results of this study indicate the need for nutritional education for haemodialysis patients, especially those with diabetes, due to numerous

mistakes related to energy consumption, intake of main nutrients, vitamins and mineral compounds.

2. Adherence to diet recommendations may prevent or decrease the risk of complications of chronic kidney disease and improve the quality of life of chronic patients.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. *Alshatwi A.A., Alshmary A., Al-Khalifa A.*: Nutritional Assessment of Hemodialysis Patients. *J Med Sci* 2007;7(2):294-298.
2. *Arslan Y., Kiziltan G.*: Nutrition-related cardiovascular risk factors in hemodialysis patients. *J Ren Nutr* 2010;20:185-192.
3. *Bataille M.D., Landrier J.F., Astier J., Cado S., Sallette J., Giaime P., Sampol J., Sichez H., Ollier J., Gugliotta J., Serveaux M., Cohen J., Darmon P.*: Hemodialysis patients with diabetes eat less than those without: a plea for a permissive diet. *Nephrology* 2016, doi: 10.1111/nep.12837.
4. *Bayes B., Pastor M.C., Bonal J., Junca J., Romero R.*: Homocysteine and lipid peroxidation in haemodialysis: Role of folic acid and vitamin E. *Nephrol Dial Transpl* 2001;16:2172-2175.
5. *Bossola M., Di Stasio E., Viola A., Leo A., Carlomagno G., Monteburini T., Cenerelli S., Santarelli S., Boggi R., Miggiano G., Vulpio C., Mele C., Tazza L.*: Dietary intake of trace elements, minerals, and vitamins of patients on chronic hemodialysis. *Int Urol Nephrol* 2014;46:809-815.
6. *Chazot C., Vo-Van C., Blanc C., Hurot J.M., Jean G., Vanel T., Terrat J.C., Charra B.*: Stability of nutritional parameters during a 5-year follow-up in patients treated with sequential long-hour hemodialysis. *Hemodial Int* 2006;10:389-393.
7. *Cho J.H., Hwang J.Y., Lee S.E., Jang S.P., Kim W.Y.*: Nutritional status and the role of diabetes mellitus in hemodialysis patients. *Nutr Res Pract* 2008;2(4):301-307.
8. *Cotton A.B.*: Medical Nutrition Therapy When Kidney Disease Meets Liver Failure. *Nephrol Nurs J* 2007;34(6):661-662.
9. *Cupisti A., D'Alessandro C., Valeri A., Capitanini A., Meola M., Betti G., Barsotti G.*: Food Intake and Nutritional Status in Stable Hemodialysis Patients. *Ren Fail* 2010;32:47-54.
10. *Delfino V.D.A., De Andrade Vianna A.C., Mocelin A.J., Barbosa D.S., Mise R.A., Matsuo T.*: Folic acid therapy reduces plasma homocysteine levels and improves plasma antioxidant capacity in hemodialysis patients. *Nutrition* 2007;23:242-247.
11. *Dos Santos A.C., Machado M.C., Pereira L.R., Abreu J.L., Lyra M.B.*: Association between the level of quality of life and nutritional status in patients undergoing chronic renal hemodialysis. *J Bras Nefrol* 2013;35(4):279-288.

12. *Dukkipati R., Kopple J.D.*: Causes and prevention of protein-energy wasting in chronic kidney failure. *Semin Nephrol* 2009;29:39-49.
13. European Guidelines for the Nutritional Care of Adult Renal Patients EDTNA/ERCA October 2002.
14. *Fouque D., Kalantar-Zadeh K., Kopple J., Cano N., Chauveau P., Cuppari L., Franch H., Guarnieri G., Ikizler T.A., Kaysen G., Lindholm B., Massy Z., Mitch W., Pineda E., Stenvinkel P., Trevinho-Becerra A., Wanner C.*: A proposed nomenclature and diagnostic criteria for protein-energy wasting in acute and chronic kidney disease. *Kidney Inter* 2008;73(4):391-398.
15. *Guariguata L., Whiting D.R., Hambleton I., Beagley J., Linnenkamp U., Shaw J.E.*: Global estimates of diabetes prevalence for 2013 and projections for 2035. *Diabetes Res Clin Pract* 2014;103(2):137-149.
16. *Ho L., Wang H.H., Peng Y.S., Chiang C.K., Huang J.W., Hung K.Y., Hu F.C., Hu K.D.*: Clinical Utility of Malnutrition-Inflammation Score in Maintenance Hemodialysis Patients: Focus on Identifying the Best Cut - Off Point. *Am J Nephrol* 2008;28:840 - 846.
17. *Jankowska A., Szupryczyńska N., Dębska-Ślizień A., Borek P., Kaczkan M., Rutkowski B., Małgorzewicz S.*: Dietary Intake of Vitamins in Different Options of Treatment in Chronic Kidney Disease: Is There a Deficiency? *Transplantation Proceedings*, 2016;48:1427-1430.
18. *Januszko-Giergielewicz B., Dębska-Ślizień A., Rutkowski B., Białobrzaska B., Górny J., Dudziak M., Barczak U., Gadomska G., Gromadziński L., Romaszko J., Piotrkowski J.*: Program edukacji kardiologicznej u bezobjawowych pacjentów z przewlekłą chorobą nerek – doświadczenia własne [Patient education program in cardiology dedicated for asymptomatic patients with chronic kidney disease – own experience]. *Nefrol Dial Pol*, 2014;18:157-163 (in Polish).
19. *Jarosz M.*: Normy żywienia dla populacji Polski [Nutritional standards for the population of Poland]. Warszawa, Wyd. IŻŻ, 2017 (in Polish).
20. *Jin Woo W., Nam-Ho K.*: Assessment of Malnutrition of Dialysis Patients and Comparison of Nutritional Parameters of CAPD and Hemodialysis Patients. *Biomed Sci Letters* 2017;23(3):185-193.
21. *Kalantar-Zadeh K., Streja E., Miller J.E., Nissenson A.R.*: Intravenous iron versus erythropoiesis-stimulating agents: friends or foes in treating chronic kidney disease anemia? *Adv Chronic Kidney Dis* 2009;16(2):143-151.
22. *Kardasz M., Ostrowska L.*: Ocena sposobu żywienia pacjentów hemodializowanych o zróżnicowanym stopniu odżywienia [Assessment of dietary habits in haemodialysis patients with differentiated nutritional status]. *Rocz Panstw Zakł Hig* 2012;63(4):463-468 (in Polish).
23. *Kardasz M., Ostrowska L., Stefańska E.*: Ocena zawartości witamin w całodziennych racjach pokarmowych pacjentów hemodializowanych z prawidłową masą ciała, z nadwagą i otyłością [Assessment of vitamin content in daily food rations of hemodialysis patients with normal mass, overweight and obesity]. *Bromat Chem Toksykol* 2011;2:134-142 (in Polish).
24. *Kardasz M., Ostrowska L., Stefańska E., Małyszko J.*: Ocena zawartości wybranych składników mineralnych w dziennych racjach pokarmowych pacjentów hemodializowanych [Assessment of the content of selected mineral components in daily food rations of haemodialysed patients]. *Probl Hig Epidemiol* 2011;92(2):272-277 (in Polish).
25. *Kim H., Lim H., Choue R.*: A Better Diet Quality is Attributable to Adequate Energy Intake in Hemodialysis Patients. *Clin Nutr Res* 2015;4(1):46-55.
26. *Kozłowska L., Łoś K.*: Realizacja zaleceń na wybrane składniki odżywcze pacjentów hemodializowanych [Realization of recommendations on selected nutrients in haemodialysis patients]. *Bromat Chem Toksykol* 2009;3:754-759 (in Polish).
27. *Kraut J.A., Madias N.E.*: Metabolic Acidosis of CKD: An Update. *Am J Kidney Dis* 2016;67(2):307-317.
28. *Kucharska E., Bober J., Bogacka A., Woś M.*: Ocena żywienia pacjentów z przewlekłą niewydolnością nerek leczonych hemodializą [The evaluation of food intake in dialysed patients]. *Bromat Chem Toksykol* 2008;2:161-167 (in Polish).
29. *Kunachowicz H., Nadolna I., Przygoda B., Iwanow K.*: Komputerowa Baza Danych- Tabele wartości odżywczej produktów spożywczych i potraw [Computer Database - Tables of components and nutritional value of food products and dishes]. Warszawa, Wyd. IŻŻ, 2005 (in Polish).
30. *Mafrá D., Farage N.E., Azevedo D.L., Viana G.G., Mattos J.P., Velarde L.G., Fouque D.*: Impact of serum albumin and body-mass index on survival in hemodialysis patients. *Int Urol Nephrol* 2007;39:619-624.
31. *Mpio I., Cleaud C., Arkouche W., Laville M.*: Results of therapeutic strategy of protein-energy wasting in chronic hemodialysis: a prospective study during 12 months. *Nephrol Ther* 2015;11(2):97-103.
32. *Nunes F.T., De Campos G., De Paula S.M.X., Merhi V.A.L., Portero-McLellan K.C., De Motta D.G., De Oliveira M.R.*: Dialysis adequacy and nutritional status of hemodialysis patients. *Hemodial Int* 2008;12:45-51.
33. *Park J., Seyed-Foad A., Streja E., Molnar M.Z., Flegel K.M., Gillen D., Kovesdy C.P., Kalantar-Zadeh K.*: Obesity Paradox in End-Stage Kidney Disease Patients. *Prog Cardiovasc Dis* 2014;56(4):415-425.
34. *Piccoli G.B., Moio M.R., Fois A., Sofronie A., Gendrot L., Cabiddu G., D'Alessandro C., Cupisti A.*: The Diet and Haemodialysis Dyad: Three Eras, Four Open Questions and Four Paradoxes. A Narrative Review, Towards a Personalized, Patient-Centered Approach. *Nutrients* 2017;9(4):372.
35. *Pietrzyk J.*: Żywienie chorych z niewydolnością nerek [Nutrition of patients with renal failure]. Kraków, Wyd. Janssen-Cilag, 2010 (in Polish).
36. *Sahin H., Ynanc N., Katrancy D., Aslan N.O.*: Is there a correlation between subjective global assessment and food intake, anthropometric measurement and biochemical parameters in nutritional assessment of haemodialysis patients? *Pak J Med Sci* 2009;25(2):201-206.
37. *Sanlier N., Demircioglu Y.*: Correlation of dietary intakes and biochemical determinates of nutrition in hemodialysis patients. *Ren Fail* 2007;29:213-218.
38. *Shroff R.*: Phosphate is a vascular toxin. *Pediatr Nephrol* 2013;28:583-593.

39. Siddiqui U.A., Halim A., Hussain T.: Nutritional profile and inflammatory status of stable chronic hemodialysis patients at nephrology department, military hospital Rawalpindi. *JAMC* 2007;19(4):29-31.
40. Sridhar N., Josyula S.: Hypoalbuminemia in hemodialyzed end stage renal disease patients: risk factors and relationships-a 2 year single center study. *BMC Nephrol* 2013;1(14):242.
41. Stojanovic M., Stojanovic D., Stefanovic V.: The Impact of malnutrition on Mortality in Patients on Maintenance Hemodialysis in Serbia. *Artif Organs* 2008;32(5):398-405.
42. Szpanowska-Wohn A., Kolarzyk E., Chowaniec E.: Estimation of intake of zinc, copper and iron in the diet of patients with chronic renal failure treated by haemodialysis. *Biol Trace Elem Res* 2008;124:97-102
43. Szponar L., Wolnicka K., Rychlik E.: Album fotografii produktów i potraw [Photo album of products and dishes]. Warszawa, Wyd. IŻŻ, 2000 (in Polish).
44. Tayyem R.F., Mrayyan M.T.: Assessing the prevalence of malnutrition in chronic kidney disease patients in Jordan. *J Ren Nutr* 2008;18(2):202-209.
45. Tonelli M., Wiebe N., Hemmelgarn B., Klarenbach S., Field C., Manns B., Thadhani R., Gill J., Alberta Kidney Disease Network: Trace elements in hemodialysis patients: a systematic review and meta-analysis. *BMC Med* 2009;7:25-30.
46. Wardak J., Głąbska D., Narojek L., Rojek-Trębicka J.: Analysis of the intake of protein and energy by predialysis patients with chronic renal failure receiving essential amino acid ketoanalogues. *Rocz Panstw Zakl Hig* 2007;58(1):153-158.
47. WHO: BMI classification. Available http://apps.who.int/bmi/index.jsp?introPage=intro_3.html (Accessed 16.02.2018)
48. Workeneh B.T., Mitch W.E.: Review of muscle wasting associated with chronic kidney disease. *Am J Clin Nutr* 2010;91:1128-1132.
49. Zaluska W., Klinger M., Kuształ M., Lichodziejewska-Niemierko M., Milkowski A., Stompór T., Sak J., Domański L., Drożdż M., Aksamit D., Durlik M., Krajewska M., Gellert R., Rutkowski R., Sułowicz W.: Rekomendacje Grupy Roboczej Polskiego Towarzystwa Nefrologicznego dotyczące kryteriów jakości leczenia dializami pacjentów z powodu schyłkowej niewydolności nerek. [Recommendations of the Working Group of the Polish Society of Nephrology for the criteria of quality treatment in dialysis patients with end-stage renal disease]. *Nefrol Dial Pol* 2015;19:6-11 (in Polish).

Received: 15.12.2017

Accepted: 15.03.2018

DIETARY PRACTICES AND NUTRITIONAL STATUS IN SURVIVORS OF BREAST CANCER

Emilia Kałędkiewicz, Dorota Szostak-Węgierek

Medical University of Warsaw, Faculty of Health Science, Department of Clinical Dietetics, Warsaw, Poland

ABSTRACT

Background. Wrong dietary practices and excessive body mass may not only influence the risk of primary breast cancer but also the risk of its recurrence.

Objective. Evaluation of dietary practices and identification of nutritional factors which may influence the risk of tumor recurrence in women with prior breast cancer.

Materials and methods. The case-control study involved 108 women aged 50 years and older with history of breast cancer who were divided into two categories: women after completed cancer treatment with no recurrence for minimum 5 years (group I, n=82) and women with diagnosed breast cancer recurrence (group II, n=26). A control group (n=74) constituted of subjects with no breast cancer diagnosis. In every subject anthropometric measurements were taken and dietary practices were evaluated by means of an original questionnaire.

Results. Average BMI and hip circumference values were higher in the group II than in the group I. In both study groups the percentage of high WHR values was significantly higher than in the control group. Women with history of cancer consumed significantly fewer vegetable and fruit and more refined cereals, dairy products, meat and cold cuts than women in the control group. Group I responders more often declared implementation and maintenance of changes in their diet after diagnosis of cancer than women from group II. Subjects with cancer history consumed more alcohol and more often used supplements than females in the control group.

Conclusion. Avoiding overweight and obesity along with following the principles of a healthy diet seems to reduce the risk of both breast cancer incidence and its recurrence.

Key words: *breast cancer, nutrition, nutritional status*

STRESZCZENIE

Wprowadzenie. Sposób żywienia i nadmierna masa ciała mogą wpływać nie tylko na powstawanie raka piersi lecz również na ryzyko wystąpienia nawrotów choroby.

Cel. Ocena sposobu żywienia oraz identyfikacja czynników żywieniowych mogących mieć wpływ na ryzyko nowotworu u kobiet po przebytym raku piersi.

Material i metody. Badanie kliniczno-kontrolne objęło 108 kobiet po 50. roku życia z rakiem piersi na podstawie wywiadu. Kobiety zostały podzielone na dwie grupy: grupa I, (n=82) - kobiety po zakończonym leczeniu, u których przez minimum 5 lat nie wystąpiło wznowienie choroby i grupa II, (n=26) - kobiety z wtórnie zdiagnozowanym rakiem piersi. Grupę kontrolną (n=74) stanowiły kobiety bez raka piersi w wywiadzie. Wykonano badania antropometryczne oraz przeanalizowano sposób żywienia kobiet przy użyciu autorskiego kwestionariusza.

Wyniki. W grupie II kobiet zaobserwowano wyższe średnie wartości BMI oraz obwodu bioder niż w grupie I. W obu grupach badanych odsetek wysokich wartości WHR był istotnie wyższy niż w grupie kontrolnej. Kobiety z historią nowotworową spożywały istotnie mniej warzyw i owoców oraz więcej nabiału, mięs i wędlin niż kobiety z grupy kontrolnej. Respondentki z grupy I istotnie częściej deklarowały wprowadzenie i utrzymanie zmian w sposobie żywienia po rozpoznaniu choroby niż kobiety z grupy II. Kobiety z historią nowotworową wypijały większe ilości alkoholu i częściej stosowały suplementy diety niż kobiety onkologicznie zdrowe.

Wnioski. Unikanie nadwagi i otyłości oraz przestrzeganie zasad zdrowej diety wydaje się zmniejszać ryzyko zarówno zachorowania na raka piersi jak i wystąpienia jego nawrotów.

Słowa kluczowe: *rak piersi, sposób żywienia, stan odżywienia*

Corresponding author: Emilia Kałędkiewicz, Medical University of Warsaw, Faculty of Health Science, Department of Clinical Dietetics, Erazma Ciołka 27 street, 01-445 Warsaw, Poland, tel. +48 606 202 953, e-mail: emilia.kaledkiewicz@wum.edu.pl

INTRODUCTION

Each year the number of women diagnosed with breast cancer rises worldwide. In Poland, this type of tumor is the second most common cause of death among cancer deaths in women (13,9% of all cancer deaths). Since the beginning of the last decade the number of subjects affected by breast cancer increased substantially. In 2014, the number of new cases was 17379, and breast cancer took the first place in the structure of cancer incidence (21,7% of all tumors in women) [29].

Studies on the association between dietary practices and breast cancer risk and/ or recurrence have been performed for many years. Although the findings are not always coherent, we can currently identify several factors that increase or decrease cancer risk. Among factors classified as probably protective there are lactation and physical activity. Among the key factors, which have been proved to increase breast cancer risk in postmenopausal women there are alcohol intake and excess of body weight [18, 19, 30]. Besides, it is suggested that the intake of various foods, as well as nutrients, may influence breast cancer risk. Although the results of research are not unambiguous [30], it seems that intake of vegetable and fruit [11], soya and soya products [2, 25], and fish [15, 36] is protective. Among potentially protective nutrients there are dietary fiber [10], folate [5], vitamin D [33], and calcium [14].

The purpose of the study was the evaluation of dietary practices and nutritional status in breast cancer survivors.

MATERIAL AND METHODS

A case-control study was conducted between 2013 and 2016. It involved 182 women over fifty-year-old living in Warsaw and surroundings.

The study group consisted of 108 women with history of breast cancer who were divided into two groups. The first one included women who completed the breast cancer treatment, without recurrence for minimum 5 years (group I, n=82). Women diagnosed with recurrent breast cancer were classified as the second group (Group II, n=26). The participants of the study were the patients of two hospitals (Szpital Specjalistyczny im. Świętej Rodziny SPZOZ and Szpital Onkologiczno – Kardiologiczny MAGODENT), and members of five divisions of the association of breast cancer patients “Stowarzysze Amazonki” (Warszawa – Centrum, Warszawa – Targówek, Warszawa – Bemowo, Warszawa – Praga, and Warszawa - Ochota). The control group (n=74) consisted of women with no breast cancer history, chosen from amongst members of Centrum Kultury in Piaseczno, patients of two medical centers, Centrum Rehabilitacji FizjoSystem, and Centrum Rehabilitacji Estetyka – med., as well as

friends and families of the above-mentioned groups. The participants were informed about possibility to take part in the study through banners, fliers, and also information provided by their physicians. On the day of enrollment, all participants of the study were postmenopausal, due to physiological cessation of menstrual cycles or prior oncological treatment.

For collection of data about clinical problems and dietary practices an original questionnaire was used. It consisted of three parts. The first one included questions about demographic data. The second part concerned problems related to the disease and its treatment. The third one was related to current dietary habits and consisted of 30 questions concerning frequency (per day, per week or per month) and amounts of 60 foods consumed during the last year. The sizes of portions were estimated on the basis of the Photo Album of Products and Dishes [28]. When asked about specific food items, the participants were presented with examples of different food portions of appropriate food stuffs. They defined the amount of food consumed by indicating the proper picture. The questionnaire included also questions about use of dietary supplements. The collected information was recalculated into average daily intake expressed in grams, and in the case of beverages in milliliters or glasses. Consumption of alcoholic beverages was expressed in grams of total ethanol intake. Additionally, women with the breast cancer history were asked about changes of their dietary habits implemented after cancer treatment.

Waist and hip circumferences were measured with a tape measure with an accuracy of 0.1 cm. Body mass was measured with an electronic weighing scale with an accuracy of 0.1 kg, without garments. Height was measured with a wall-mounted stadiometer with an accuracy of 1 cm. On the basis of the obtained results BMI and WHR values were calculated using the formulas: body weight (kg)/height (m) ² for BMI, and waist (cm)/hip circumference (cm) for WHR. BMI values were classified according to WHO: the range of 18.5-24.9 kg/m² was classified as normal, <18.5 kg/m² was the basis to identify underweight, 25-29.9 kg/m² overweight, and ≥30 kg/m² – obesity [31]. Abdominal overweight and obesity were recognized using criteria: waist circumference above 80 or 88 cm. WHR value ≥0.85 was identified as high [32].

Continuous variables were evaluated using the *Shapiro-Wilk* test to assess compliance with the normal distribution. In addition, the degree of asymmetry in the distribution of these variables was also estimated by calculating the skewness parameter. Since large deviations from compliance with the normal distribution were found, it was decided to use nonparametric statistics in the analyzes of these variables. For the statistical assessment of differences between groups the *U Mann-Whitney* test was used for continuous variables, and *Chi² Pearson* test for categorical variables. A p-value <0.05 was considered statistically significant.

Table 1. Characteristics of the control and study groups

Parameter	Groups				P (I vs II)
	Control n=74	I n=82	II n=26	I+II n=108	
Age (years) x ± SD median	65.7 ± 6.54 66.0	67.0 ± 7.08 66.0	71.1 ± 8.05*** 72.5	68.0 ± 7.50* 67.0	<0.01
Menopause prior to diagnosis of the first cancer No (%) Yes (%)	-----	59.76 40.24	34.62 65.38	53.70 46.30	<0.05
Years after diagnosis of the first cancer x ± SD median	-----	14.6 ± 6.92 13.5	16.8 ± 7.18 17.0	15.2 ± 7.02 15.0	ns
Years after diagnosis of the second cancer x ± SD median	-----	-----	10.5 ± 8.22 10.5	-----	-----
Age at the time of diagnosis of the first cancer (years) x ± SD median	-----	52.3 ± 8.19 51.0	54.2 ± 10.55 56.0	52.8 ± 8.80 52.0	ns
Age at the time of diagnosis of the second cancer (years) x ± SD median	-----	-----	60.5 ± 11.82 60.0	-----	-----
Residence Big town (%) Small town (%) Village (%)	95.95 2.70 1.35	90.24 8.54 1.22	88.46 11.54 0.00	89.81 9.26 0.93	ns

Statistical significance for comparisons with control group: *p<0.05, ** p<0.01, ***p<0.001, ****p<0.0001

Table 2. Anthropometric data of the control and study groups.

Parameter	Groups				P (I vs II)
	Control n=74	I n=82	II n=26	I+II n=108	
BMI (kg/m ²) x ± SD median	26.3 ± 4.23 26.3	26.8 ± 2.67 26.9	29.2 ± 6.31* 28.5	27.8 ± 4.73 27.3	<0.05
BMI <18.5 kg/m ² (%) 18.5-24.9 kg/m ² (%) 25-29.9 kg/m ² (%) ≥30 kg/m ² (%)	2.70 32.43 43.24 21.62	1.27 34.18 40.51 24.05	3.85 15.38 34.62 46.15	1.90 29.52 39.05 29.52	ns
Waist circumference (cm) x ± SD median	82.7 ± 12.95 85.0	88.9 ± 9.22 90.0	91.0 ± 11.77** 92.0	89.8 ± 10.33* 90.0	ns
Waist circumference ≤80 cm >80 - ≤88 cm >88 cm	31.08% 22.97% 45.95%	23.17% 29.27% 47.56%	11.54% 23.08% 65.38%	20.37% 27.78% 51.85%	ns
Hip circumference (cm) x ± SD median	102.3 ± 10.94 102.0	105.0 ± 6.81 103.5	109.7 ± 10.49** 111.0	107.1 ± 8.82* 105.5	<0.01
WHR x ± SD median	0.81 ± 0.065 0.81	0.83 ± 0.066 0.83	0.84 ± 0.051 0.83	0.83 ± 0.063 0.83	ns
WHR (%) WHR < 0.85 WHR ≥ 0.85	74.32 25.68	58.54* 41.46	57.69* 42.31	58.33* 41.67	ns

Statistical significance for comparisons with control group: *p<0.05, ** p<0.01, ***p<0.001, ****p<0.0001

Table 3. Plant foods consumption in the control and study groups

Products	Groups				p (I vs II)
	Control n=74	I n=82	II n=26	I+II n=108	
Vegetable (g) x ± SD median	318.24 ± 186.537 400.00	185.71 ± 90.183**** 200.00	124.86 ± 82.316**** 100.00	171.06 ± 91.778**** 200.00	<0.01
Fruit (g) x ± SD median	236.00 ± 139.943 300.00	171.86 ± 92.829** 100.00	166.21 ± 118.727* 125.00	170.50 ± 99.110** 100.00	ns
White bread (g) x ± SD median	6.57 ± 8.765 2.08	16.49 ± 25.075 3.33	29.59 ± 44.453** 9.36	19.65 ± 31.134** 4.00	ns
Wholemeal bread, mixed (g) x ± SD median	35.85 ± 24.109 35.00	44.22 ± 41.812 35.00	41.04 ± 35.060 35.00	43.45 ± 40.156 35.00	ns
White rice (g) x ± SD median	8.86 ± 12.750 6.67	15.07 ± 17.989** 8.33	17.04 ± 15.275*** 8.33	15.55 ± 17.326*** 8.33	ns
White pasta (g) x ± SD median	10.5 ± 15.55 6.7	15.1 ± 17.24* 6.7	17.1 ± 17.84* 6.7	15.6 ± 17.33* 6.7	ns
Whole-grain pasta (g) x ± SD median	5.19 ± 11.223 0.00	3.73 ± 8.870 0.00	1.74 ± 5.788* 0.00	3.25 ± 8.253 0.00	ns
Potatoes (g) x ± SD median	33.64 ± 31.407 36.43	57.33 ± 55.456** 48.57	86.05 ± 73.430*** 72.86	64.25 ± 61.156*** 48.57	ns
Dry pulses (g) x ± SD median	11.24 ± 16.477 6.67	17.65 ± 20.125* 6.67	17.70 ± 19.240* 8.33	17.67 ± 19.832** 6.67	ns
Nuts, almonds and seeds (g) x ± SD median	15.57 ± 16.940 9.29	11.91 ± 13.729 4.43	6.43 ± 9.478** 1.43	10.59 ± 13.008 3.00	<0.05
Nuts (g) x ± SD median	5.41 ± 5.919 2.18	4.70 ± 5.988 1.00	2.05 ± 3.433** 0.52	4.06 ± 5.586 1.00	<0.01
Almonds (g) x ± SD median	5.02 ± 5.790 1.50	3.16 ± 4.239* 1.00	1.98 ± 3.529*** 0.00	2.87 ± 4.095** 1.00	<0.05

Statistical significance for comparisons with control group: *p<0.05, ** p<0.01, ***p<0.001, ****p<0.0001

The study was accepted by the Bioethical Committee of Warsaw Medical University. All subjects were asked for their approval before starting the interview and a consent form was explained and then signed by all subjects.

RESULTS

Characteristics of the participants are shown in Table 1. Women from group II were significantly older than both women from the control group and group I, and also significantly more often postmenopausal before primary cancer diagnosis than women from group I.

Results of anthropometric measurements are shown in Table 2. Mean BMI, waist and hip circumference values were significantly higher in group II than in the

control group. In both study groups the percentage of high WHR values was significantly higher than in the control group.

Data on the consumption of food products of various groups is shown in Tables 3, 4 and 5. Women from the study groups consumed significantly less vegetable and fruit than women from the control group. It applied to almost all categories of these products. Women with history of breast cancer consumed greater amounts of highly refined cereals and potatoes, as well as dairy products, pulses, meats and cold cuts, while smaller amounts of nuts and almonds in comparison with the control group. Women from the study groups significantly more often used supplements of calcium and vitamin D, as well as of n-3 fatty acids than participants from the control group (Table 6).

Table 4. Animal foods consumption in the control and study groups

Products	Groups				p (I vs II)
	Control n=74	I n=82	II n=26	I+II n=108	
Milk overall (ml) x ± SD median	73.70 ± 107.799 16.67	106.37 ± 109.998 50.00	02.84 ± 126.281 35.71	105.52 ± 113.524 50.00	ns
Fermented milk beverages (ml) x ± SD median	63.71 ± 65.961 42.86	101.78 ± 84.096*** 85.71	93.45 ± 120.388 64.29	99.77 ± 93.556** 85.71	ns
Cottage cheese overall (g) x ± SD median	24.29 ± 23.199 17.14	32.75 ± 20.511** 34.29	32.25 ± 30.725 34.29	32.63 ± 23.136** 34.29	ns
Hard cheese overall (g) x ± SD median	6.78 ± 8.265 2.50	16.32 ± 18.691*** 10.71	16.30 ± 18.030** 8.57	16.31 ± 18.450**** 10.36	ns
Other cheese (g) x ± SD median	2.66 ± 5.445 0.00	7.18 ± 11.935*** 1.67	13.62 ± 26.002* 1.67	8.73 ± 16.537*** 1.67	ns
Fish and seafood (g) x ± SD median	35.52 ± 38.077 20.00	41.82 ± 36.612 26.67	38.96 ± 33.481 28.57	41.13 ± 35.751 26.67	ns
White meat (g) x ± SD median	27.36 ± 28.536 10.00	49.67 ± 38.276**** 42.86	126.15 ± 272.961** 57.14	68.09 ± 139.987**** 50.00	ns
Red meat (g) x ± SD median	6.77 ± 9.396 5.00	15.08 ± 16.618**** 10.00	28.69 ± 36.617**** 14.17	18.36 ± 23.591**** 10.00	ns
Low-quality cold cuts (g) x ± SD median	0.69 ± 1.128 0.00	3.72 ± 6.758**** 0.58	6.51 ± 12.587* 0.00	4.37 ± 8.496**** 0.00	ns
High-quality cold cuts (g) x ± SD median	3.87 ± 4.799 2.06	8.22 ± 7.061**** 6.86	14.49 ± 15.014*** 9.71	9.73 ± 9.882**** 6.86	ns

Statistical significance for comparisons with control group: *p<0.05, ** p<0.01, ***p<0.001, ****p<0.0001

A substantial percentage of respondents, 76.8% of group I, and 42.3% of group II, declared implementation and maintenance of changes in diet after breast cancer diagnosis, and this difference was statistically significant ($p < 0.001$). These changes included increase in consumption of vegetable and fruit (71.6% of women under study), whole grains (36.5%), fish (31%), green tea (4%), and also decrease in meat consumption (37.8%), dairy products (1.4%), high fat foods (8.1%), fried foods (6.8%), sugar and sweets (9.5%), and also reduction of portion size (1.4%). Some participants included red wine, linseed oil and legumes in their diet.

DISCUSSION

Participants with breast cancer recurrence had higher average BMI and higher incidence of abdominal fat distribution than those from the control group. It may

be assumed that excess of body fat mass, especially of the abdominal deposition, could result in greater tumor malignancy. Results of other studies suggest this relationship. Meta-analyses of case-control and cohort studies, which have been published in recent years [19, 30], showed that excess of body mass increases the risk of cancer in postmenopausal women. Moreover, obesity in females with diagnosed breast cancer increases the risk of its recurrence [34]. On the other hand, we cannot rule out that large gain of abdominal fat in study participants took place after the diagnosis of breast cancer. Some studies demonstrated that many patients with breast cancer gain weight during and/or after cancer treatment [19].

It is worth noting that women with breast cancer history, when compared with participants from the control group, consumed smaller amounts of vegetable and fruit, nuts, and almonds, and bigger amounts of refined cereals, dairy products, meat and cold cuts. Other studies also

Table 5. Consumption of sugar, sweets and alcohol in the control and study groups

Products	Group				p (I vs II)
	Control n=74	I n=82	II n=26	I+II n=108	
Sugar (g) x ± SD median	5.17 ± 7.844 0.00	2.70 ± 5.950 0.00	2.36 ± 4.832 0.00	2.62 ± 5.681* 0.00	ns
Honey (g) x ± SD median	2.73 ± 3.702 0.80	5.00 ± 4.934*** 3.43	4.01 ± 4.689 0.80	4.76 ± 4.873** 3.43	ns
Sugar + Honey (g) x ± SD median	7.90 ± 8.713 5.17	7.70 ± 6.874 6.86	6.37 ± 7.712 5.07	7.38 ± 7.070 6.86	ns
Beer (ml) x ± SD median	4.78 ± 15.685 0.00	6.10 ± 55.216** 0.00	0.42 ± 2.157 0.00	4.73 ± 48.114** 0.00	ns
Wine (ml) x ± SD median	12.96 ± 43.212 0.00	15.47 ± 31.413*** 5.00	22.34 ± 46.842 0.00	17.12 ± 35.614** 5.00	ns
Vodka (ml) x ± SD median	0.14 ± 0.602 0.00	0.30 ± 1.706 0.00	0.32 ± 0.945 0.00	0.30 ± 1.553 0.00	ns
Ethanol, total (g) x ± SD median	1.73 ± 5.011 0.00	2.64 ± 5.124* 0.56	2.62 ± 5.286 0.00	2.64 ± 5.138* 0.56	ns

Statistical significance for comparisons with control group: *p<0.05, ** p<0.01, ***p<0.001, ****p<0.0001

Table 6. Use of dietary supplements in the control and study groups.

Supplement	Group				p (I vs II)
	Control n=74	I n=82	II n=26	I+II n=108	
Supplements overall					
No (%)	70.27	57.32	34.62	51.85	<0.05
Yes (%)	29.73	42.68	65.38**	48.15**	
Calcium					
No (%)	100.00	87.80***	73.08****	84.26***	ns
Yes (%)	0.00	12.20	26.92	15.74	
Vitamin D3					
No (%)	97.30	89.02*	76.92**	86.11**	ns
Yes (%)	2.70	10.98	23.08	13.89	
N-3 fatty acids					
No (%)	98.65	81.71***	84.62**	82.41**	ns
Yes (%)	1.35	18.29	15.38	17.59	

Statistical significance for comparisons with control group: *p<0.05, ** p<0.01, ***p<0.001, ****p<0.0001

confirmed an inverse relationship between the intake of vegetable and fruit and the risk of breast cancer [1, 3, 13, 17]. Adverse effect of consumption of red and processed meat on breast cancer risk was observed by some authors [7, 9, 12], while other investigators demonstrated this relationship only for processed meat [23, 35]. The impact of intake of dairy products is not fully clear. However, some studies suggest a positive relationship between intake of high fat dairy products and increased risk of breast cancer [16]. Similarly, the link between pulses

consumption and breast cancer incidence is not clear and requires further investigation [6].

Because of the case-control design of our study, we cannot rule out that the discussed negative features of dietary practices appeared after the diagnosis of breast cancer. In fact, a large percentage of the participants declared substantial changes in their diet. However, the introduced modifications involved increased consumption of foods considered as healthy and reduced of those that are potentially harmful. Thus, it seems that

the respondents diet before cancer diagnosis might be even worse than that observed after cancer treatment.

Compared with women who have never had breast cancer, women with breast cancer history consumed more honey and less sugar. This phenomenon is probably related to commonly available information on the harmfulness of sugar consumption. It seems that the women with cancer history, in order to eat healthier, replaced sugar with honey, which is perceived as a pro-health product. However, it should be noted that the results of studies focused on the link between sugar intake and the risk of breast cancer are not consistent. Some of them do not show any relationship whereas other show that such a relationship exists [26, 27].

In our study, participants with history of breast cancer consumed larger amounts of alcohol than the women from the control group. It suggests adverse effect of alcohol consumption. The results of studies on the relationship between consumption of alcohol beverages on breast cancer risk are consistent with ours. Alcohol consumption, based on a number of both case-control and cohort studies, has been identified as an established risk factor for breast cancer in women [30].

Participants of our study who had no recurrence of breast cancer significantly more often introduced beneficial changes in their diet than those in whom cancer recurrence was diagnosed. We speculate that these changes could to some extent facilitate the avoidance of breast cancer recurrence. It is worth mentioning that the results of the analysis performed in the British population, which suggested that lifestyle changes, including diet, can prevent 25-30% of breast cancer cases [24].

The participants of the study with the history of breast cancer more often used dietary supplements of calcium, vitamin D and n-3 fatty acids than women who had never been diagnosed with this type of cancer. This is probably related to the fact that cancer, including breast cancer, favors the development of osteoporosis [21, 22]. Therefore, it may be assumed that the observed common use of calcium and vitamin D supplements in subjects with history of breast cancer was justified more often than in other participants. It is worth mentioning that the results of array of studies suggest that supplementation with vitamin D and n-3 fatty acids may reduce the risk of breast cancer and its recurrence [4, 8]. It appears that women who have had breast cancer, knowing about the potentially beneficial effects of n-3 fatty acids, consciously took them more often than healthy women.

CONCLUSIONS

1. It seems that excess of body mass and abdominal fat distribution are associated with the risk of breast cancer.

2. The results of the study suggest the potential beneficial effects of high consumption of vegetable and fruit on the risk of breast cancer.
3. It may be speculated high intake of meats and cold cuts, as well as refined cereals and alcohol products have adverse impact on the risk of breast cancer.
4. It may be assumed that avoiding overweight and obesity, as well as adhering to the principles of a healthy diet may reduce the risk of breast cancer.
5. Counseling women with breast cancer concerning change in their adverse dietary habits would be beneficial.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Aune D., Chan D.S., Viera A.R., Rosenblatt D.A., Vieira R., Greenwood D.C., Norat T.: Fruits, vegetables and breast cancer risk: a systematic review and meta-analysis of prospective studies. *Breast Cancer Res Treat* 2012;134(2):479-93.
2. Bahrom S., Idris N., Ruzni N.: Soy intake and breast cancer risk: A meta-analysis of epidemiological studies. In: 2nd International Conference on Mathematical Sciences and Statistics 2016 (ICMSS2016), 26-28 January 2016, Kuala Lumpur, Malaysia.
3. Boggs D.A., Palmer J.R., Wise L.A., Spiegelman D., Stampfer M.J., Adams-Campbell L.L., Rosenberg L.: Fruit and vegetable intake in relation to risk of breast cancer in the Black Women's Health Study. *Am J Epidemiol* 2010;172(11), 1268-1279.
4. Chen P., Hu P., Xie D., Qin Y., Wang F.: Wang H.: Meta-analysis of vitamin D, calcium and the prevention of breast cancer. *Breast Cancer Res Treat* 2010;121(2), 469-477.
5. Chen P., Li C., Li X., Li J., Chu R., Wang H.: Higher dietary folate intake reduces the breast cancer risk: a systematic review and meta-analysis. *Br J Cancer* 2014;110(9),2327.
6. Demetriou C.A., Hadjisavvas A., Loizidou M.A., Loucaides G., Neophytou I., Sieri S., Kakouri E., Middleton N., Vineis P., Kyriacou K.: The mediterranean dietary pattern and breast cancer risk in Greek-Cypriot women: a case-control study. *BMC* 2012;Cancer 12:113.
7. Egeberg R., Olsen A., Autrup H., Christensen J., Stripp C., Tentens I., Overvad K., Tjønneland A.: Meat consumption, N-acetyl transferase 1 and 2 polymorphism and risk of breast cancer in Danish postmenopausal women. *Eur J Cancer Prev* 2008;17:39-47.
8. Fabian C.J., Kimler B.F.; Hursting S.D.: Omega-3 fatty acids for breast cancer prevention and survivorship. *Breast Cancer Res* 2015;17(1), 62.
9. Farvid, M.S., Cho E., Chen W.Y., Eliassen A.H., Willett W.C.: Dietary protein sources in early adulthood and breast cancer incidence: prospective cohort study. *BMJ* 2014;348: g3437.

10. Farvid M.S., Eliassen A.H., Cho E., Liao X., Chen W.Y., Willett W.C.: Dietary fiber intake in young adults and breast cancer risk. *Pediatrics*, 2016;137(3), e20151226.
11. Farvid M.S., Willett W.C., Eliassen A.H.: Fruit and vegetable intake and risk of breast cancer: Pooled analysis of the Nurses' Health Study and the Nurses' Health Study II. *Cancer Res* 2017;77(13):Supplement, pp.5325A.
12. Guo J., Wei W., Zhan L.: Red and processed meat intake and risk of breast cancer: a meta-analysis of prospective studies. *Breast Cancer Res Treat* 2015;151(1): 191-198.
13. Hawrysz I., Krusińska B., Słowińska M.A., Wądołowska L., Czerwińska A., Biernacki M.: Nutritional knowledge, diet quality and breast or lung cancer risk: a case-control study of adults from Warmia and Mazury region in Poland. *Rocz Panstw Zakl Hig* 2016;67(1):9-15.
14. Hidayat K., Chen G.C., Zhang R., Du X., Zou S.Y., Shi B.M., Quin L.Q.: Calcium intake and breast cancer risk: meta-analysis of prospective cohort studies. *Br J Nutr* 2016;116(1), 158-166.
15. Khankari N.K., Bradshaw P.T., Steck S.E., He K., Olshan A.F., Shen J., Ahn J., Chen Y., Ahsan H., Terry M.B., Teitelbaum S.L., Neugut A.I., Santella R.M., Gammon M.D.: Dietary intake of fish, polyunsaturated fatty acids, and survival after breast cancer: A population-based follow-up study on Long Island, New York. *Cancer*. 2015;121(13):2244-52.
16. Kroenke C.H., Kwan M.L., Sweeney C., Castillo A., Caan B.J.: High- and Low-Fat Dairy Intake, Recurrence, and Mortality After Breast Cancer Diagnosis. *J Natl Cancer Inst* 2013;105 (9): 616-623.
17. Kruk J.: Jedzenie owoców i warzyw a ryzyko raka piersi. *Współcz Onkol*, 2008;10(5): 224-230.
18. Kushi L.H., Doyle C., McCullough M. and The American Cancer Society 2010 Nutrition and Physical Activity Guidelines Advisory Committee: American Cancer Society guidelines on nutrition and physical activity for cancer prevention. *CA: Cancer J Clin* 2012;62:30-67.
19. Kyrgiou M., Kalliala I., Markozannes G., Gunter M.J., Paraskevidis E., Gabra H., Martin-Hirsch P., Tsilidis K.K.: Adiposity and cancer at major anatomical sites: umbrella review of the literature. *BMJ* 2017;356:j477.
20. Makari-Judson G., Braus B., Jerry D.J., Mertens W.C.: Weight gain following breast cancer diagnosis: Implication and proposed mechanisms. *World J Clin Oncol* 2014;5(3), 272-282.
21. Michaud L.B.: Managing cancer treatment-induced bone loss and osteoporosis in patients with breast or prostate cancer. *Am J Health Syst Pharm* 2010;67(7), Suppl 3,20-30.
22. Miller K.D., Siegel R.L., Lin C.C., Mariotto A.B., Kramer J.L., Rowland J.H., Stein K.D., Alteri R., Jemal A.: Cancer treatment and survivorship statistics, 2016. *CA: Cancer J Clin* 2016;66(4),271-289.
23. Mourouti N., Kontogianni M.D., Papavagelis C., Plytzanopoulou P., Vassilakou T., Psaltopoulou T., Malamos N., Linos A., Panagiotakos D.B.: Meat consumption and breast cancer: a case-control study in women. *Meat Sci*, 2015;100, 195-201.
24. Parkin D.M., Boyd L., Walker L.C.: The fraction of cancer attributable to lifestyle and environmental factors in the UK in 2010. *Br J Cancer* 2011;105, Suppl 2:77-81.
25. Radzikowski C., Wietrzyk J., Grynkiewicz G.: Genisteina – izoflawonoid soi o zróżnicowanym mechanizmie działania – implikacje kliniczne w leczeniu i prewencji chorób nowotworowych. *Postepy Hig Med Dosw.* 2004; 58: 128-139.
26. Shikany J.M., Redden D.T., Neuhauser M.L., Chlebowski R.T., Rohan T.E., Simon M.S., Liu S., Lane D.S., Tinker L.: Dietary glyceemic load, glyceemic index, and carbohydrate and risk of breast cancer in the Women's Health Initiative. *Nutr Cancer* 2011;63(6), 899-907.
27. Sulaiman S., Shahril M.R., Wafa S.W., Shaharudin S.H., Hussin S.N.: Dietary Carbohydrate, Fiber and Sugar and Risk of Breast Cancer According to Menopausal Status in Malaysia. *Asian Pac J Cancer Prev* 2014;15(14), 5959-5964.
28. Szponar L, Wolnicka K, Rychlik E.: Photo album of meals and products. *IŻŻ*, Warsaw 2001: 5-85.
29. Wojciechowska U., Olasek P., Czauderna K., Didkowska J.: Nowotwory złośliwe w Polsce w 2014 roku. Krajowy Rejestr Nowotworów, Centrum Onkologii – Instytut im. Marii Skłodowskiej-Curie. Warszawa, 2016. <http://onkologia.org.pl/wp-content/uploads/Nowotwory2014.pdf>
30. World Cancer Research Found, American institute for cancer Research. Continuous Update Project. Breast Cancer Report. Diet, nutrition, physical activity and breast cancer, 2017.
31. World Health Organization. BMI Classification. Available http://apps.who.int/bmi/index.jsp?introPage=intro_3.html (Accessed 10.10.2017)
32. World Health Organization: Waist circumference and waist-hip ratio: Report of a WHO expert consultation, Geneva, 8-11 December 2008, 2011.
33. Yao S., Kwan M.L., Ergas I.J., Roh M.J., Cheng T.D., Hong C.C., McCann S.E., Tang L., Davis W., Liu S., Quesenberry C.P.Jr, Lee M.M., Ambrosone C.B., Kushi L.H.: Association of serum level of vitamin D at diagnosis with breast cancer survival: a case-cohort analysis in the pathways study. *JAMA oncology* 2017;3(3),351-357.
34. Yung R.L., Ligibel J.A.: Obesity and breast cancer: risk, outcomes, and future considerations. *Clin Adv Hematol Oncol* 2016;14(10):790-797.
35. Zhang C.X., Ho S.C., Chen Y.M., Lin F.Y., Fu J.H., Cheng S.Z.: Meat and egg consumption and risk of breast cancer among Chinese women. *Cancer Causes Control* 2009;20(10):1845-53.
36. Zheng J.S., Hu X.J., Zhao Y.M., Yang J., Li D.: Intake of fish and marine n-3 polyunsaturated fatty acids and risk of breast cancer: meta-analysis of data from 21 independent prospective cohort studies. *BMI* 2013;346: f3706.

Received: 16.12.2017

Accepted: 10.04.2018

THE ASSESSMENT OF THE NUTRITIONAL VALUE OF MEALS CONSUMED BY PATIENTS WITH RECOGNIZED SCHIZOPHRENIA

Ewa Stefańska¹, Agnieszka Wendolowicz¹, Magdalena Lech¹, Karolina Wilczyńska², Beata Konarzewska², Joanna Zapolska¹, Lucyna Ostrowska¹

¹Department of Dietetics and Clinical Nutrition, Medical University of Białystok, Poland

²Department of Psychiatry, Medical University of Białystok, Poland

ABSTRACT

Background. As studies show, changes in diet - so important in the therapy of psychiatric disorders and related to changes in appetite and nutritional preferences, including avoiding of the consumption of specific groups of products and dishes - are much more frequent among patients affected by schizophrenia.

Objective. The aim of the study was to assess the chosen nutritional habits, including the number and type of meals usually consumed during a day, snacking between meals and the energy value and content of the chosen nutrients in the diets of persons with recognized schizophrenia.

Material and methods. The study was carried out in a group of 85 patients with recognized schizophrenia, and 70 healthy volunteers ranging in age from 18-65 years without mental or nutritional disorders. For the purpose of the study, we used a questionnaire containing questions on nutritional habits. A 24-hour diet recall was used in the quantitative nutritional assessment with the use of the computer program Dieta 5.0.

Results. Female patients with recognized schizophrenia were having 3 meals a day significantly more frequently as compared to healthy women. They were also having an afternoon snack much more frequently as compared to the control group. The food rations of female patients were characterized by a significantly higher energy value and the content of most of the assessed nutrients as compared to the food rations of healthy women. The food rations of men with recognized schizophrenia were characterized by a much lower energy intake and the content of the majority of assessed nutrients as compared to the food rations of healthy men. In all compared groups, we observed an energetic structure of food rations with the breakdown by specific meals that was inconsistent with the applicable recommendations.

Conclusions. Despite of differences between the nutritional value of the meals of patients with recognized schizophrenia and those of healthy subjects, it seems advisable to involve patients with recognized schizophrenia in the education of forming appropriate nutritional habits.

Key words: *schizophrenia, nutritional value of meals, nutritional habit*

STRESZCZENIE

Wprowadzenie. Jak wykazały badania u pacjentów chorujących na schizofrenię częściej występują zmiany sposobu żywienia, tak istotnego w terapii zaburzeń psychiatrycznych, związane ze zmianą łaknienia, preferencji żywieniowych, w tym unikanie spożywania określonych grup produktów i potraw.

Cel. Celem pracy była ocena wybranych nawyków żywieniowych, w tym liczby i rodzaju zwyczajowo spożywanych posiłków w ciągu dnia, pojadania między nimi oraz wartości energetycznej i zawartości wybranych składników odżywczych w jadłospisach osób z rozpoznaniem schizofrenii.

Material i metody. Badania przeprowadzono w grupie 85 pacjentów z rozpoznaniem schizofrenii oraz 70 zdrowych ochotników w wieku 18-65 lat bez zaburzeń psychicznych i zaburzeń odżywiania. W badaniach wykorzystano kwestionariusz ankiety zawierający pytania dotyczące nawyków żywieniowych. Ocenę ilościową dziennych racji pokarmowych dokonano przy użyciu 24-god. wywiadu żywieniowego wykorzystując program komputerowy Dieta 5.0.

Wyniki. Pacjentki z rozpoznaniem schizofrenii istotnie częściej spożywały 3 posiłki w ciągu dnia, istotnie częściej też uwzględniały w swoich jadłospisach podwieczorki w porównaniu z kobietami zdrowymi. Racje pokarmowe kobiet chorych charakteryzowały się istotnie wyższą wartością energetyczną oraz zawartością większości ocenianych składników odżywczych w porównaniu z racjami kobiet zdrowych. Racje pokarmowe mężczyzn z rozpoznaniem schizofrenii cechowała istotnie niższa podaż energii oraz zawartość większości ocenianych składników odżywczych w porównaniu z racjami pokarmowymi mężczyzn zdrowych. We wszystkich porównywanych grupach odnotowano niezgodną z zaleceniami strukturę energetyczną racji pokarmowych z uwzględnieniem podziału na posiłki.

Wnioski. Pomimo wykazanych różnic w wartości odżywczej posiłków pacjentów z rozpoznaniem schizofrenii jak i zdrowych, zasadnym wydaje się, objęcie pacjentów z rozpoznaniem schizofrenii edukacją kształtującą właściwe nawyki żywieniowe.

Słowa kluczowe: *schizofrenia, wartość odżywcza posiłków, zwyczaje żywieniowe*

Corresponding author: Ewa Stefańska, Department of Dietetics and Clinical Nutrition, Medical University, Mieszka I 4 b, 15-054 Białystok, Poland, tel./fax: +48 857328244, e-mail: estef@umb.edu.pl

INTRODUCTION

As the studies showed, changes in nutritional behaviors related to changes in appetite, nutritional preferences, including avoiding specific products and dishes, too rare consumption of meals or too frequent snacking of convenience food between main meals are significantly more frequent among patients with recognized schizophrenia [5, 16]. It is reflected by an incorrect nutritional value of the meals consumed by these patients. Some authors noted that patients with recognized schizophrenia are characterized, among others, by the consumption of products that are rich in fats and simple carbohydrates and poor in dietary fiber as compared to the population of healthy people [4, 5, 15]. Other authors showed that patients with recognized schizophrenia are characterized by the intake of basic nutrients with practically no different content of these nutrients in the general energy value of daily intake as compared to the control group [4]. There is also research in which any significant differences in terms of nutritional habits between people affected by schizophrenia and healthy people were not stated [8]. It was also noted that patients with recognized schizophrenia are characterized by a more frequent occurrence of many somatic disorders, the development of which is related to the nutritional factors [3]. An inappropriate diet, right next to low physical activity, smoking as well as a lack of interest in physical health may worsen the health condition of these patients [5]. Monitoring of the diets of patients affected by schizophrenia may help in indicating abnormalities that would allow to ensure adequate correction through both the formation of appropriate nutritional habits in this group and the creation of educational programs. In the available literature, there are no studies concerning the assessment of the nutritional value of specific meals consumed by people with recognized schizophrenia.

The aim of the study was to assess the chosen nutritional habits, including the number and type of meals consumed usually during a day, snacking between meals and the energy value and content of the chosen nutrients in the diets of people with recognized schizophrenia.

MATERIALS AND METHODS

The research carried out from September 2016 to June 2017 covered 85 patients with recognized schizophrenia (according to the ICD-10 criteria) [21], that is to say, 45 women and 40 men ranging in age from 18-65 years (ambulatory patients under the care of the Outpatient Mental Clinic) and 70 healthy volunteers (40 women and 30 men) ranging in age from 18-65 years without any mental or nutritional disorders. Patients

with schizophrenia have been receiving atypical or typical antipsychotics for at least 1 year before being included in the study and they were mentally stable. Persons taking psychoactive substances, affected by other mental, cognitive or nutritional disorders were excluded from the study. In the group of patients with schizophrenia, 39% have been receiving 1 antipsychotic, 61% - 2 or 3 antipsychotics at the same time. In the case of men, 45% have been receiving 1 antipsychotic, 55% - 2 or 3 antipsychotics at the same time. Olanzapine, risperidone, haloperidol and clozapine were applied the most frequently. The patients taking part in the study were informed about the aim and methods of the research. Each patient gave a written consent to conduct them. The study obtained permission number R-I-002/355/2016 issued by the Bioethics Committee of the Medical University of Białystok. We used a survey questionnaire containing, among others, questions on nutritional habits, including those concerning the number and type of typically consumed meals and snacking between them. In the quantitative assessment of the daily food rations, we used a 24-hour diet recall covering 3 weekdays and one day of the weekend. In order to elaborate the nutritional value of daily food rations, we used the Diet 5.0 computer program elaborated by the Institute of Food and Nutrition in Warsaw. In order to assess the compliance of nutrient consumption with the recommendations, we used the nutritional standards for Polish people [6]. The following values were adopted as the proper content of energy derived from basic nutrients: 12% from protein, 30% from fats, 58% from carbohydrates. Furthermore, the intake of dietary fiber at the level of 25g/day, of dietary cholesterol at the level of 300 mg/day, the intake of saturated fatty acids (SFA), monounsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs) respectively as 10%, 12%, 8% of the daily energy intake were considered as consistent with the recommendations [6]. In the assessment of the percentage of energy derived from each meal consumed during a day as compared to the total energy intake, we used the nutritional recommendations according to *Jaros* [6]. The statistical analysis of the obtained results was carried out with the use of the computer program STATISTICA 12.0, made by StatSoft, using the χ^2 test and t-test for independent variables and adopting the results with $p < 0.05$ as significant.

RESULTS

Table 1 presents the socio-demographic characteristics of the patients. It was observed that the number of single women and men and those with a primary/vocational education was significantly higher in the group of patients with recognized schizophrenia as compared to the control group.

Table 1. General characteristics of subject groups

Variables	Women		Men	
	Schizophrenia n=45	Controls n=40	Schizophrenia n=40	Controls n=30
Age (years)	39.0(6.7)	38.2(12.5)	37.8(11.6)	35.9(8.6)
Body height (cm)	163.5 (5.4)	166.0(4.4)	177.8(6.8)	180.9(5.2)
Body weight (kg)	68.1(16.3)	65.0(11.8)	80.3(17.3)	85.1(12.9)
Body mass index (kg/m ²)	25.1(5.3)	24.4(5.0)	25.0(4.6)	25.9(4.2)
<25.0 (%)	64	67	30	34
≥25.0 (%)	36	33	70	66
Waist circumference (cm)	93.3 (14.0) **	85.5(13.3)	96.2(12.8)	92.9(10.2)
Marital status (%)				
Married	18	62	25	56
Single	82*	38	75*	44
Education (%)				
Primary	4***	0	29***	0
Vocational	13	0	25	0
Secondary	53	25	33	35
University	30	75	13	65
Age of onset (years)	27.3(7.1)	-	26.7(9.0)	-
Disease duration (years)	12.3(7.2)	-	10.0(6.7)	-

Values for categorical variables are arithmetic mean (standard deviation) or percentages of subjects. For continuous variables the independent t test was used; for categorical variables, chi-square test was used; *p<0.05, **p<0.01, ***p<0.001

Statistically significant differences concerning the anthropometric parameters of the patients taking part in the study were not stated, except for the waist circumference that was significantly larger in the case of women affected by schizophrenia as compared to healthy women. While assessing the number and type of meals consumed by patients taking part in the study, it was stated that women with recognized schizophrenia were having three meals a day much more frequently as compared to healthy women (Table 2). At the same time, the largest group of healthy women declared a rational nutritional model that assumes 5 meals

a day. The consumption of 3-4 meals a day was preferred in both groups of men. While assessing the type of consumed meals, it was stated that more than 90% of women from both groups were having three main meals, that is to say breakfast, lunch and dinner. It was stated at the same time that additional snacking between meals was significantly more frequent in the group of women with recognized schizophrenia as compared to healthy women (sweets were chosen the most often in the group of women with schizophrenia, while fruits - in the group of healthy women).

Table 2. Details of subjects' dietary habits selected for assessment.

Variables	Women				Men			
	Schizophrenia n=45		Controls n=40		Schizophrenia n=40		Controls n=30	
	n	%	n	%	n	%	n	%
Number of meals								
≤2	1	2	0	0	5	12	0	0
3	21	47*	5	12	14	36	8	27
4	10	22	15	38	12	30	12	40
≥5	13	29	20	50	9	22	10	33
Type of meals								
Breakfast	43	95	37	93	28	70	24	80
Mid-morning meal	19	42	25	62	11	27	10	33
Lunch	43	95	39	97	33	82	25	85
Afternoon tea	17	38	12	30	10	25	5	16
Dinner	41	91	38	95	33	82	18	60
Additional eating between meals	29	64*	15	37	18	45	9	30
Type of additional snacks								
Sweets	14	48	5	33	7	36	4	44
Sandwiches	6	21	3	20	8	46	2	21
Fruit	9	31	10	67	3	18	3	35

*p<0.05

A more frequent consumption of afternoon and evening meals (more than 80% of the subjects) was stated in the group of men with schizophrenia, whereas in the group of healthy men, an opposite tendency was stated. Snacking between meals in the case of men was also more frequent in the group of patients with schizophrenia who were choosing sandwiches more often as opposed to healthy men who were eating sweets more frequently. Table 3 presents the average energy value and average content of the chosen nutrients in the daily food rations of the patients taking part in the study (Table 3). It was noted that the daily food rations of women with recognized schizophrenia were characterized by a higher energy value and content of the majority of assessed nutrients. Statistically significant differences were noted in the case of the all-

day energy intake and total fat and saturated fatty acids (SFA) content, the percentage of energy derived from saturated fatty acids and total carbohydrate content and the percentage of energy derived from carbohydrates. Furthermore, the food rations of women with schizophrenia were characterized by a statistically significantly lower percentage of energy derived from proteins. It was stated at the same time that despite a higher content of the majority of assessed nutrients in the diets of women with schizophrenia, these diets were providing polyunsaturated fatty acids and dietary fiber at a level that is below the recommendations, whereas saturated fatty acids were being consumed in excess. The diets of healthy women were not satisfying the recommendations in terms of all assessed nutrients, except for total protein intake.

Table 3. Nutrient intake comparison between patients with schizophrenia and controls.

Variables	Women				Men			
	Schizophrenia n=45		Controls n=40		Schizophrenia n=40		Controls n=30	
	Mean (SD)	% of standard	Mean (SD)	% of standard	Mean (SD)	% of standard	Mean (SD)	% of standard
Energy (kcal/day)	1785.0 (558.3)**	91	1478.5 (446.3)	75.8	2052.4 (639.9)*	84	2464.9 (800.8)	101
Total protein (g/day)	63.4 (16.6)	109	65.7 (20.4)	113	72.7 (20.0)**	99	111.7 (30.4)	153
Total fat (g/day)	60.0 (23.0)*	95	49.3 (25.6)	76	86.7 (40.0)	106	91.4 (37.1)	111
SFA (g/day)	27.6 (15.5)**	125	17.8 (12.0)	81	38.6 (20.9)	143	37.6 (16.3)	139
MUFA (g/day)	24.5 (15.5)	94	19.2 (12.0)	74	33.9 (17.5)	103	37.3 (15.8)	113
PUFA (g/day)	8.0 (7.0)	47	8.4 (5.0)	49	8.0 (4.2)*	36	12.3 (5.1)	56
Cholesterol (g/day)	226.0 (128.3)	75	265.0 (224.2)	88	379.5 (261.9)	126	465.8 (331.6)	155
Total Carbohydrates (g/day)	248.9 (100.4)**	90	193.0 (78.2)	68	259.7 (90.8)*	73	319.7 (135.4)	90
Fibre (g/day)	18.2 (7.0)	73	19.9 (7.9)	80	15.9 (5.0)*	64	23.3 (9.7)	93
Protein (%E)	14.3 (2.3)***	-	19.4 (5.4)	-	14.6 (3.0)*	-	18.8 (4.9)	-
Fat (%E)	31.0 (7.9)	-	30.3 (10.1)	-	36.5 (9.0)	-	33.4 (9.9)	-
SFA (% E)	13.4 (4.1)*	-	10.8 (4.7)	-	16.9(3.9)	-	13.7(3.1)	-
MUFA (%E)	12 (3.8)	-	14.9 (5.2)	-	14.7 (4.1)	-	13.6 (3.0)	-
PUFA (%E)	3.9 (2.1)	-	4.8 (2.3)	-	3.5 (1.7)	-	4.5(2.0)	-
Carbohydrates (%E)	54.8 (7.9)*	-	50.8 (11.0)	-	48.7 (10.5)	-	47.7 (9.7)	-

SD-standard deviation, SFA- saturated fatty acids, MUFA-monounsaturated fatty acids, PUFA-polyunsaturated fatty acids, %E-percentage of energy, for continuous variables the independent t-test was used, *p<0.05, **p<0.01, ***p<0.001

An opposite tendency was stated in the compared groups of men: the nutritional rations of men with schizophrenia were characterized by a lower content of the majority of assessed nutrients. A statistically significant lower energy intake and a lower content of total protein, polyunsaturated fatty acids, carbohydrates, dietary fiber as well as the percentage of energy derived from protein was stated in this group as compared to the group of healthy men. At the same time, while comparing the food rations of men affected by schizophrenia with the recommendations for the Polish population, we stated a too low intake of energy, polyunsaturated fatty acids, total carbohydrates and dietary fiber and a too high intake of saturated fatty acids and dietary cholesterol. In the case of the nutritional rations of healthy men, we stated a too low polyunsaturated fatty acid content and a too high total protein, saturated fatty acids and dietary cholesterol content.

Figure 1 presents an energetic structure of the nutritional rations of women with a breakdown by meals (Figure 1). In the group of women affected by schizophrenia, we stated a too low energy value of the breakfast as compared to the recommendations; the other meals were characterized by an energy value that is compliant with the recommendations. In the case of healthy women, an improper distribution of energy value (too low as compared to the recommendations) concerned lunches, afternoon tea and dinners. At the same time, a contribution of snacking in providing energy in the diet was stated (in both groups of women, it amounted to 8%). In the case of men with recognized schizophrenia, we observed a too low energy value of the lunches and afternoon tea and a too high energy value of dinners as compared to the recommendations, whereas in the control group, we stated a too low energy value of the breakfasts and mid-morning meals and lunches and a too high energy value of the dinners. Snacking between meals in this group was providing 5% of the total energy intake (Figure 2).

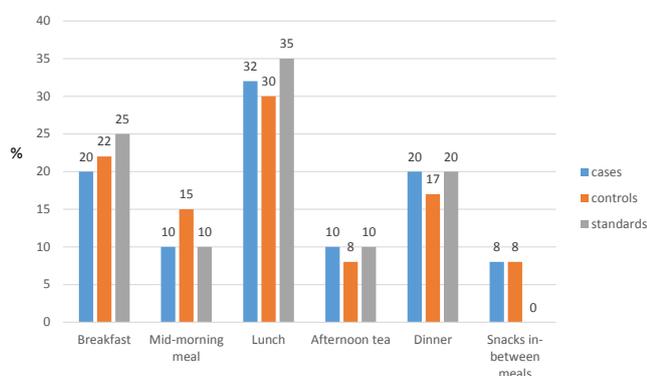


Figure 1. Energy content (%) breakdown per meal determined in both subject groups (women) along with recommended reference values

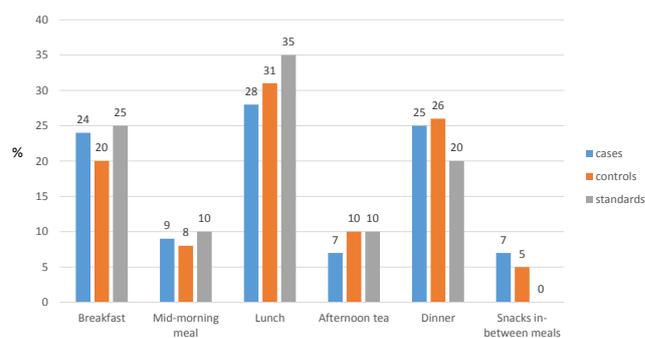


Figure 2. Energy content (%) breakdown per meal determined in both subject groups (men) along with recommended reference values

While assessing the energy value and nutritional value of specific meals consumed by female subjects, it was stated that, in the case of breakfasts, their nutritional value was similar in both compared groups, except for the intake of total fat, saturated and monounsaturated fatty acids, the intake of which was significantly higher in the group of women with recognized schizophrenia (Table 4). In the case of mid-morning meals, the diets of women with recognized schizophrenia were characterized by a significantly lower intake of total protein and dietary fiber as compared to the diets of healthy women. On the other hand, the lunches consumed by women affected by schizophrenia were characterized by a significantly higher energy value and total carbohydrate and dietary fiber content as compared to the lunches of women from the control group. In the case of afternoon tea, both the energy value and intake of specific nutrients were very similar in the food rations of both compared groups and did not show any statistically significant differences. The study also showed that both the energy value of the dinners and the intake of total fat, saturated, monounsaturated and polyunsaturated fatty acids and total carbohydrates was significantly higher in the food rations of women with schizophrenia as compared to the food rations consumed by the control group. While assessing a negative habit, i.e. snacking between meals, it was stated that the food rations of women from both compared groups were characterized by a similar nutritional value (providing mainly carbohydrates and dietary cholesterol) without any statistically significant differences in the intake of specific nutrients. The breakfasts of men with schizophrenia were characterized by a significantly lower content of carbohydrates and dietary fiber as compared to the control group. A significantly lower dietary fiber intake in the food rations of patients was also observed in the case of mid-morning meal. The lunches of the male patients were characterized by a lower intake of energy, total protein, total fat and saturated fatty acids as compared to this kind of meals among healthy people.

Table 4. Nutritional values of meals consumed by subjects.

Variables	Women		Men	
	Schizophrenia n=45	Controls n=40	Schizophrenia n=40	Controls n=30
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Breakfast				
Energy (kcal)	354.3±216.7	326.7±136.1	480.3±244.4	494.2±204.2
Total protein (g)	12.0±6.9	13.5±6.7	16.2±9.5	17.1±8.8
Total fat (g)	14.2±10.5**	9.7±6.8	24.2±16.8	19.8±11.8
SFA (g)	7.4±5.3*	4.4±4.1	12.2±8.3	8.8±5.9
MUFA (g)	5.4±5.2**	3.6±4.1	9.0±6.8	7.9±5.3
PUFA (g)	1.8±1.7	1.6±1.2	1.9±1.8	2.3±1.7
Cholesterol (g)	60.3±70.2	56.3±62.7	150.7±236.9	109.0±182.7
Carbohydrates (g)	50.4±44.4	45.1±23.5	52.0±28.4*	71.6±31.9
Fibr	3.2±3.6	4.3±3.1	2.5±1.6*	4.4±3.1
Mid-morning meal				
Energy (kcal)	174.0±185.0	225.5±151.1	190.5±245.1	210.7±274.0
Total protein (g)	4.0±4.3**	9.8±9.2	5.7±7.9	9.5±15.2
Total fat (g)	5.6±8.6	7.4±7.0	8.0±13.1	7.5±10.4
SFA (g)	2.7±3.6	3.0±2.8	3.7±6.7	3.2±3.9
MUFA (g)	2.1±3.1	2.9±3.4	3.0±4.9	2.7±5.2
PUFA (g)	0.6±0.9	1.2±1.2	1.0±1.7	1.0±2.6
Cholesterol (g)	12.3±19.2	26.7±16.67	22.3±48.0	40.0±24.0
Carbohydrates (g)	26.5±29.2	30.2±22.3	24.7±31.1	35.0±40.3
Fibre (g)	1.9±2.1**	3.9±3.3	1.0±1.3**	2.7±3.9
Lunch				
Energy (kcal)	574.3±251.9**	442.8±160.4	566.9±214.4**	757.0±379.1
Total protein (g)	25.2±11.4	26.7±10.7	25.7±10.2***	44.2±17.8
Total fat (g)	15.0±11.5	14.7±9.8	15.8±11.3***	30.7±21.9
SFA (g)	5.7±5.2	5.0±4.0	6.1±4.1***	11.3±6.9
MUFA (g)	7.0±5.0	6.4±4.7	7.3±5.8	14.2±8.6
PUFA (g)	2.5±2.1	3.0±2.0	1.3±0.9	3.4±1.3
Cholesterol (g)	80.4±61.7	119.2±150.7	83.3±51.7	189.5±195.4
Carbohydrates (g)	79.0±43.4***	52.7±31.8	86.2±39.8	82.5±64.9
Fibre (g)	7.2±3.9**	5.8±3.5	7.2±3.1	6.8±4.4
Afternoon tea				
Energy (kcal)	189.2±170.0	109.2±146.1	155.3±171.5	240.9±270.4
Total protein (g)	5.9±12.1	3.8±6.9	4.3±8.2*	9.2±10.2
Total fat (g)	7.0±11.0	3.3±7.1	6.4±10.0	13.2±15.9
SFA (g)	3.6±1.1	0.9±1.7	2.8±5.0	4.9±4.5
MUFA (g)	2.4±3.7	1.8±2.6	2.5±4.7	4.3±7.5
PUFA (g)	0.8±1.7	0.6±1.1	1.0±1.3	2.2±2.4
Cholesterol (g)	14.1±12.6	8.7±11.1	38.1±35.6	25.8±39.5
Carbohydrates (g)	48.6±51.6	21.2±20.1	20.8±30.9	33.4±34.8
Fibre (g)	1.6±3.3	1.8±2.3	1.2±3.0*	3.1±3.0
Dinner				
Energy (kcal)	364.4±154.4***	247.8±172.5	517.9±278.1	650.5±641.0
Total protein (g)	17.0±14.5	11.7±10.2	16.1±9.0***	28.4±19.7
Total fat (g)	17.0±12.6*	9.7±10.7	26.3±20.6	16.6±13.1
SFA (g)	7.7±5.7***	3.4±4.4	12.4±9.6	7.0±5.6
MUFA (g)	6.5±5.4**	3.2±4.2	10.2±6.9	7.0±5.8
PUFA (g)	2.5±2.0*	1.7±3.2	2.9±1.9	2.3±4.2
Cholesterol (g)	57.1±64.3	51.4±63.9	75.5±78.9	95.3±88.5
Carbohydrates (g)	40.1±18.6***	27.1±20.5	59.5±41.7	71.7±54.7
Fibre (g)	3.3±1.8	3.1±2.5	2.9±1.9*	4.1±3.0
Snacks in-between meals				
Energy (kcal)	134.2±197.2	125.9±168.9	142.7±180.9	113.0±113.3
Total protein (g)	2.7±4.8	2.5±5.0	4.4±7.6	3.4±6.7
Total fat (g)	4.9±7.9	5.0±6.8	6.6±5.3	3.7±6.2
SFA (g)	2.2±3.5	1.7±3.0	2.5±5.3	1.1±2.0
MUFA (g)	1.6±2.1	2.0±3.8	3.0±6.2	1.2±0.6
PUFA (g)	0.9±1.7	1.3±2.0	0.7±1.0	1.1±0.7
Cholesterol (g)	7.6±12.0	8.5±7.2	8.4±8.1	6.9±3.9
Carbohydrates (g)	20.4±16.1	19.2±18.4	16.4±13.5	26.6±12.6
Fibre (g)	1.5±2.5	1.8±3.0	1.1±1.8	2.4±4.3

*p<0.05, **p<0.01, ***p<0.001

The afternoon snacks and dinners of male patients were also characterized by a significantly lower protein intake as compared to the control group. We did not note statistically significant differences in the nutritional value of additional snacks consumed by men.

DISCUSSION

As the research shows, the diet of patients with recognized schizophrenia may deviate from the nutritional habits of healthy people [1, 4, 8]. The in-house study revealed a lack of statistically significant differences in terms of both number and type of usually consumed meals, except for the diets of women with schizophrenia who were consuming 3 meals a day more frequently and were having additional episodes of snacking much more frequently as compared to healthy women. We did not observe any statistically significant differences in the type of snacks consumed between the meals; however, in the group of female patients, sweets were chosen much more frequently, whereas in the group of male patients - these were mainly sandwiches and sweets. There was no statistically significant difference in the nutritional value of products eaten between the meals between the compared groups; however, these were mainly products providing carbohydrates, fats and dietary cholesterol with a little amount of protein. These results are compliant with the studies of *Kampov-Polevoy et al.*, which showed that women with mental disorders and more frequent mood changes were claiming lower self-control while consuming sweet snacks [7].

The in-house study revealed that regardless of the compared group, the afternoon tea and mid-morning meal were the meals that were skipped the most frequently. It was shown in the study of *Roick et al.* that a significantly lower number of patients with recognized schizophrenia was consuming the breakfast and mid-morning meal as compared to healthy people. Statistically significant differences were not stated in the case of the choice of other meals. The authors also revealed statistically significant differences in the more frequent consumption of evening snacks by patients with recognized schizophrenia and the less frequent consumption of products such as, among others, raw/cooked vegetables, whole-grain cereal products and the significantly more frequent consumption of low-calorie products and products belonging to the group of convenience food as compared to the control group [16]. It was shown in the study of *Kim et al.* that patients with recognized schizophrenia admittedly were characterized by a higher regularity in the consumption of meals; however, these meals were poorer in terms of nutritional value, in particular in terms of low intake of protein, polyunsaturated fatty

acids, niacin, folates and vitamin C as compared to the food rations of healthy people. This situation is due to a low consumption of products being a nutritional source of the above-mentioned nutrients [8].

As the research shows, what is most beneficial for the human body is to distribute the total energy value of the daily food ration into 5 meals. In the five-meal model, breakfast should provide 25%, mid-morning meal 10%, lunch 35%, afternoon tea 10%, whereas dinner 20% of the total amount of the all-day food ration [6]. The presented in-house study results are deviated from the quoted recommendations, in particular in the case of the breakfasts of women with schizophrenia and the lunches and dinners in the group of men affected by this disorder. An advantageous aspect was the fact that the snacking habit in the group of women was not providing more than 8% of the total energy intake (7% in the group of men). The previous in-house research conducted among patients with mental disorders revealed a higher energy intake provided by snacking. The products consumed the most frequently were carbohydrate-fat products, while the energy value of consumed snacks was exceeding the energy value of the mid-morning meals and afternoon snacks [18].

A popular nutritional model of societies living in developed countries is characterized by the consumption of a large amount of food that is poor, in particular, in nutrients that condition the proper functioning of the brain, such as e.g. polyunsaturated fatty acids, in particular those from the n-3 group or vitamins from the B group and minerals [4, 8, 14]. While assessing the average energy and nutritional value of the compared food rations of women, it was stated that the food rations of women with recognized schizophrenia were characterized by a significantly higher energy value and content of the majority of the assessed nutrients. Similar results were obtained by other authors [4, 8, 9]. In the case of the compared groups of men, an opposite tendency was observed - the diets of patients with recognized schizophrenia were characterized by a lower energy intake and intake of the majority of the assessed nutrients as compared to healthy people. Other results were obtained in the study of *Kim et al.* [8]. Not only is the total energy intake meaningful in the all-day ration, but also the mutual contribution of specific basic nutrients in providing this energy. The recommended values are applicable to 10-15% of energy derived from protein, 25-30% from fat and 55-65% of energy derived from carbohydrates in its all-day intake [6]. The results obtained in this study are close to the recommended values; however, we observed a higher percentage of energy derived from total fat, saturated fatty acids, total carbohydrates and a lower percentage in the case of proteins and polyunsaturated acids in the food rations

of patients of both sexes as compared to the food rations of healthy subjects. A beneficial influence of the diet providing 46% of energy from carbohydrates, 24% from proteins and 30% from fats (including <8% from saturated fatty acids intake) not only in terms of body mass reduction, but also in connection with cognitive functions was revealed in the research of *Brinkworth et al.* [2]. The protein intake in the food rations of the compared groups of the women assessed in the in-house study did not show any statistically significant differences. Only the diets of male patients were characterized by a significantly lower content of this nutrient as compared to the control group. A protein intake that was similar to the one obtained in this study was observed in the studies of other authors [4, 9]. While assessing the fat intake, we observed a significantly higher content of those in the food rations of women with recognized schizophrenia. A lower content of fat in the food rations of patients with recognized schizophrenia (44.0g-50.0g/day) than the one obtained in this study was observed in the researches of other authors [8, 9, 19]. Not only does the total fat intake have a great importance in appropriately balanced diet, but also paying attention to the content of specific acid groups, in particular polyunsaturated acids, is so important in the functioning of the central nervous system. A very low intake (approx. 40-50% of the recommendations) of polyunsaturated acids was observed in all groups. This situation is disadvantageous because the *omega-6* and *omega-3* fatty acids, as the structural components of the nervous system, fulfil an important role in its functioning. In particular, the *omega-3* fatty acids fulfil an essential role in cerebral processes, having an impact on the liquidity of the cell membranes, function of the membrane's enzymes and synthesis of eicosanoids. Low levels of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in cerebral tissue are considered the main factors of neuropathology of schizophrenia [8]. These acids may prevent mood changes, improve the blood flow and provide better access of the nutrients to the brain [20]. The study of *Pawelczyk et al.* showed that a 6-month-long intervention with fish oil (2.2 g/day EPA + DHA) significantly decreased the psychotic symptoms among patients with schizophrenia [11]. The study revealed that the food rations of female patients were significantly different in terms of a higher saturated fatty acids content as compared to the healthy women. A disadvantageous aspect was a fact of too high consumption of those as compared to the recommendations in the group of women with schizophrenia and in both groups of men. A high consumption of these acids exceeding 7% that is recommended along with an insufficient intake of monounsaturated and polyunsaturated acids, so popular within the Polish population, may have an impact on the

development of cardiovascular diseases, amplifying the bad health condition of psychiatric patients [17]. The studies of other authors also revealed a higher content of saturated fatty acids in the food rations of patients with recognized schizophrenia as compared to healthy people [8, 9]. The in-house study also revealed a too high consumption of dietary cholesterol, but only in the groups of men. The dietary cholesterol intake revealed in other authors' studies was lower than the one obtained in this paper and oscillated between 190-209mg/d in the group of women and between 241-275mg/d in the group of men [8, 9]. While assessing the total carbohydrate content in the food rations of the patients, it was stated that the diets of women with recognized schizophrenia were providing significantly higher amounts of this nutrient as compared to healthy women, whereas among the male patients, an opposite tendency was observed. A value of these nutrients that is similar to the one obtained in this study was observed in the diets of people with schizophrenia examined by other authors [8, 9]. At the same time, the in-house study revealed that the diets of women with recognized schizophrenia were characterized by a percentage of energy derived from carbohydrates that was the closest to the recommendations as compared to the other groups. The in-house study in all the compared groups revealed also a low dietary fiber intake (the lowest intake – 15.9g/d on average in the group of men with recognized schizophrenia). An even lower intake of this nutrient (9-13g/d) than the one revealed in the in-house study was stated in the studies of other authors [4, 19]. As the studies showed, this situation may be due to an insufficient consumption of products being a source of this nutrient: that is to say, raw vegetables and fruits, whole-grain cereal products, pulses [13, 16, 19]. According to *Sugawara et al.*, the most desired nutritional model intended for patients with recognized schizophrenia allowing to maintain the appropriate nutritional state, including, among others, the prevention of excessive body mass, is a model taking into consideration an appropriate intake of protein, fats, in particular of polyunsaturated fatty acids from the n-3 and n-6 group, as well as the intake of dietary fiber, folates, riboflavin, pyridoxine, cobalamin and vitamin C [19].

The study of *Peet et al.* revealed that there is a relationship between the consumption of foodstuffs and an intensification of symptoms and frequency of schizophrenic relapses. These researchers observed that there is a negative correlation between consumption of such products as meat, dairy products or eggs and the prognosis of schizophrenia measured by a percentage of people with severe functional impairment. The multiple regression analysis revealed though that the consumption of monosaccharides was the most significant factor associated with the course of illness

[13]. The regression analysis conducted by *Roick et al.* revealed that, in the case of patients with recognized schizophrenia, the factors affecting their habits related to health are – among others – sex, educational level and age [16]. These researchers noted that women choose foodstuffs with a higher nutritional value more frequently than men; they drink less alcohol and smoke fewer cigarettes. Furthermore, patients with a higher education degree choose healthier foodstuffs more often and smoke fewer cigarettes during a day, just like the older patients [16]. According to *Kim et al.*, the standard recommendations related to the diet of patients with recognized schizophrenia should take into account a higher consumption of whole-grain cereal products, in particular brown rice, products with barley and rye grains, but also products rich in niacin such as eggs, poultry, dairy products. These authors point out that it is necessary to increase the consumption of products rich in polyunsaturated fatty acids such as mackerel, tuna, salmon, vegetable oils, nuts while maintaining, at the same time, the total intake of fats and saturated fatty acids respectively below the level of 30% and 7% of the energy value in the diet. According to these authors, it is necessary to consume vegetables and fruits at least 5 times a day, taking into account, in particular, dark green vegetables, mainly spinach, lettuce, broccoli and seasonal fruits being a source of vitamin C [8].

CONCLUSIONS

Despite the differences between the nutritional value of meals of the patients with recognized schizophrenia and those of healthy people, it seems necessary to involve the patients with recognized schizophrenia in the education of forming proper nutritional habits that promote the principles of rational nutrition and increase the motivation for preparation one's own healthy meals.

Acknowledgement

This study was performed as a project of the Faculty of Health Sciences, Medical University, Białystok (No. N/ST/ZB/17/001/3316).

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. *Bly M.J., Taylor S.F., Dalack G., Pop-Busui R., Burghardt K.J., Evans S.J., McInnis M.I., Grove T.B., Brook R.D., Zöllner S.K., Ellingrod V.L.*: Metabolic syndrome in bipolar disorder and schizophrenia: dietary and lifestyle factors compared to the general population. *Bipolar Disord* 2014;16(3):277-288.
2. *Brinkworth G.D., Buckley J., Noakes M., Clifton P.M., Wilson C.J.*: Long-term effects of a very low-carbohydrate diet and a low-fat diet on mood and cognitive function. *Arch Intern Med* 2009;169(20):1873-1880.
3. *Correll Ch.U., Roninson D.G., Schooler N.R., Brunette M.F., Mueser K.T., Rosenheck R.A., Marcy P., Addington J., Estroff S.E., Roninson J., Penn D.L., Azrin S., Goldstein A., Severe J., Heinszen R., Kane J.M.*: Cardiometabolic risk in patients with first-episode schizophrenia spectrum disorders. Baseline results from the RAISE-ETP study. *JAMA Psychiatry* 2014;71(12):1350-1363.
4. *Ito H., Kumagai T., Kimura M., Koike S., Shimizu T.*: Dietary intake in body mass index differences in community-based Japanese patients with schizophrenia. *Iran J Public Health* 2015;44(5):639-645.
5. *Jahrami H.A., Faris M.A.E., Saif Z.Q., Hammad L.H.*: Assessing dietary and lifestyle risk factors and their associations with disease comorbidities among patients with schizophrenia: A case-control study from Bahrain. *Asian J Psychiatr* 2017;28:115-123.
6. *Jarosz M.*: Normy żywienia dla populacji polskiej-nowelizacja [Revised dietary standards for the Polish population]. Intytut Żywności i Żywienia, Warszawa 2012 (in Polish).
7. *Kampov-Polevoy A.B., Alterman A., Khalitov E., Garbutt J.C.*: Sweet preference predicts mood altering effect of and impaired control over eating sweet foods. *Eating Behaviors* 2006;7(3):181-187.
8. *Kim E.J., Lim S.V., Lee H.J., Lee J.Y., Choi S., Kim S.Y., Kim J.M., Shin I.S., Yoon J.S., Yang S.J., Kim S.W.*: Low dietary intake of n-3 fatty acids, niacin, folate, and vitamin C in Korean patients with schizophrenia and the development of dietary guidelines for schizophrenia. *Nutr Res* 2017;45:10-18.
9. *Konarzewska B., Stefańska E., Wendołowicz A., Cwalina U., Golonko A., Malus A., Kowzan U., Szulc A., Rudzki L., Ostrowska L.*: Visceral obesity in normal-weight patients suffering from chronic schizophrenia. *BMC Psychiatry* 2014;14:35 doi:10.1186/1471-244X-14-35.
10. *Nunes D., Eskinazi B., Rockett F.C., Delgado V.B., Perry I.D.S.*: Nutritional status, food intake and cardiovascular disease risk in individuals with schizophrenia in southern Brazil: A case-control study. *Rev Psiquiatr Salud Ment* 2014;7(2):72-79.
11. *Pawelczyk T., Grancow-Grabka M., Kotlicka-Antczak M., Trafalska E., Pawelczyk A.*: A randomized controlled study of the efficacy of six-month supplementation with concentrated fish oil rich in omega-3 polyunsaturated fatty acids in first episode schizophrenia. *J Psychiatr Res* 2016;73:34-44.
12. *Peet M.*: Eicosapentaenoic acid in the treatment of schizophrenia and depression: rationale and preliminary double-blind clinical trial results. *Prostaglandins Leukot Essent Fatty Acids* 2003;69(6):477-485.
13. *Peet M.*: International variations in the outcome of schizophrenia and the prevalence of depression in relation to national dietary practices: an ecological analysis. *BJP* 2004;184(5):404-408.
14. *Peet M.*: Omega-3 Polyunsaturated fatty acids in the treatment of schizophrenia. *Isr J Psychiatry Relat Sci* 2008;45(1):19-25.

15. Ratliff J.C., Palmese L.B., Reutenauer E.L., Liskov E., Grilo C.M., Tek C.: The effect of dietary and physical activity pattern on metabolic profile in individuals with schizophrenia: A cross-sectional study. *Compr Psychiatry* 2012;53(7):1028-1033.
16. Roick Ch., Fritz-Wieacker A., Matschinger H., Heider D., Schindler J.: Health habits of patients with schizophrenia. *Soc Psychiatry Epidemiol* 2007;42(4):268-276.
17. Stefańska E., Wendolowicz A., Cwalina U., Konarzewska B., Waszkiewicz N., Ostrowska L.: Eating habits and the risk of cardiovascular disease in patients with recurrent depressive disorders. *Psychiatr Pol* 2016;50(6):1119-1133.
18. Stefańska E., Wendolowicz A., Kowzan U., Konarzewska B., Szulc A., Ostrowska L.: Nutritional values of diets consumed by women suffering unipolar depression. *Rocz Panstw Zakl Hig* 2014;65(2):139-145.
19. Sugawara N., Yasui-Furukori N., Sato Y., Saito M., Furukori H., Nakagami T., Ishioka M., Kaneko S.: Dietary patterns are associated with obesity in Japanese patients with schizophrenia. *BMC Psychiatry* 2014;14:184 doi:10.1186/1471-244X-14-184.
20. Wilk J.B., Tsai M.Y., Hanson N.Q., Gaziano M., Djousse L.: Plasma and dietary omega-3 fatty acids, fish intake, and heart failure risk in the Physicians' Health Study. *Am J Clin Nutr* 2012;96(4):882-888.
21. World Health Organisation. International statistical classification of diseases and health-related problems. 10th rev. Geneva, WHO, 1992.

Received: 08.12.2017

Accepted: 10.03.2018

EATING BEHAVIOURS OF PRIMARY SCHOOL PUPILS FROM ŚLĄSKIE, MAŁOPOLSKIE AND OPOLSKIE VOIVODESHIPS IN POLAND

Anna Dolipska¹, Monika Majerczyk¹, Aleksandra Góra¹, Karolina Janion², Elżbieta Szczepańska³

¹Scientific Society of Young Educators, Department of Human Nutrition,

School of Public Health in Bytom, Medical University of Silesia in Katowice, Poland

²Department of Nutrition-Related Disease Prevention, School of Public Health in Bytom, Medical University of Silesia in Katowice, Poland

³Department of Human Nutrition, School of Public Health in Bytom, Medical University of Silesia in Katowice, Poland

ABSTRACT

Background. Nutrition is one of the major environmental factors affecting children's physical development and health, with nutrition mistakes made in early years of life having short- and long-term health consequences.

Objective. This study has been aimed at evaluating eating behaviours of primary school pupils and determining whether there are relationships between pupils' eating habits and their area of residence.

Material and methods. The study was conducted in primary schools located in the following voivodeships (administrative units) in Poland: Śląskie, Opolskie and Małopolskie, on a total sample of 1138 pupils. A survey specially designed for the purpose of this study was used to investigate the pupils' eating behaviours. The findings were then analysed with the use of MS Excel 2010 and Statistica 12.0 software.

Results. According to the survey, 61.42% of pupils in our study ate the recommended number of meals daily. 72.74% reported eating breakfast daily, 66.17% stated they ate packed lunch/midmorning snack daily, 17.49% reported eating wholemeal bread more than once daily, whilst milk and natural yoghurt were consumed daily by 20.04% and 10.81% of pupils, respectively. Sweets and salty snacks were excluded from the diet of 2.2% and 3.08% of pupils respectively. 6.59% of pupils reported not eating fast food at all.

Conclusions. The eating behaviours of primary school pupils differ. Regional variations in eating behaviours have been found to exist, revealing a correlation between the pupils' area of residence (voivodeship) and some eating behaviours. The largest number of healthy eating behaviours were reported by pupils from Małopolskie Voivodeship.

Key words: children eating behaviours, pupils, primary school children

STRESZCZENIE

Wprowadzenie. Odżywianie jest jednym z najważniejszych czynników środowiskowych wpływających na rozwój fizyczny i stan zdrowia dziecka. Błędy żywieniowe popełniane we wczesnych latach życia dziecka mają zarówno krótko- jak i długoterminowe konsekwencje zdrowotne.

Cel. Ocena zachowań żywieniowych uczniów szkół podstawowych oraz stwierdzenie czy istnieją zależności pomiędzy zachowaniami żywieniowymi uczniów i ich miejscem zamieszkania.

Material i metodyka. Badanie zostało przeprowadzone w szkołach podstawowych na terenie województwa śląskiego, opolskiego i małopolskiego wśród 1138 uczniów. Do oceny zachowań żywieniowych posłużył autorski kwestionariusz ankiety. Uzyskane wyniki analizowano przy pomocy programów MS Excel 2010 i Statistica 12.0.

Wyniki. Spożywanie zalecanej liczby posiłków deklarowało 61,42% uczniów. Na codzienne spożywanie I śniadania wskazało 72,74% uczniów, II śniadanie codziennie spożywało 66,17% uczniów. 17,49% uczniów zadeklarowało kilkukrotne spożycie ciemnego pieczywa w ciągu dnia, mleko i jogurty naturalne z tą częstością spożywało odpowiednio 20.04% i 10.81% uczniów. Wykluczenie z diety słodczy oraz słonych przekąsek zadeklarowało odpowiednio 2.2% i 3.08% uczniów. 6.59% uczniów nie spożywa produktów typu fast-food.

Wnioski. Zachowania żywieniowe uczniów szkół podstawowych są różnicowane. Stwierdzono występowanie zależności pomiędzy niektórymi zachowaniami żywieniowymi uczniów i ich miejscem zamieszkania. Najwięcej korzystnych zachowań żywieniowych zaobserwowano u uczniów zamieszkujących województwo małopolskie.

Słowa kluczowe: dzieci, zachowania żywieniowe, uczniowie, dzieci szkół podstawowych

Corresponding author: Elżbieta Szczepańska, Department of Human Nutrition, School of Public Health in Bytom, Medical University of Silesia in Katowice, Jordana Street 19, 41-808 Zabrze, Poland, tel. +48 32 275 51 97, e-mail: eszczepanska@sum.edu.pl

INTRODUCTION

Nutrition is one of the major factors affecting human health and lifespan. Requirements for energy and nutrients supplied with food vary with age. In children, energy and nutrient intake must cover the needs of the growing and developing body. An adequate amount of energy must also be supplied to facilitate proper mental and physical activity [6, 12].

Eating behaviours are in other word dietary choices, including i.a. the selection of eaten foods, as well as the number and timing of meals eaten every day. These are all components that make up nutrition models which, along with the level of physical activity, affect an individual's health and optimum physical, psychological and social growth [4].

Eating behaviours shaped in childhood are frequently maintained in adulthood. While making dietary choices, children are not driven by the nutritional value of foods they eat, primarily paying attention to food's appearance, taste and smell. They are also susceptible to dietary trends and fads, and are always keen to copy their peers. School-age children tend to have a low level of nutritional awareness, hence the significant role of parents and school in proper education as regards nutrition [3, 25].

Imitating parents' unhealthy eating habits, a low level of nutrition education/awareness, dietary trends, the ubiquitous promotion of high-calorie snacks in media and their wide availability may all result with unhealthy eating behaviours with grave consequences for children's future [18]. Inadequate nutrition at this stage of life has both short- and long-term health consequences. The prevalence of child obesity has been observed to soar recently in many countries, including Poland. The results of multiple studies point to a relationship between unhealthy eating behaviours in children and the incidence of diabetes, osteoporosis or cardiovascular diseases in adults [13, 15].

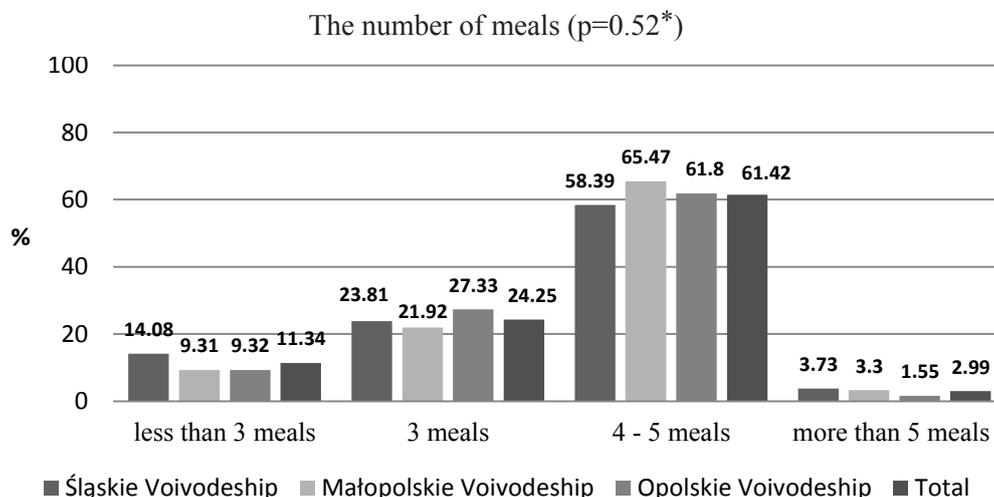
This study has been aimed at evaluating eating behaviours of primary school pupils and determining whether there are relationships between pupils' eating habits and their area of residence.

MATERIAL AND METHODS

The study was carried out personally in spring 2017, and covered a total of 1138 pupils attending primary schools in Śląskie Voivodeship (n=483, 42.4%), Małopolskie Voivodeship (n=333; 29.3%) and Opolskie Voivodeship (n=322; 28.3%), including 573 (50.4%) girls and 565 (48.6%) boys. Among the participants, 339 (29.8%) were Year 4 pupils, 420 (36.9%) Year 5, and 379 (33.3) Year 6 pupils. A dedicated survey was specially developed for the purpose of the study to be used as the research tool, which consisted of a demographic section and a section containing questions facilitating the evaluation of eating behaviours, including the frequency of consumption of given foods within the last 30 days preceding the study. The obtained results were then processed with Microsoft Excel 2010 software, and statistical analysis was performed with Statistica 12.0 (StatSoft. Inc) software. For the purpose of the statistical analysis, various response options in the questions concerning the frequency of food product consumption were pooled together, with the following options distinguished: every day, several times a week, several times a month, occasionally and/or never. Chi square test was utilized to examine the relationship between pupils' eating behaviours and frequency of the consumption of given foods and the voivodeship where students live. For all analyses, $p < 0.05$ was assumed as statistically significant.

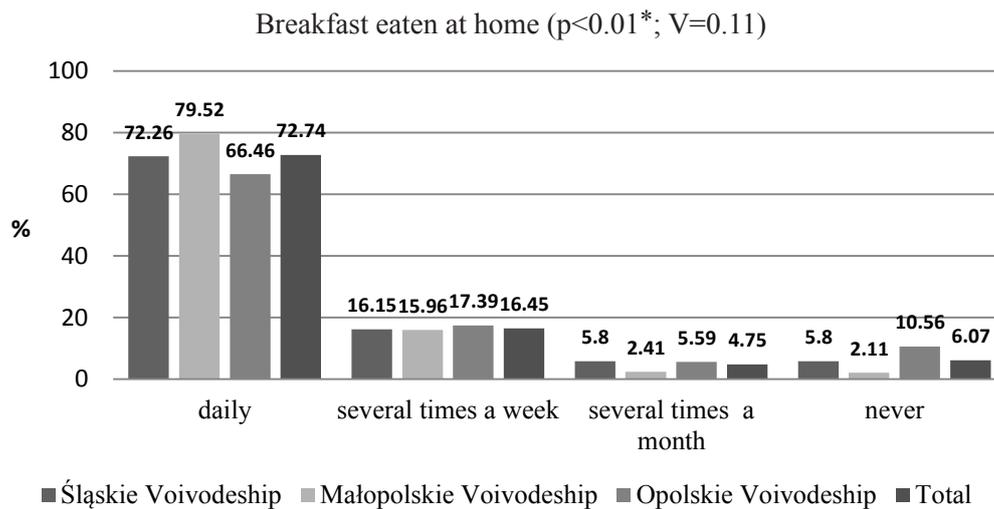
RESULTS

Selected eating behaviours of the studied primary school pupils have been shown in Figures 1-3.



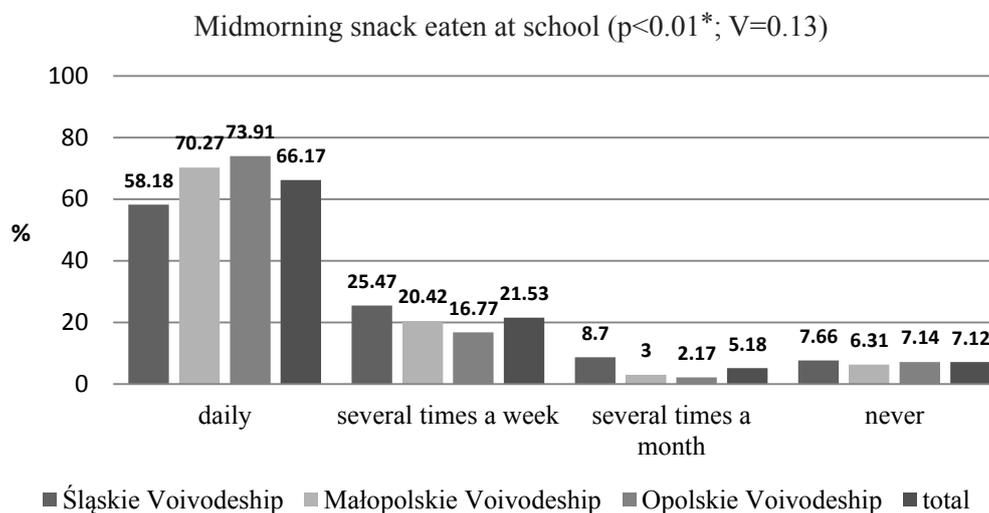
*significance level for Chi square test

Figure 1. The number of meals eaten daily by pupils



*significance level for Chi square test

Figure 2. Breakfast eaten at home by pupils



*significance level for Chi square test

Figure 3. Midmorning snack eaten at school by pupils

61.42% of pupils reported eating the recommended number of 4-5 meals every day, including 58.3% of pupils from Śląskie Voivodeship vs 65.47% of pupils from Małopolskie Voivodeship vs 61.8% of pupils from Opolskie Voivodeship. Breakfast was eaten daily by 72.26%, 79.52 and 66.46% of pupils from respective voivodeships, 72.74% in total. Midmorning snack was eaten daily by 66.17% of pupils, including 58.18% from Śląskie vs 70.27% from Małopolskie vs 73.91% from Opolskie Voivodeship (Figures 1-3).

A correlation between the children's area of residence and their frequency of breakfast intake ($p < 0.01$; $V = 0.11$) and midmorning snack intake ($p < 0.01$; $V = 0.13$) was identified (Figures 1-3).

The frequency of intake of selected foods has been shown in Tables 1-3.

The analysis of intake food products of plant origin showed that 17.49% of pupils ate wholemeal bread, including 21.02% of pupils from Małopolskie Voivodeship, with this answer less frequently selected by pupils from Śląskie and Opolskie voivodeships, 17.6% and 13.66% respectively. Vegetables and fruits are eaten several times a day by 37.79% and 55.45% of participants respectively, including 41.41% and 55.28% from Śląskie vs 40.24% vs 60.60% from Małopolskie, and 29.81% and 50.93% of pupils from Opolskie Voivodeship (Table 1).

Correlation between the studied pupils' area of residence and the frequency of their intake of wholemeal bread was statistically significant. The obtained results suggest that children from Małopolskie Voivodeship eat wholemeal bread significantly more frequently than those living in Śląskie or Opolskie Voivodeship ($p = 0.03$; $V = 0.08$) (Table 1).

Table 1. Intake of food products of plant origin

Group of food products	Frequency of intake of selected foods	Voivodeship						Total		Result of the test*
		śląskie		małopolskie		opolskie		n	%	
		n	%	n	%	n	%			
Wholemeal bread	Several times a day	85	17.60	70	21.02	44	13.66	199	17.49	p=0.03 V=0.08
	Once-a-day	67	13.87	65	19.52	48	14.91	180	15.82	
	Several times a week	104	21.53	70	21.02	77	23.91	251	22.06	
	Several times a month	65	13.46	39	11.71	53	16.46	157	13.80	
	Occasionally	69	14.29	39	11.71	46	14.29	154	13.53	
	Never	93	19.25	50	15.02	54	16.77	197	17.31	
Vegetables	Several times a day	200	41.41	134	40.24	96	29.81	430	37.79	p=0.43
	Once-a-day	139	28.78	102	30.63	110	34.16	351	30.84	
	Several times a week	94	19.46	66	19.82	80	24.84	240	21.09	
	Several times a month	20	4.14	15	4.50	18	5.59	53	4.66	
	Occasionally	14	2.90	10	3.00	11	3.42	35	3.08	
	Never	16	3.31	6	1.80	7	2.17	29	2.55	
Fruits	Several times a day	267	55.28	200	60.60	164	50.93	631	55.45	p=0.22
	Once-a-day	117	24.22	80	24.02	84	26.09	281	24.69	
	Several times a week	73	15.11	43	12.91	54	16.77	170	14.94	
	Several times a month	12	2.48	7	2.10	12	3.73	31	2.72	
	Occasionally	5	1.04	1	0.30	6	1.86	12	1.05	
	Never	9	1.86	2	0.6	2	0.62	13	1.14	

*significance level for *Chi*- square test

Table 2. Intake of animal origin food products

Group of food products	Frequency of intake of selected foods	Voivodeship						Total		Result of the test*
		śląskie		małopolskie		opolskie		n	%	
		n	%	n	%	n	%			
Milk	Several times a day	89	18.43	75	22.52	64	19.88	228	20.04	p<0.01 V=0.11
	Once-a-day	136	28.16	119	35.74	84	26.09	339	29.79	
	Several times a week	126	26.09	94	28.23	87	27.02	307	26.98	
	Several times a month	51	10.56	19	5.71	22	6.83	92	8.08	
	Occasionally	33	6.83	8	2.40	26	8.07	67	5.89	
	Never	48	9.94	18	5.41	39	12.11	105	9.23	
Natural yoghurt	Several times a day	52	10.77	45	13.51	26	8.07	123	10.81	p=0.13
	Once-a-day	74	15.32	58	17.42	54	16.77	186	16.34	
	Several times a week	122	25.26	99	29.73	93	28.88	314	27.59	
	Several times a month	96	19.88	51	15.32	69	21.43	216	19.98	
	Occasionally	66	13.66	34	10.21	41	12.73	141	12.39	
	Never	73	15.11	46	13.81	39	12.11	158	13.88	
Cottage cheese	Several times a day	34	7.04	20	6.01	22	6.85	76	6.68	p<0.01 V=0.11
	Once-a-day	50	10.35	76	22.82	48	14.95	174	15.29	
	Several times a week	105	21.74	91	27.33	89	27.64	285	25.04	
	Several times a month	117	24.22	55	16.52	56	17.45	228	20.04	
	Occasionally	77	15.94	31	9.31	46	14.33	154	13.53	
	Never	100	20.70	60	18.02	61	19.00	221	19.42	
Cheese (hard or processed cheese)	Several times a day	87	18.01	56	16.82	42	13.04	185	16.26	p=0.92
	Once-a-day	123	25.47	101	30.33	76	23.60	300	26.36	
	Several times a week	156	32.30	108	32.43	130	40.37	394	34.62	
	Several times a month	44	9.11	30	9.01	32	9.94	106	9.31	
	Occasionally	27	5.29	13	3.90	18	5.59	58	5.10	
	Never	46	9.52	25	7.51	24	7.45	95	8.35	
Meat	Several times a day	130	26.92	62	18.62	60	18.63	252	22.14	p=0.26
	Once-a-day	162	33.54	146	43.84	122	37.89	430	37.79	
	Several times a week	145	30.20	108	32.43	109	33.85	362	31.81	
	Several times a month	25	5.18	9	2.70	16	4.97	50	4.39	
	Occasionally	8	1.66	7	2.10	12	3.73	27	2.37	
	Never	13	2.69	1	0.30	3	0.93	17	1.49	
Fish	Several times a day	21	4.35	13	3.90	6	1.86	40	3.51	p<0.01 V=0.12
	Once-a-day	22	4.55	31	9.31	22	6.83	75	6.59	
	Several times a week	122	25.26	123	36.94	92	28.57	337	29.61	
	Several times a month	156	32.30	109	32.73	119	36.96	384	33.74	
	Occasionally	100	20.7	42	12.61	46	14.29	188	16.52	
	Never	62	12.94	15	4.50	37	11.49	114	10.02	

*significance level for *Chi* square test

The analysis of intake of food products of animal origin showed that milk and natural yoghurt were consumed several times a day by 20.04% and 10.81% of pupils respectively, including 18.43% and 10.77% of pupils from Śląskie Voivodeship vs 22.52% and 13.51% of pupils from Małopolskie Voivodeship vs 19.88% and 8.07% of pupils from Opolskie Voivodeship. A total of 34.62% of pupils reported eating cheese (hard or processed cheese), including 32.30% of pupils from Śląskie Voivodeship vs 32.43% pupils from Małopolskie Voivodeship vs 40.37% of pupils from Opolskie Voivodeship. Once-a-day intake of meat was reported by 37.79% of pupils, including 33.54% of pupils from Śląskie Voivodeship vs 43.84% from

Małopolskie Voivodeship vs 37.89% from Opolskie Voivodeship. The recommended frequency of fish intake (several times a week) was noted among 29.61% of pupils, including 25.26% of pupils from Śląskie vs 36.94% of pupils from Małopolskie vs 28.57% of pupils from Opolskie Voivodeship (Table 2).

Correlation between the children's area of residence and the frequency of milk, cottage cheese and fish intake was statistically significant. The results suggest that children from Małopolskie Voivodeship drink milk ($p<0.01$; $V=0.11$), eat cottage cheese ($p<0.01$; $V=0.11$) and eat fish ($p<0.01$; $V=0.12$) significantly more frequently than those from Śląskie and Opolskie Voivodeship (Table 2).

Table 3. Intake of foods not recommended for school-age children

Group of food products	Frequency of intake of selected foods	Voivodeship						Total		Result of the test*
		śląskie		małopolskie		opolskie		n	%	
		n	%	n	%	n	%			
Sweets	Several times a day	79	16.36	39	11.71	48	14.91	166	14.59	p=0.07
	Once-a-day	118	24.40	75	22.52	63	19.57	256	22.50	
	Several times a week	134	27.74	101	30.33	125	38.82	360	31.63	
	Several times a month	75	15.53	70	21.02	45	13.98	190	16.70	
	Occasionally	65	13.46	42	12.61	34	10.56	141	12.39	
	Never	12	2.48	6	1.80	7	2.17	25	2.20	
Salty snacks	Several times a day	43	8.90	23	6.91	20	6.21	86	7.56	p=0.25
	Once-a-day	69	14.29	45	13.51	35	10.87	149	13.09	
	Several times a week	134	27.74	94	28.23	105	32.61	333	29.26	
	Several times a month	124	25.67	100	30.03	96	29.81	320	28.12	
	Occasionally	97	20.08	61	18.32	57	17.70	215	18.89	
	Never	16	3.31	10	3.00	9	2.80	35	3.08	
Fast food products	Once-a-day	26	5.38	17	5.11	10	3.11	53	4.66	p=0.69
	Several times a week	66	13.66	43	12.91	38	11.80	147	12.92	
	Several times a month	164	33.95	112	33.63	121	37.58	397	34.89	
	Occasionally	195	40.47	135	40.54	126	42.24	466	40.95	
	Never	32	6.63	26	7.81	17	5.28	75	6.59	
"Instant" food products	Several times a day	14	2.90	3	0.90	8	2.48	25	2.20	p<0.01 V=0.13
	Once-a-day	23	4.76	14	4.20	4	1.24	41	3.60	
	Several times a week	49	10.14	17	5.11	43	13.35	109	9.58	
	Several times a month	69	14.29	41	12.31	75	23.29	185	16.26	
	Occasionally	113	23.40	60	18.02	103	31.99	276	24.25	
	Never	215	44.51	198	59.46	89	27.64	502	44.11	
Sweetened carbonated Drinks	Several times a day	48	9.94	19	5.71	27	8.39	94	8.26	p=0.04 V=0.08
	Once-a-day	50	10.35	21	6.31	22	6.83	93	8.17	
	Several times a week	109	22.57	67	20.12	72	22.26	248	21.79	
	Several times a month	129	26.71	100	30.03	89	27.64	318	27.94	
	Occasionally	107	22.15	98	29.43	79	24.53	284	24.96	
	Never	40	8.28	28	8.41	33	10.25	101	8.88	

*significance level for *Chi* square test

The analysis of intake of foods not recommended in the diet of school-age children showed 2.2% and 3.08% of pupils in our study to report not eating sweets and salty snacks (respectively), including 2.48% and 3.31% from Śląskie Voivodeship vs 1.8% and 3% from Małopolskie Voivodeship vs 2.17% and 2.8% from Opolskie Voivodeship. A total of 6.9% of

pupils reported never eating fast food products, including 6.63% from Śląskie Voivodeship vs 7.81% from Małopolskie Voivodeship vs 5.25% from Opolskie Voivodeship. As far as "instant" food products are concerned, 44.51% of pupils reported exclusion of this group of foods from their diet, including 44.51% of pupils from Śląskie Voivodeship vs 59.46% from

Małopolskie Voivodeship. Pupils from Opolskie Voivodeship made up a much lower percentage of those never eating “instant” food products, at 27.64%. A total of 8.88% of respondents reported not drinking sweetened carbonated drinks, including 8.28% from Śląskie Voivodeship vs 8.41% from Małopolskie Voivodeship vs 10.25% from Opolskie Voivodeship (Table 3).

Relationships between the pupils’ area of residence and intake of “instant” food products and sweetened carbonated drinks were found to be statistically significant ($p < 0.01$; $V = 0.13$ and $p = 0.04$; $V = 0.08$, respectively) (Table 3).

DISCUSSION

Nutrition is one of the major environmental factors affecting children’s physical development and health. In recent years, an increase in the numbers of obese and overweight children has been seen, with the problem affecting developed and developing countries alike [12,22]. According to the estimates by the International Obesity Task Force for the World Health Organization 1 in 5 European children is overweight. The phenomenon is on the rise, with the group of overweight individuals under 18 years old expanding by 4000 000 yearly [8,12]. The results of an audit conducted in Poland by the Supreme Audit Office (*Najwyższa Izba Kontroli, NIK*) in the period from 19th of September 2016 to 3rd of January 2017, which covered 20 state-run schools and 10 Municipality Offices from Lubelskie, Małopolskie, Mazowieckie, Podlaskie and Kujawsko-Pomorskie voivodeships raise major concerns. According to the audit report, the rate of obese and overweight pupils is increasing, and the programmes aimed at promoting healthy nutrition/lifestyle and education aimed at shaping healthy eating behaviours have failed to put a stop to this trend. In 19 out of 20 audited schools, the percentage of pupils with weight disorders increased from 16.8% in the school year of 2012/2013 to 22% in the school year of 2015/2016, with the percentage of overweight and obese children having increased most rapidly [7].

Meal frequency affects the processes of weight control. According to the available reports, individuals who eat more frequent meals tend to eat smaller portions in any given meal, accounting for a smaller total energy intake. The amount of energy supplied every day must account for a person’s age, sex and level of physical activity [23]. School-age children and adolescents are recommended to eat 5 meals at regular times of the day, with intervals between the meals not exceeding 3-4 hours [6]. In our study, we found that only 58.39% of pupils from Śląskie Voivodeship, 61.8% of pupils from Opolskie Voivodeship and 65.47% of children from Małopolskie Voivodeship ate 4-5 meals

a day. Similar results were obtained in a study investigating the eating behaviours of primary school pupils from Kaliski Powiat which found that only 53% of respondents ate 4-5 meals a day [23], and in a study investigating the eating behaviours of children aged 6-13 years old attending selected primary schools in rural areas of Śląskie and Opolskie voivodeships, carried out by *Jonczyk et al.* The authors of the latter study found as little as 46.11% of girls and 50.69% of boys to eat 4-5 meals a day [9].

Nutrition specialists stress the role of breakfast as the most important meal of day. In our study, breakfast was eaten by 72.6%, 79.53% and 66.46% of pupils from respective voivodeships. Similar results were acquired in a study conducted in 2015 in Piekary Śląskie, in which approximately 67.32% of respondents (64.45% of girls and 70.24% of boys) had breakfast daily before school [10]. Pupils who spend more than 6 hours at school should receive one nutritious meal (midmorning snack or cooked lunch) during that time [23]. In our study, only 58.18% of children from Śląskie Voivodeship reported eating daily a midmorning snack at school. Małopolskie and Opolskie Voivodeship had better results in this respect, with 70.27% vs 73.91% of children reporting eating a midmorning snack at school on a daily basis. Similarly, in the study by *Jonczyk et al.*, midmorning snack was consumed daily by 69.76% of pupils (68.91% of girls vs 70.51% of boys) [9].

Daily energy requirements should be met by well-balanced meals providing all the necessary nutrients. With this goal in mind, daily nutrition must include various food groups. Wholemeal food products, including wholemeal bread, are a good source of complex carbohydrates. Pupils in our study, however, rarely ate wholemeal bread, with as few as 33.31% of participants eating this group of foods on a daily basis (including 17.49% eating wholemeal bread several times a day and 15.82% - once a day). This result is similar to the results obtained by *Wojtyła-Bucior et al.* in the study examining eating behaviours of primary school pupils in Kaliski Powiat [23]. The study showed that pupils were typically very reluctant to eat wholemeal bread, with as much as 31% of respondents reporting intake of wholemeal bread less frequent than once a week. Only 11% of pupils in that study stated that they ate wholemeal bread on a daily basis [23].

Fruits and vegetables should be a daily component of children’s diet due to their health benefits. Fruits and vegetables intake reduces the risk for many diseases, such as obesity and diabetes [24]. In our study, 41.41% children from Śląskie Voivodeship vs 40.42% of children from Małopolskie Voivodeship vs 29.81% of children from Opolskie Voivodeship reported daily vegetable intake. Alarmingly, 1 in every 20 participants of our study (5.36%) did not eat vegetables at

all or only occasionally. Fruits, in turn, were found to be eaten several times a day by 60.6% of pupils from Małopolskie Voivodeship vs 55.28% of respondents from Śląskie Voivodeship vs 50.93% of respondents from Opolskie Voivodeship, which is consistent with the results of the study by *Jonczyk et al.*, which demonstrated that few pupils ate adequate amounts of fruits and vegetables daily. According to their study, 69.83% of girls and 57.43% of boys ate fruits and vegetables several times a day, whilst 29% of girls and 39% of boys ate fruits and vegetables once daily. Alarming, 1.17% of girls and 3.57% of boys stated they had no access to fresh fruit and vegetables at all [9,10].

According to the principles of healthy nutrition of children and adolescents, milk or dairy products should be consumed 3-4 times a day, as they are rich in calcium. Intake of dairy products has also been found to counteract hypertension [14]. In our study, 58.26% of pupils from Małopolskie Voivodeship vs 46.5% from Śląskie Voivodeship vs 45.97% of pupils from Opolskie Voivodeship reported milk intake at least once a day. Similar results were obtained by *Ambroży et al.*, who investigated eating behaviours and intake of selected foods by children aged 10-13 years old living in urban and rural areas. In their study, they found milk to be consumed on a daily basis by 48.6% of respondents from urban areas vs 48.3% of respondents from rural areas [2]. In the group of school-age children 6-13 years old living in Piekary Śląskie, studied by *Jonczyk et al.*, milk was consumed daily by 53.1% of respondents, including 49.61% of girls and 56.75% of boys [10].

In children's diet, meat is a valuable source of numerous nutrients, and is especially difficult to replace by other products. In our study, 62.46% of pupils from Małopolskie, vs 60.46% of pupils from Śląskie vs as little as 56.52% of pupils from Opolskie Voivodeship reported eating meat at least once daily. The overall percentage of respondents in our study who stated that they did not eat meat at all amounted to 3.86%. *Szczepańska et al.*, who analysed eating behaviours of pupils from Upper Silesia (a geographical region in Poland) had similar findings. In their study, 61.3% of pupils ate meat and/or meat-based products (such as ham, sausage and other types of charcuterie) at least once daily [21]. *Jonczyk et al.*, however, who investigated eating behaviours of children aged 6-13 years old from rural areas of Śląskie and Opolskie voivodeships obtained different results. In their study, only 12.86% of respondents reported daily meat intake, including 11.92% of girls and 13.36% of boys, with as little as 0.73% of their respondents reporting not eating meat at all [9].

In our study, also fish intake was demonstrated to be far from sufficient. According to WHO recommendations, the minimum fish intake for optimum health

is considered 1-2 times every week [5]. These recommendations are met by as few as 25.26% of pupils from Śląskie Voivodeship vs 28.57% of pupils from Opolskie Voivodeship vs 36.94% of pupils from Małopolskie Voivodeship. The significance of fish intake is unique in children's diet, as apart from high-quality protein necessary for muscle growth and minerals, fish also contain an abundance of omega-3 fatty acids that play a significant role in early and adolescent development. They contribute to normal brain function and good sight, as well as decrease the risk for atopic diseases, allergies, and protect from cardiovascular diseases [5]. Insufficient intake of fish and fish-based products was also identified by *Jonczyk et al.* in their study, which demonstrated the dietary recommendations in this respect to be met by only 11.22% of respondents [9]. The findings of a study by *Szczepańska et al.*, were more favourable, with regular fish intake at the level of 1-2 times a week reported by 44.9% of respondents [21].

Children who eat high-calorie snacks typically find them very satisfying, and as result tend to skip nutritious meals. In long term, this leads to body weight disorders, overweight and obesity [23]. This group of foods comprises sweets, which in our study were eaten several times daily by 14.59% of pupils and once daily by 22.5% of pupils, and salty snacks, which were not eaten at all by as few as 3.08% of respondents. These results are very alarming, as excessive amounts of sweets not only lead to nutrient deficiencies in children's diets, but also contribute to caries [17]. In the studied group, only 2.20% of the participants stated they never ate any sweets. Even less favourable results were obtained in a study carried out in a group of children aged 10-12 years old from Upper Silesia, aimed at evaluating i.a. sweets intake. The authors demonstrated that sweets were eaten by 32.7% of children from urban and 46.6% from rural areas, with only 1.3% of respondents in each of the groups reporting that they did not eat sweets at all [19].

The analysis of fast food intake in our study showed that 12.92% of respondents ate fast food products several times a week, whilst 34.89% ate fast food several times a month. The least favourable data regards pupils from Śląskie Voivodeship, as 13.66% of children from that group reported eating fast food products several times a week. Similar results were obtained by *Kotyrbka et al.* [11], who conducted a study aimed at identifying eating behaviours of children from year 3-5 of elementary school (9-11 year-olds). According to that study, 48% of their respondents used fast food restaurants once a month, 16% several times a week, and only 17% did not use fast food restaurants at all. *Jonczyk et al.* [9] had more optimistic findings, with 83% of their respondents reporting using fast food restaurants less frequently than once a month.

Drinking carbonated beverages high in sugar instead of water results with intake of large amounts of simple sugars [23]. In our study, intake of this type of beverages several times a day was reported by 8.26% of respondents, whilst 8.17% reported once-daily soft drink intake. *Szczepańska* et al. [20] evaluated eating behaviours of a sample of 884 pupils of lower secondary and higher secondary schools, demonstrating 26% of underweight pupils, 21.4% of pupils with normal body weight and 22.4% of overweight pupils to drink sweetened beverages at least once a day. A study conducted in 2009-2011 in the city Thessaloniki (Greece) on a group of 607 pupils aged 7-15 years old, showed daily intake of carbonated beverages to be prevalent, at 79.4% [16]. Excessive intake of soft drinks has also been pointed out by numerous other authors [12, 23].

The results of our conducted analysis, concerning the eating behaviours are consistent with data obtained earlier in other research projects conducted among primary school students in Poland. Based on earlier examples, it can be concluded that there are no marked differences between eating behaviours and dietary habits in results obtained in earlier periods of time and in other voivodeships.

CONCLUSIONS

1. The eating behaviours of primary school pupils differ. Regional variations in eating behaviours have been found to exist, revealing a correlation between the pupils' area of residence (voivodeship) and some eating behaviours.
2. Increasingly among children incorrect eating behaviours and low physical activity indicate the need for implementation multidirectional educational and health activities.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. *Adolphus K., Lawton C.L., Dye L.*: The effects of breakfast on behavior and academic performance in children and adolescents. *Front Hum Neurosci* 2013;7:425 doi:10.3389/fnhum.2013.00425.
2. *Ambroży J., Bester J., Czuchraj W., Dostał K., Dubiel M.*: Nawyki żywieniowe oraz częstość spożycia wybranych produktów przez dzieci w wieku 10–13 lat zamieszkałe na terenach miejskich i wiejskich [Eating habits and frequency of consumption of selected products among children aged 10–13 years residing in urban and rural areas]. *Ann Acad Med Siles* 2013;67(4):231-237 (in Polish).
3. *Bielaszka A., Grochowska-Niedworok E., Kiciak A., Szczepańska E., Kardas M., Całyniuk B., Zima-Dańczyk A.*: Preferencje żywieniowe dzieci w wieku 7–10 lat [Nutrition preferences of children ages 7–10]. *Ann Acad Med Siles* 2014;68(4):187-191 (in Polish).
4. *Decyk-Chęcel A.*: Zwyczaje żywieniowe dzieci i młodzieży [Children's and adolescents' eating habits]. *Probl Hig Epidemiol* 2017;98(2):103-109 (in Polish).
5. *Dymkowska-Malesa M., Walczak Z., Zakrzewski J.*: Ocena poziomu spożycia ryb wśród uczniów klas 4-6 szkół podstawowych w Koszalinie [Evaluation of the level of fish consumption among students in grades 4-6 of primary school in Koszalin]. *Probl Hig Epidemiol* 2014;95(1):182-185 (in Polish).
6. *Halcz J., Warechowska M.*: Ocena sposobu żywienia dzieci w wieku 10–12 lat mieszkających w Olsztynie [Assessments of eating behaviours of children aged 10-12 in the city of Olsztyn]. *Pediatr Endocrinol Diabetes Metab* 2015;23(1):23-31 (in Polish) doi:10.18544/pedm-21.01.0021.
7. Informacja o wynikach kontroli. Wdrażanie zasad zdrowego żywienia w szkołach publicznych [Information on inspection results. Implementation of the principles of healthy nutrition in public school]. *Najwyższa Izba Kontroli*, 04.05.2017 (in Polish).
8. International Obesity Task Force EU Platform Briefing Paper, 15.03.2005.
9. *Jonczyk P., Potempa M., Kajdaniuk D.*: Analiza stopnia odżywienia i zaburzeń odżywiania oraz charakterystyka przyzwyczajzeń żywieniowych i aktywności fizycznej wśród dzieci w wieku 6–13 lat uczęszczających do wybranych szkół podstawowych na terenach wiejskich województw śląskiego i opolskiego [Level of nutrition and nutrition disorders as well as characteristics of dietary habits and physical activity among 6–13-year-old children attending selected primary schools in Opole and Silesia Provinces in Poland]. *Pediatr Med Rodz* 2016;12(2):177-193 (in Polish) doi:10.15557/pimr.2016.0018.
10. *Jonczyk P., Potempa M., Kajdaniuk D.*: Analiza stopnia odżywienia i zaburzeń odżywiania oraz charakterystyka przyzwyczajzeń żywieniowych i aktywności fizycznej wśród dzieci szkolnych w wieku 6–13 lat w mieście Piekary Śląskie [Level of nutrition and nutrition disorders as well as characteristics of dietary habits and physical activity among 6–13-year-old school children in the city of Piekary Śląskie in Poland]. *Pediatr Med Rodz* 2015;11(3):302-314 (in Polish) doi:10.15557/PiMR.2015.0029.
11. *Kotyrbka J., Wróblewska I.*: Analiza zachowań żywieniowych dzieci klas III-V szkoły podstawowej [Analysis of dietary behaviours of children of classes III - V primary school]. *Puls Uczelni* 2014;8(3):11-15 (in Polish).
12. *Mendyk K., Antos-Latek K., Kowalik M., Pagacz K., Lewicki M., Obel E.*: Zachowania prozdrowotne w zakresie odżywiania i aktywności fizycznej u dzieci i młodzieży szkolnej w wieku do 18. roku życia [Pro-health behavior in adolescents in regard to nourishment and physical activity up to 18 years old]. *Piel Zdr Publ* 2017;26(1):13-17 (in Polish) doi:10.17219/pzp/64690.
13. *Miller R., Benelam B., Stanner S.A., Buttriss J.L.*: Is snacking good or bad for health: An overview. *Nutr Bull* 2013;38:302-322 doi:10.1111/nbu.12042.

14. *Moreno L.A., Bel-Serrat S., Santaliestra-Pasías A., Bueno G.*: Dairy products, yogurt consumption, and cardiometabolic risk in children and adolescents. *Nutr Rev* 2015; 73(Suppl 1):8-14 doi:10.1093/nutrit/nuv014.
15. *Naeeni M.M., Jafari S., Fouladgar M., Heidari K., Farajzadegan Z., Fakhri M., Karami P., Omidi R.*: Nutritional Knowledge, Practice, and Dietary Habits among school Children and Adolescents. *Int J Prev Med.* 2014;5(Suppl 2):S171-S178.
16. *Papandreou D., Andreou E., Heraclides A., Rousso I.*: Is beverage intake related to overweight and obesity in school children? *Hippokratia* 2013;17(1):42-46.
17. *Sankeshwari R.M., Ankola A.V., Tangade P.S., Hebball M.I.*: Association of socio-economic status and dietary habits with early childhood caries among 3- to 5-year-old children of Belgaum city. *Eur Arch Paediatr Dent* 2013;14(3):147-153 doi:10.1007/s40368-013-0035-6.
18. *Sielicka M., Pacholek B., Matuszak L., Gabryelczyk M., Majos A.*: Ocena świadomości zdrowotnej i pożądalności produktów przekąskowych przez dzieci [Evaluation of health awareness and desirability of food snacks in children]. *Probl Hig Epidemiol* 2015;96(3):607-612 (in Polish).
19. *Szczepańska E., Piórkowska K., Niedworok E., Muc-Wiergoń M.*: Konsumpcja słodczy i napojów wysokosłodzonych w aspekcie występowania otyłości na przykładzie dzieci zamieszkujących obszary miejskie i wiejskie [The consumption of sweets and sweetened beverages in terms of obesity occurrence on the example of children living in rural and urban environment]. *Endokrynol Otyłość* 2010;6(2):79-84 (in Polish).
20. *Szczepańska E., Szeja N., Dudzik I., Koldon A., Jędzura K., Pochopień E., Oleszko M.*: Zachowania żywieniowe a wiedza żywieniowa uczniów wybranych szkół na terenie Górnego Śląska w zależności od wskaźnika wagi-owo-wzrostowego BMI [Eating behaviours and nutrition knowledge of students from selected schools of the Upper Silesian region, depending on the Body Mass Index]. *Nowa Pediatria* 2015;19(2):68-75 (in Polish).
21. *Szczepańska E., Szeja N., Szymkiewicz A., Kowalska A., Lenard B., Bulwiczka A.*: Eating behaviours of middle and secondary-school pupils from the Upper Silesian region in Poland. *Rocz Państw Zakł Hig* 2014;65(4):337-344.
22. *Świdorska-Kopacz J., Marcinkowski J.T., Jankowska K.*: Zachowania zdrowotne młodzieży gimnazjalnej i ich wybrane uwarunkowania. Cz. IV. Sposób żywienia. [Health behaviour of secondary school pupils and its chosen determinants. Part IV. Nutritional habits]. *Probl Hig Epidemiol* 2008;89(2):241-245 (in Polish).
23. *Wojtyła-Buciora P., Żukiewicz-Sobczak W., Wojtyła K., Marcinkowski J.T.*: Sposób żywienia uczniów szkół podstawowych w powiecie kaliskim – w opinii dzieci i ich rodziców [Nutrition of primary school children in Kalisz district – in children's and their parents' opinions]. *Probl Hig Epidemiol* 2015; 96(1):245-253 (in Polish).
24. *Wolnicka K., Jaczewska-Schuetz J., Taraszewska A.*: Analiza czynników wpływających na spożycie warzyw i owoców przez dzieci w wieku szkolnym [Analysis of factors affecting consumption of fruit and vegetables in school-aged children]. *Probl Hig Epidemiol* 2014;95(2):389-393 (in Polish).
25. *Zalewska M., Maciorowska E.*: Rola edukacji żywieniowej w populacji dzieci i młodzieży [The role of nutrition education in the population of children and adolescents]. *Med Og Nauk Zdr* 2013;19(3):375-378 (in Polish).

Received: 21.11.2017

Accepted: 23.01.2018

EVALUATION OF HEALTH STATUS OF CHILDREN ATTENDING PRIMARY SCHOOLS WITH DIFFERENT ORGANISATION OF PHYSICAL EDUCATION LESSONS

Oleksandra S. Kondratiuk, Maria M. Korshun, Serhii I. Garkavyi, Serhii S. Garkavyi

Bogomolets National Medical University, Department of Hygiene and Ecology No 3, Kyiv, Ukraine

ABSTRACT

Background. The mandatory swimming lesson in primary schools, equipped with swimming pools, was introduced without studying of its health-saving effectiveness.

Objective. The purpose of this study was to evaluate the health status of pupils studying in schools with different organization of physical education lessons.

Materials and Methods. Cross-sectional study was organized in two schools with different organization of physical education lessons. The experimental group (E) consisted of 408 children of 1-4 year of study (210 girls and 198 boys) who during one of the lessons of physical education were engaged in swimming in the school basin. Control group (C) consisted of 279 primary school children (210 girls and 156 boys) from a neighboring educational institution where all physical education lessons were organized in the gym. The health status was evaluated using classical method of complex assessment of the state of health with the subsequent assignment of each child to one of the health groups.

Results. In result of evaluation of state of health there was established that among pupils from E group the proportion of boys with harmonious anthropometric parameters is higher ($p < 0.05$), children from this group are stronger than C group ($p < 0.05$). The prevalence of diseases of the musculoskeletal system and the eyes among pupils in E group was lower comparing to the C group ($p < 0.01$). In the E group percentage of pupils assigned to health group I was significantly higher and lower for the II (children with some morpho-functional abnormalities) comparing to the C group.

Conclusion. Organization of one mandatory swimming lesson per week in primary school has positive effect on health status of children.

Key words: *child's health, primary school children, health status, swimming lessons, physical education lessons*

INTRODUCTION

The proclamation of the World Health Organization's Ottawa Charter for health promotion has contributed to the active implementation of the health promoting projects in the educational process. Programs focused on the problems of children's physical activity, adequate nutrition, etc. were designed and implemented in the educational process as part of the World Health Organization's (WHO's) Health Promoting Schools (HPS) framework [7]. European Network for Health Promoting Schools (ENHPS) was a pilot project, which started in 1991 in four countries of Central and Eastern Europe: Czech Republic, Hungary, Poland and Slovakia and has been expanded to 38 countries of all over Europe by 1997. Without a doubt, the effectiveness of health-saving programs

should be justified in the course of scientific research [1, 8]. A study of effectiveness of the implementations in the framework of ENHPS has shown evidence that projects aimed at achieving the target body mass index, reasonable physical activity, good physical shape, sufficient fruit and vegetable intake and prevention of smoking have some positive effects [7].

Since many decades in our country there has been a tendency to deterioration in the health of children over the years of schooling, the experience of developing and implementing measures aimed at preserving and strengthening of health has been adopted by Ukrainian educational institutions. The majority of studies indicate that mechanical loading is a key mechanism linking chronic disease development and increasing of inflammatory mediators [5]. That's why one among many health-saving projects was the introduction of

Corresponding author: Oleksandra S. Kondratiuk, Department of Hygiene and Ecology, Bogomolets National Medical University, Peremogy avenue, Kiev 03680, Ukraine, Tel. + 380 96 4112070, e-mail: aleksandra.kondratiuk@nmu.ua

a mandatory swimming lesson in primary schools equipped with swimming pools. The innovative organization of physical culture includes swimming lessons during one of the three classes of physical culture stipulated in the curriculum. Swimming has a great recreational potential, on the other hand recent studies showed that concentration of disinfection by-products, formed as a result of water chlorination (trihalomethanes), in the air exceeded the admissible norm (100 $\mu\text{g/L}$) [2]. The influence of this factor has not been adequately studied yet, which could lead to the children's health status declining.

The purpose of our study was to evaluate the health status of children studying in schools with different organization of physical education lessons.

MATERIALS AND METHODS

Cross-sectional study was organized in two schools in Kyiv with different organization of physical education lessons. Schools of one of the sleeping areas of the city were built according to a standard design and differed only by the presence of a swimming pool in one of them. The experimental group (E group) consisted of 408 pupils (210 girls and 198 boys) of 1-4 year of study who during one of the lessons of physical education were engaged in swimming in the school basin. Control group (C group) consisted of 279 primary school pupils (210 girls and 156 boys) from a neighboring educational institution where all physical education lessons were organized in the gym. Using designed by us questionnaire we interviewed parents and children from equal research groups. The questionnaire revealed information about level of physical activity, leisure activities, well-being during the day. The block of questions that characterized social state of families helped to reduce socio-economic differences between children in research groups. Pupils who attend sport sections were excluded from the research.

The health status was evaluated using classical method of complex assessment of the state of health with the subsequent assignment of each child to one of the health groups [3]. The method includes an assessment of 4 mandatory health indicators: 1) the level and harmony of physical development (PD); 2) the functional state of individual body systems; 3) the degree of resistance to unfavorable environment factors; 4) the presence or absence of chronic diseases at the time of examination.

The level of PD was determined by comparing the growth of the child using the evaluation tables of physical development [3]. To assess the harmony of development, the correspondence of body weight and chest circumference (CC) to growth was studied according to the same tables.

For the evaluation of functional state of the respiratory system, the vital capacity of the lungs (VCL) was assessed using a dry portable spirometer according to the standard method [3]. Except absolute values of VCL, the Respiratory Indexes was calculated. Respiratory index is a ratio of VCL to the body weight. The functional state of the muscular system was assessed by hand dynamometry using a manual dynamometer [3]. In addition to the absolute values of hand strength in kg, the relative parameter to the mass of the body is calculated, expressed as a percentage - the strength index (SI).

Chronic pathology data and information about frequency and nature of acute illnesses were obtained from the „Medical card of the child” (form 026/o), in addition the data of class journals on school absences due to illness were also used.

On the basis of an individual assessment of 4 mandatory health indicators, each child was assigned to one of five groups of health: I – healthy children; II – children who do not have chronic diseases, but with some morpho-functional abnormalities; III – children suffering from chronic diseases in a state of remission; IV – children suffering from chronic diseases in active stage with incomplete compensation of functional abilities, V – children suffering from chronic diseases with rare remissions and significant decompensation of the body's functional capabilities. A more detailed description of each of the health groups is given in [3].

The differences between research groups for indicators corresponding to the normal distribution law were assessed according to the *Student's* t-criterion. Reliability of differences in the prevalence of diseases in the C and E groups was assessed by the *Pearson* χ^2 criterion. Calculations, visualization and analysis of data were carried out using IBM SPSS Statistics Base v.22, Microsoft Office Excel 2007. The study was performed in Bogomolets National Medical University as a part of independent research work “Hygienic evaluation of the operation conditions of the swimming pools in educational institutions” (number of State registration 0113U000673).

RESULTS AND DISCUSSION

The distribution of children from C and E groups according to the body length (high, above average, average, below average, low) is not significantly different ($\chi^2 = 4.64$, $p > 0.05$). The majority of pupils have average growth: 60.29 % in the C and 64.87 % in the E group respectively.

Evaluation of body weight and chest circumference correspondence to the body length shows that there are no children with sharply disharmonic physical development (Table 1, 2). There were no significant differences in the distribution of children (boys +

girls) in C and E groups, depending on the degree of correlation of body weight to body length. ($\chi^2=4.64$, $p>0.05$), but distribution of boys differs at the trend level ($\chi^2=5.73$, $0.05<p<0.1$). A detailed analysis revealed that the proportion of harmonically developed boys in the E group (59.61 %) is significantly higher in comparison with the C group (47.62 %, $t=2.29$, $p<0.05$) (Table 1).

Evaluation of chest circumference (CC) correspondence to the body length has shown the significant difference in the distribution of pupils from C and E groups according to this parameter ($\chi^2=8.17$, $p<0.05$) (Table 2).

Portion of harmoniously developed pupils according to the CC in the E group (64.87 %) is significantly higher compared with the C group (54.9 %, $t=2.05$, $p<0.05$). This is achieved mainly because of boys: portion of harmoniously developed boys according to the CC in the E group (68.59 %) is significantly higher compared with the C group (57.14 %, $t=2.45$, $p<0.05$).

The distribution of girls depending on the degree of PD harmoniousness in the E and C groups is not significantly different ($p>0.05$), although CC appeared to be more sensitive to physical loads in the basin ($\chi^2=4.81$) than body weight ($\chi^2=0.44$) (Table 1, 2).

Thus, children in schools with different organization of physical education do not differ in their growth. However, among pupils attending one swimming lesson per week, the proportion of boys with harmonious anthropometric parameters is higher, as well as the proportion of children of a gender-mixed group with harmonious CC and body length.

Functional capacity assessment is obligatory part of children's health status evaluation. The data obtained during dynamometry indicate that among children of the E group the functional capabilities of the muscular system are higher in comparison with the C group in terms of the absolute value of the wrist muscle strength and relative to the body mass parameter – strength index (Table 3).

There was no significant difference between the indices VCL and RI among schoolchildren studying at schools with different physical education organizations ($p>0.05$).

During evaluation of disease prevalence, premorbid states were taken into account as well. For instance, at the chapter "Diseases of the musculoskeletal system and connective tissue" disorders of posture were included.

Table 1. Distribution of primary school pupils with different organization of physical education according to the correspondence of the body weight to the body length

Harmoniousness of physical development	n	Boys + girls		Boys		Girls	
		C	E	C	E	C	E
		408	279	210	156	198	123
Harmonic	abs.	203	160	100	93	103	67
	%	49.75	57.35	47.62	59.61*	52.02	54.47
Disharmonic due to the body overweight	abs.	84	55	44	29	40	26
	%	20.59	19.71	20.95	18.59	20.20	21.14
Disharmonic due to the deficiency of the body weight	abs.	121	64	66	34	55	30
	%	29.65	22.94	31.43	21.79	27.78	24.39
χ^2		4.64		5.73		0.44	

Note: C – control group, E – experimental group

* - statistically significant differences in comparison with the C group by *Student's* t-test, $p<0.05$.

Table 2. Distribution of primary school pupils with different organization of physical education according to the correspondence of the chest circumference to the body length

Harmoniousness of physical development	n	Boys + girls		Boys		Girls	
		C	E	C		C	
		408	279	210		408	
Harmonic	abs.	224	181	120	107	104	74
	%	54.90	64.87*	57.14	68.59*	52.52	60.16
Disharmonic due to excessive chest circumference	abs.	85	54	46	26	39	28
	%	20.83	19.35	21.90	16.66	19.69	22.76
Disharmonic due to insufficient chest circumference	abs.	99	44	44	23	55	21
	%	24.26	15.77	20.95	14.74	27.77	17.07
χ^2		8.71		5.02		4.81	

Note: C – control group, E – experimental group

* - statistically significant differences in comparison with the C group by *Student's* t-test, $p<0.05$.

Table 3. Physiometric indicators of pupils studying at schools with different organization of physical education

Indicator		C		E		Boys		Girls	
		Boys	Girls	Boys	Girls	t	p	t	p
Wrist muscle strength, kg	right hand	8.05 ±0.12	7.39 ±0.11	8.43 ±0.18*	8.91 ±0.26*	3.15	<0.001	5.21	<0.001
	left hand	7.69 ±0.10	7.09 ±0.11	8.30 ±0.22*	8.75 ±0.25*	2.10	<0.05	6.05	<0.001
Strength Index, %	right hand	26.22 ±0.46	25.16 ±0.52	29.94 ±0.72*	29.04 ±0.75*	4.07	<0.001	4.60	<0.001
	left hand	25.24 ±0.45	24.16 ±0.46	29.25 ±0.72*	28.62 ±0.73*	4.30	<0.001	5.11	<0.001
Vital capacity of the lungs, ml		1586.20 ±17.02	1469.90 ±18.27	1523.89 ±24.60	1484.46 ±22.74	1.90	>0.05	0.49	>0.05
Respiratory Index, ml/kg		52.91 ±0.68	50.30 ±0.74	51.52 ±1.06	50.18 ±1.01	0.47	>0.05	0.14	>0.05

Note: C – control group, E – experimental group

* - statistically significant differences comparing to the C group, t - *Student t*-test, p – significance level.

It is established that prevalence of diseases of the musculoskeletal system and connective tissue among pupils that attended one swimming lesson per week (23.7 %) was lower comparing to the C group (34.2 %, $\chi^2=9.65$, $p<0.01$), (Table 4). There were no significant differences in the prevalence of diseases in the first two classes between C and E groups. On the third and fourth years, prevalence of diseases of the musculoskeletal system and connective tissue among pupils attending swimming pool (21.0 % и 14,0 % respectively) was lower comparing to C group ($\chi^2=4.82$, $p<0.05$ and $\chi^2=10.84$, $p<0.01$ respectively). Therefore, musculoskeletal system relief at weightlessness condition during swimming lessons prevents the development of pathological conditions.

Also, the prevalence of the eye and adnexa diseases is lower among pupils from E group compared with C group (7.3 % vs. 15.4 %, $\chi^2=11.55$, $p<0.01$). Significant differences between C and E groups were founded at 3rd and 4th years of study ($\chi^2=6.52$, $p<0.05$ и $\chi^2=14.67$, $p<0.01$ respectively). It is known that on the way of visual system pathology formation such prenosological states as spasm of accommodation and violation of contrast vision are formed [6]. The lower prevalence of eye diseases among children that attended swimming lessons compared to the C group could result from relaxing effect of exercises in water. In our previous studies based on the analysis of functional state of organism and state of vegetative nervous system, the relaxing effect of swimming lessons was evidenced: among children from group C the tone of the sympathetic nervous system prevailed while schoolchildren that attended swimming lessons were in a state of vegetative balance [4].

At the finale stage of the research an individual assessment of health status of schoolchildren was carried out. It was found that in a school were schoolchildren (1-4 classes) attended one swimming lesson the distribution of children by health groups is statistically significantly different compared to the C group ($\chi^2=24.09$, $p<0.01$) due to a higher proportion of children belonging to group of health I ($t=2.96$, $p<0.05$), and lower – to group II ($t=5.06$, $p<0.01$) (Table 5).

The distributions of pupils of C and E groups for health groups in the first and second classes do not differ ($p>0.05$). Significant differences were revealed in the 3rd and 4th classes ($\chi^2=14.56$ and 16.39 respectively, $p<0.01$). In the 3rd class, the proportion of pupils from group E in health group I (healthy children) was higher than in group C ($t=2.85$, $p<0.05$) due to the fact that the C group had more children assigned to health group II ($t=4.29$, $p<0.01$). In the 4th class the same differences were found: in the group E the percentage of pupils assigned to health group I was significantly higher and lower for the II health group ($t=2.85$, $p<0.05$ and $t=4.26$, $p<0.01$ respectively). This observation shows that with the increase in swimming experience, the health effect of one swimming lesson per week increases.

Thus, by the end of primary school education, with the organization of one swimming lesson per week, the proportion of children who have passed to group II of health – an intermediate category between healthy children and those suffering from chronic diseases - was lower compared to schoolchildren who were engaged only in traditional physical education classes.

Table 4. The prevalence of chronic diseases of children studying at schools with different organization of physical education lessons, %

ICD 10 chapter	Years of study									
	1		2		3		4		1 - 4	
	C	E	C	E	C	E	C	E	C	E
XIII Diseases of the musculoskeletal system and connective tissue	31	26	33	30	39	21*	36	14**	34.2	23.7**
VII Diseases of the eye and adnexa	6	5	9	12.5	18	3*	30	7**	15.4	7.3**
X Diseases of the respiratory system	12	11	16	16	21	17	13	13	13.8	14.07
XI Diseases of the digestive system	9	14	11.2	6.8	18	22	13	6	12.3	11.7

Note: C – control group, E – experimental group

the differences are reliable according to the *Pearson* chi-squared criterion * – $p < 0.05$; ** – $p < 0.01$

Table 5. Distribution of primary school pupils with different organization of physical education by health groups

Class	Research group	n	Health group								χ^2	p
			I		II		III		IV			
			Abs.	%	Abs.	%	Abs.	%	Abs.	%		
1	C	109	32	29.36	49	44.95	27	24.77	1	0.91	1.53	>0.05
	E	99	37	37.37	39	39.39	22	22.22	1	1.01		
2	C	133	53	39.85	62	46.62	18	13.54	-	-	7.19	>0.05
	E	60	24	40	19	31.66	17	28.33	-	-		
3	C	94	24	25.53	49	52.13	21	22.34	-	-	14.56	<0.01
	E	51	23	45.09*	10	19.61*	18	35.29	-	-		
4	C	72	21	29.16	44	61.11	6	8.33	1	1.38	16.39	<0.01
	E	69	36	52.17*	19	27.53*	13	18.84	1	1.44		
1-4	C	408	130	31.86	204	50.00	72	17.65	2	0.49	24.09	<0.01
	E	279	120	46.01*	87	31.18**	70	25.09	2	0.71		

Notes: * $p < 0.05$, ** $p < 0.01$ by the *Student's* test.

CONCLUSIONS

Organization of one mandatory swimming lesson per week in primary school has a positive effect on children health status. In result of complex assessment the following findings has been established.

1. The proportion of boys attended one swimming lesson per week with harmonious physical development was higher ($p < 0.05$), compared to the control group.

2. Children attended lessons in swimming pool had higher functional capabilities of the muscular system than in control group: the strength of the muscles of both hands in boys and girls was higher in absolute and relative indices ($p < 0.05$). Functional capabilities of the respiratory system of children of control and experimental groups did not differ significantly ($p > 0.05$).

3. Among primary school pupils of experimental group the incidence of diseases of the musculoskeletal system and the pathology of the eye were lower than in the control group ($p < 0.01$).

4. In the school with one swimming lesson per week, the percentage of junior schoolchildren belonging to the health group I (healthy children) was

higher ($p < 0.05$) and lower – to the II group (children with functional deviations) compared with pupils who didn't attend the swimming pool.

Acknowledgement

The study was performed in Bogomolets National Medical University as a part of independent research work "Hygienic evaluation of the operation conditions of the swimming pools in educational institutions" (number of State registration 0113U000673).

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Blair M., De Bell D.: Reconceptualising health services for school-age children in the 21st century. Arch Dis Child 2011; 96 (7): 616 - 618.
2. Bozym M., Wzorek M., Klosok-Bazan I.: Health risk as a consequence of exposure to trihalomethanes in swimming pool water. Rocznik Państw Zakł Hig 2017; 68(4): 331-337

3. *Ivakhno O.P., Kozyarin I.P., Nyemtsova Yu.V.*: Methods of assessment of physical development and health status of child population: study guide. Kyiv, Shupyk National Medical Academy, 2012 (in Ukrainian).
4. *Kondratiuk O.S., Korshun M.M., Garkavyi S.I.*: Adaptive capacity assessment of primary school children in case of various forms of organization of physical training classes. *Deutscher Wissenschaftsherold German Science Herald* 2017; 3:12-14, doi:10.19221/201734.
5. *Majorczyk M., Smoląg D.*: Effect of physical activity on IGF-1 and IGFBP levels in the context of civilization diseases prevention. *Rocz Panstw Zakl Hig* 2016; 67(2): 105-111
6. *Podrygalo L.V.*: Study of the levels of body functions at the assessment and prediction of donosologic health states in the children, adolescents and youth. *Environment and Health* 2013; 3(62): 69-74 (in Ukrainian).
7. The WHO Health Promoting School framework for improving the health and well-being of students and their academic achievement. *Cochrane Database of Systematic Reviews*. Available at: http://www.cochrane.org/CD008958/BEHAV_the-who-health-promoting-school-framework-for-improving-the-health-and-well-being-of-students-and-their-academic-achievement. (Accessed 27.12.2017)
8. *Vanaelst B., Huybrechts I., De Bourdeaudhuij I., Bammann R., Hadjigeorgiou C., Eiben G., Konstabel K., Michels N.*: Prevalence of negative life events and chronic adversities in European pre- and primary-school children: results from the ID EFICS study. *Arch Pub Health* 2012; 70: 26 doi:10.1186/0778-7367-70-26.

Received: 28.12.2017

Accepted: 19.03.2018

HEALTH POLICY PROGRAMS REALISED IN POLAND IN 2016–2017

Patrycja Kurowska^{1,2}, Anna Królak¹, Wojciech Giermaziak¹

¹The Stanisław Konopka Main Medical Library, Warsaw, Poland

²Department of Pharmacognosy and Molecular Basis of Phytotherapy, Faculty of Pharmacy, Medical University of Warsaw, Poland

ABSTRACT

Background. Health Policy Program (*Program Polityki Zdrowotnej* – PPZ) is a state policy tool for engaging local government units into the mechanism of granting provision of health services. Authors show areas in which self-governments most often took preventive health care actions and describe legislative changes in the Act on provision of health services.

Objective. The aim of the article is to quantitative and qualitative statement of PPZ prepared in Poland in 2016 and 2017, as well as presenting changing legal situation in the scope of evaluation of these projects.

Materials and methods. Authors use descriptive method, presenting changes of legal status. The article includes data available in the Bulletin of Public Information by The Agency for Health Technology Assessment. 590 programs were analyzed (239 from 2016 and 351 from 2017).

Results. In 2016 – 67% of submitted programs were given a positive opinion and in 2017 – 71%. The most of positively evaluated PPZ submitted by local government units (53% in 2016; 47% in 2017) referred to prevention of infectious diseases by vaccines. On the basis of analyses conducted, significant differences were observed in the implementation of the PPZ in various regions of Poland.

Conclusions. In the recent years a big improvement in the quality of planned self-government health programs is observed. It is suggested that due to the regulation defining the model of the health policy program and the model of the final report, this trend will continue.

Key words: *Health Policy Programmes, local government unit, Poland, Agency for Health Technology Assessment and Tariff System*

STRESZCZENIE

Wprowadzenie. Program polityki zdrowotnej (PPZ) stanowi narzędzie polityki państwa, pozwalające zaangażować jednostki samorządu terytorialnego w mechanizm udzielania świadczeń opieki zdrowotnej. Autorzy wskazują obszary, w których samorządy najczęściej podejmowały działania profilaktyki zdrowotnej oraz opisują zmiany legislacyjne w ustawie o świadczeniach opieki zdrowotnej.

Cel. Celem jest jakościowa i ilościowa analiza PPZ zgłoszonych w Polsce w latach 2016-2017, a także przedstawienie zmieniającej się sytuacji prawnej w zakresie oceny zgłoszonych programów.

Material i metody. Autorzy posługują się metodą opisową, prezentując zmiany stanu prawnego. Artykuł uwzględnia dane udostępnione w Biuletynie Informacji Publicznej przez Agencję Oceny Technologii Medycznych. Przeanalizowano 590 programów (239 z roku 2016 i 351 z roku 2017).

Wyniki. W 2016 roku pozytywnie zaopiniowano 67% zgłoszonych Programów, a w 2017 – 71%. Najwięcej PPZ zgłoszonych przez jednostki samorządu terytorialnego (53% w 2016 i 47% w 2017) dotyczyło profilaktyki chorób zakaźnych za pomocą szczepień ochronnych. Na podstawie przeprowadzonych analiz zaobserwowano istotne różnice w realizacji PPZ w różnych regionach Polski.

Wnioski. W ostatnich latach obserwuje się dużą poprawę w jakości planowanych samorządowych programów zdrowotnych. Sugeruje się, że dzięki rozporządzeniu określającemu wzór programu polityki zdrowotnej oraz wzór raportu końcowego trend ten się utrzyma.

Słowa kluczowe: *Programy Polityki Zdrowotnej, jednostki samorządu terytorialnego, Agencja Oceny Technologii Medycznych i Taryfikacji*

Corresponding author: Patrycja Kurowska, Główna Biblioteka Lekarska im. S. Konopki, Centrum Informacji Medycznej, ul. Chocimska 22, 00-791 Warszawa, tel. +48 22 8497851, e-mail: p.kurowska@gbl.waw.pl

INTRODUCTION

Fundamental legal act regulating the functioning of Health Policy Program (in Polish: Program Polityki Zdrowotnej – PPZ) in the health care system is the Act of August 27th, 2004 on healthcare services financed from public funds published in the *Dziennik Ustaw* (Journal of Laws) of 2017 item 1938, with subsequent amendments, hereafter called “u.ś.o.z”. According to the Act mentioned (art. 5 point 29a) Health Policy Program is “a set of planned and intended health care activities assessed as effective, safe and justified, enabling the set targets to be achieved within a given timeframe by detecting and meeting specific health needs and improving the health of a given group of beneficiaries, developed, implemented and financed by the minister or a local government unit”.

It is worth to note, that discussed Act – since the amendment valid since January 1st, 2015 – differentiates the concept of “health policy program” and “health program”. Definition of Health Program (art. 5 point 30), that it is “a set of planned and intended health care activities assessed as effective, safe and justified, enabling the achievement of targets within a given time, consisting in detecting and meeting specific health needs and improving the health of a given group of beneficiaries, developed, implemented and financed by the Fund” [13].

Therefore the difference between health policy program and health program boils down to establishing the entity responsible for the task. The aim of such “cosmetic” change was facilitating the categorization of programs implemented by the National Health Fund from those implemented by ministers or local government units (jednostki samorządu terytorialnego – JST). In this article new nomenclature was used for Programs realized before January 1st, 2015 as well.

On November 30th, 2017 new changes in PPZ regulations were introduced, that corrects legislative deficiencies and specifies the elements that should be included in the draft of the Program [14]. In the earlier version of the Act, there were no legal regulations regarding respecting the opinion issued by the President of the Agency for Health Technology Assessment and Tariff System (Agencja Oceny Technologii Medycznych i Taryfikacji – AOTMiT). It was obligatory to receive it, nonetheless, even in case of negative evaluation, the subject did not have to comply with it. This enabled the implementation even of those tasks that not only did not improve the health of the target group, but were actually harmful – such as a program for slimming pregnant women in the second trimester, where measurement of waist circumference was proposed to monitor the progress of weight loss. Other examples with dubious economic justification, that came to AOTMiT are: apitherapy and supply of mineral waters to children living in the Zagłębie Miedziowe (Copper Basin) with the level of lead in the

blood >5µg/dL or a population-based vaccination program against HPV (human papilloma virus) that was to cover the “population” of four girls [1]. The previous, residual legal regulation included in “u.ś.o.z.” referred only to the whole of the institution in question (chapter 4, art. 48). There was no clarification regarding the construction, evaluation process and assessment. Now these gaps have been filled and, as part of the making of the statutory authorization included in art. 48a section 16 of the “u.ś.o.z.” the Regulation of the Minister of Health of December 22, 2017 on defining the model of the health policy program, the final report on the implementation of the health policy program and the method of preparing the health policy program draft and the final report on the implementation of the health policy program (Dz.U. of 2017 item 2476) was adopted. Unified standards will facilitate both the creation and implementation as well as the assessment of PPZ. Introducing necessity of the final report of implementation and results of PPZ to AOTMiT will enable implementation of good model for the following Programs and, at the same time, public funds for these purposes will be more effectively managed [11,13, 14].

Amendments to the regulations assumed that the implementation of PPZ in the event that the project receives a negative opinion of the President of AOTMiT (or the opinion will not be obtained at all) will involve a violation of the public finance discipline. All activities carried out under the PPZ will have to be presented on the basis of literature indicating scientific evidence or existing recommendations. A PPZ may be discontinued when there are circumstances indicating the unintentionality of further implementations, for example in the case of new scientific reports regarding a given health problem.

Despite directing changes to simplify and clarify the procedures of creating the PPZ, there were media reports full of concern. Even before the vote for amendments to the Act, deputies formed thesis that this update was to prevent the implementation of self-government programs for the refund of infertility treatment using the method of in vitro fertilization [12]. Concerns were compounded by changes in the management of the Agency – on November 8th, 2017 Minister of Health appointed new President of AOTMiT. It should be emphasized, however, that in accordance with the applicable legal structure, in the scope of issuing opinions on health policy programs AOTMiT is independent from Ministry of Health. The Agency in its position indicated that the process of evaluation is modeled on the activities already tested in other healthcare systems. Institutions assessing medical technologies include: PHAC (Public Health Advisory Committee), NICE advisory body (National Institute Health and Care Excellence), SIGN (Scottish Intercollegiate Guidelines Network) or USPSTF (U.S. Preventive Services Task Force) [1].

The aim of the article is to quantitative and qualitative statement of PPZ prepared in Poland in 2016 and 2017, as well as presenting changing legal situation in the scope of evaluation of these projects. The self-government bodies, closest to the local community, can accurately diagnose its needs, hence emphasis was put on Programs submitted by local government units. Only unified activities of politicians, local government units and the health care environment can guarantee success in extending life in health, improving health and related to it quality of life of the population and reducing social inequities in health.

MATERIALS AND METHODS

For presenting changes of legal status, the descriptive method has been used. The article includes data available in the Bulletin of Public Information by The Agency for Health Technology Assessment (*Biuletyn Informacji Publicznej Agencji Oceny Technologii Medycznych i Taryfikacji*). 590 programs were analyzed (239 from 2016 and 351 from 2017). These data were elaborated in analyses, charts and maps.

RESULTS

Since 2010 increase in number of developed health policy programs can be noticed. This is presented on the graph below (Figure 1.)

In 2016 240 PPZ (239 programs were used for analysis, that content was determined based on the data available on AOTMiT Bulletin of Public Information website; the program number 199/2016 was omitted in the analyzes, due to the inability to determine its content) were given to evaluation by AOTMiT, four of which were submitted by Ministry of Health (An outpatient support program for diabetic foot syndrome; Program for comprehensive procreative health care in Poland; Nationwide program of primary prevention and early detection of head and neck cancer; Nationwide Primary Prevention and Early Detection Program for Rheumatoid Arthritis). In 2017 352 programs were evaluated (351 programs were used to analysis, the

program number 335/2017 was omitted, due to the inability to determine its content), including eight submitted by Ministry of Health (Nationwide Prevention Program of Brain Disorders; Nationwide educational and prevention program for chronic obstructive pulmonary disease (COPD) – twice; Nationwide educational and prevention program in the field of depression – due to negative opinion it was changed to Program in the field of education and prevention of postpartum depression; Program of Prevention and Treatment of Cardiovascular System Diseases POLKARD for years 2017–2020; Program for the coordination of osteoporotic fracture prevention; ABCDE of birthmarks self-checking-nationwide skin cancer prevention program).

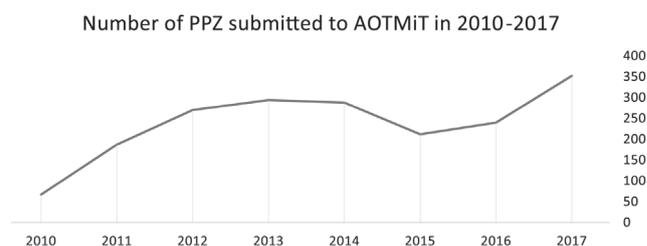


Figure 1. Number of Health Policy Programs submitted to AOTMiT in 2010-2017. Authors on the basis of Agency for Health Technology Assessment and Tariff System Bulletin of Public Information data [2]

In 2016 AOTMiT positively or partially positively valued on 67% of submitted programs, and in 2017 – 71%, which may seem not very satisfying, however in comparison with percent in 2012 (only 58.5% positively evaluated programs) the progress in this field is noticeable. It is suggested, that it could have been caused, among others, by the opinion of the Law Department of Ministry of Health from March 2013, that released the Agency from the duty of evaluating appointed PPZ types, such as: mental health protection, counteracting alcoholism, nicotine or drug addiction [4]. Coordination and establishment of tasks on this subject is regulated by relevant, separate statutory provisions, which are indicated in the table below (Table 1.) [5].

Table 1. Legal basis regulating the activity of local government units in the given subject

Subject of health problem	Legal basis regulating the activity of local government units in the given subject (or regulation established at the national level)
Prevention and solving alcohol related problems	Act of October 26 th , 1982 on education in sobriety and counteracting alcoholism (art. 4 ¹ section 2)
Drug addiction prevention	Act of July 29 th , 2005 on drug addiction prevention (art. 9 section 1 and art. 10 section 1)
Nicotine addiction prevention	Act of November 9 th , 1995 on protection of health against the consequences of tobacco use (art. 4 section 1; repealed since January 1 st , 2018)
Mental health care	Act of August 19 th , 1994 on mental health care (art. 2 section 4. point 1) Annex to Council of Ministers regulation of February 8 th , 2017 on National Program of Mental Health Care for years 2017–2022 (item 458) (point 1.3)

A PPZ on this subject implemented in the light of the bills mentioned in the table is obligatory and not optional, as in the case of PPZs carried out on the basis of "u.ś.o.z." Until the opinion from 2013, a significant part of the negative opinion programs (due to non-compliance with the statutory definition of PPZ) were projects related to mental health [4].

Below are the tables showing the issues of PPZ reported by JST and positively (provided that the

proposed corrections are taken into account) approved by AOTMiT in 2016 and 2017 (Tables 2 and 3). It should be remembered that in 2016 and until November 30th, 2017, the positive opinion of AOTMiT was not yet a condition necessary for the implementation of the program, the tables are an attempt to transfer the current legal situation to the prevailing conditions.

Table 2. Health Policy Programs submitted by local government units in 2016 and positively evaluated by Agency for Health Technology Assessment and Tariff System by general and detailed topics. Authors on the basis of Agency for Health Technology Assessment and Tariff System data

Group of health policy programs	Number ^a (n = 157)	Specific issues	Number ^a	
Infectious diseases	88	Preventive vaccines (83)	Influenza	30
			HPV	27
			Pneumococcal bacteria	23
			Meningococcus	4
			Rotaviruses	1
			Chickenpox	1
		Hepatitis C – detection	3	
		HPV infections – detection	1	
		Tick-borne diseases	1	
Dental prophylaxis	17	Tooth decay	17	
Systematic activity	11	Health of the elderly	5	
		First aid education	3	
		School medicine	2	
		Health education	1	
Musculoskeletal system diseases and disability	11	Rehabilitation	5	
		Postural defects	4	
		Osteoporosis	1	
		Osteoarthritis	1	
Lifestyle diseases	8	Overweight and obesity	4	
		Cardiovascular diseases	2	
		Diabetes (type 2)	3	
Sensory organs and neurological diseases	7	Hearing impairment	5	
		Visual impairment	2	
		Neurological diseases	1	
Reproductive health	8	Infertility, in vitro	5	
		Perinatal care + mother and child care	3	
Neoplasms	6	Neoplasms (in general)	2	
		Prostate	1	
		Cervix	1	
		Lungs	1	
		Skin	1	
Cancer patients	1	Psychomotor rehabilitation after mastectomy	1	
Urinary system	1	Detection of chronic renal failure	1	
Birth defects	1	Congenital craniofacial abnormalities	1	

^a Some programs concerned several different general and/or specific issues, hence the total number of general issues is lower than the total number of specific issues, and the total number of general issues is higher than the total number of programs (positively evaluated by AOTMiT). The subjective division was made by authors for the purposes of analysis

Both in 2016 and 2017 the vast majority were programs for infectious diseases: influenza and human papillomavirus. In 2016 on the third place in terms of the frequency of positively evaluated programs for

pneumococcal vaccination were placed, and in the following year their number significantly decreased, which is related to the introduction of changes to the 2017 Program for Preventive Vaccination.

Table 3. Health Policy Program submitted by local government units in 2017 and positively evaluated by Agency for Health Technology Assessment and Tariff System by general and detailed topics. Authors on the basis of Agency for Health Technology Assessment and Tariff System data

Group of health policy programs	Number ^a (n = 244)	Specific issues	Number ^a	
Infectious diseases	128	Preventive vaccines (115)	Influenza HPV Pneumococcal bacteria Meningococcus Chickenpox HBV	55 38 9 9 3 1
		Tick-borne diseases Hepatitis C detection		10 3
Lifestyle diseases	30	Overweight and obesity Diabetes Cardiovascular diseases		17 9 6
Dental prophylaxis	23	Tooth decay		23
Musculoskeletal system diseases and disability	18	Rehabilitation Postural defects Movement disorders prophylaxis Spine disease		11 5 1 1
Reproductive health	16	Infertility, <i>in vitro</i> Perinatal care + mother and child care and reproductive health education		9 7
Systematic activity	9	Health of the elderly Health education First aid education Life envelope Daily care medical		4 2 1 1 1
Sensory organs and neurological diseases	8	Visual impairment Hearing impairment		5 4
Neoplasms	6	Prostate Breast Women's (in general) Large intestine		2 2 1 1
Lung diseases	4	Tuberculosis Fibrous dust complications prophylaxis Pulmonological rehabilitation		2 1 1
Mental health	3	Autism Neurosis prophylaxis		2 1
Birth defects	2	Birth defects (in general)		2
Cancer patients	2	Edema prophylaxis/ rehabilitation for cancer patients		2

^a Some programs concerned several different general and/or specific issues, hence the total number of general issues is lower than the total number of specific issues, and the total number of general issues is higher than the total number of programs (positively evaluated by AOTMiT). The subjective division was made by authors for the purposes of analysis

Vaccinations against pneumococcal bacteria have become mandatory not only for children at risk, but for all children from 2 months of age, born after December 31st, 2016. In this example, health policy programs can sometimes be considered as a kind of guidance which can launch the implementation of national programs. The amendment to the Act, however, outlined a separate legal framework for conducting health-related strictly pilot programs financed from the state budget from the part of the minister in charge of health matters.

In 2016, programs designed for children or people over 60 years of age accounted for 41% of all positively evaluated JST programs, while in 2017 – 65%.

In the case of self-government voivodships, in 2016 – 7 of them made efforts to implement a new health policy program in their area. These were voivodships: Opolskie (with 6 proposals), Wielkopolskie and Mazowieckie (4 each), Łódzkie (3), Świętokrzyskie (2), Kujawsko-Pomorskie and Lubelskie voivodships (1 proposition each). In 2017, at least one voivodship-wide program was reported by all voivodships except Zachodnio-Pomorskie Voivodeship.

The number of PPZs, broken down by voivodships, submitted for opinion by AOTMiT, is presented on the maps below (Figure 2).

Within two years, clearly more PPZ were reported by JST from Mazowieckie and Dolnośląskie voivodships and the Podlaskie Voivodeship was by far the worst.

Another confirmation of regional inequalities in access to the PPZ is the presentation of the territorial

distribution of local governments, which in 2016 and 2017 submitted projects to AOTMiT.

On the maps (Figure 3) attention is paid to stratification in the activities of JST. Many of them do not carry out any program, and in opposition to them there are those that submit several programs.

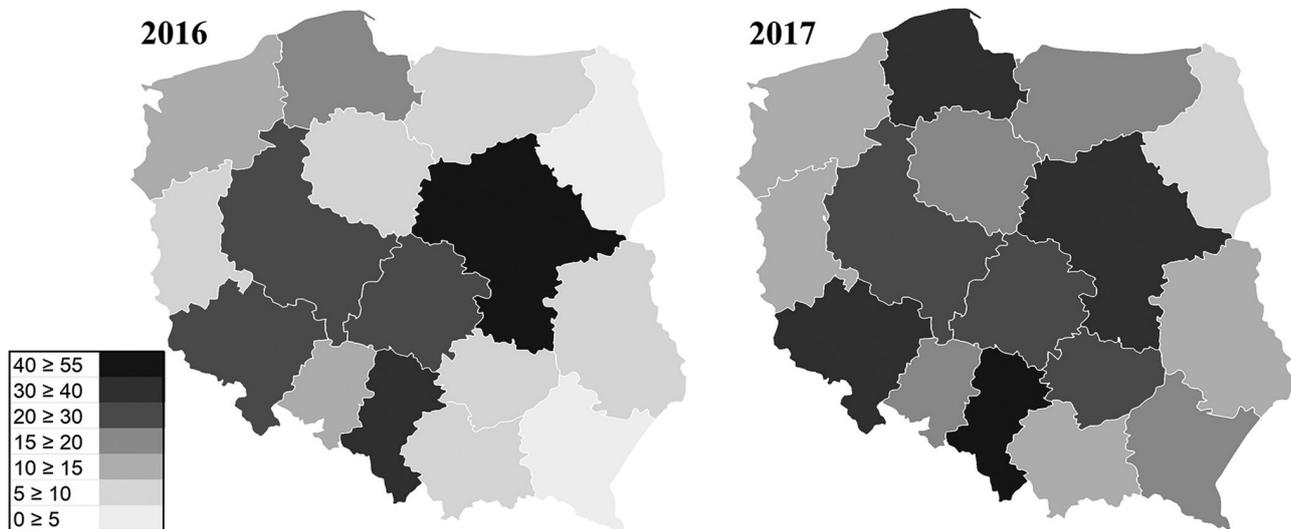


Figure 2. Number of Health Policy Programs submitted for opinion by Agency for Health Technology Assessment and Tariff System in 2016 and 2017, broken down into voivodships. Authors on the basis of Agency for Health Technology Assessment and Tariff System data

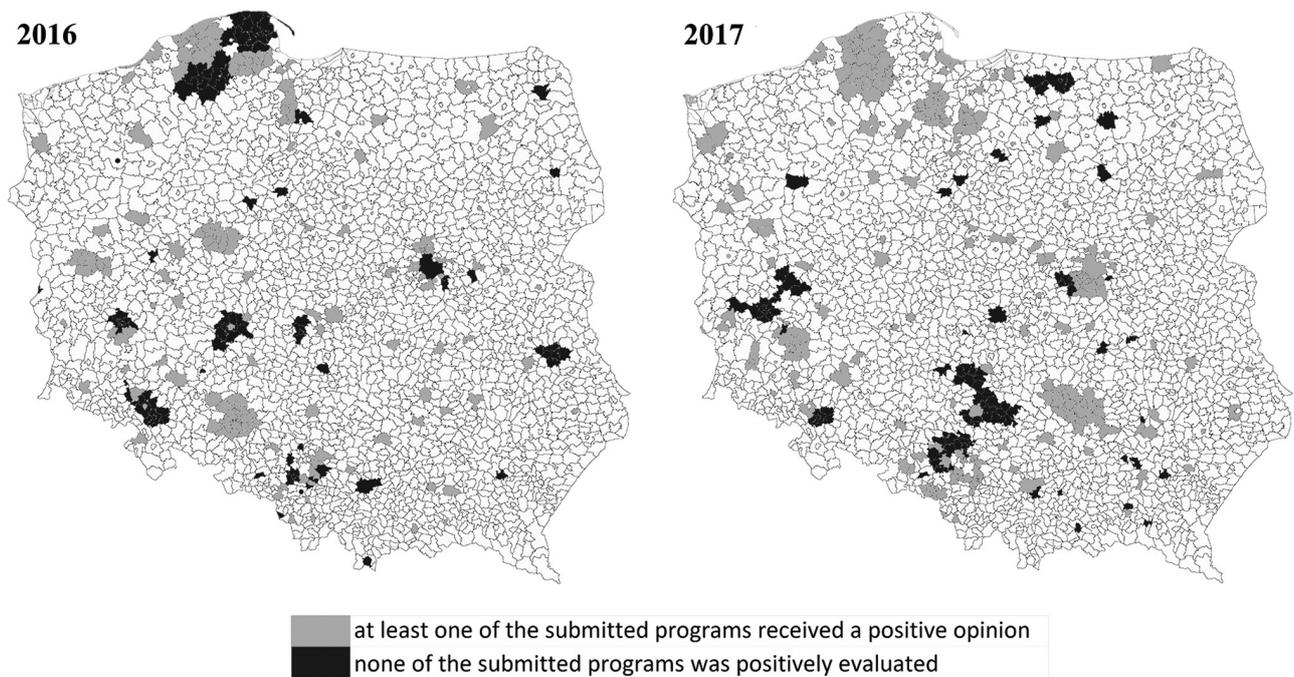


Figure 3. Local Government Units (municipalities, poviats and cities with poviat rights), which in 2016 and 2017 submitted a PPZ for Agency for Health Technology Assessment and Tariff System evaluation. Authors on the basis of Agency for Health Technology Assessment and Tariff System data. Origin of contour map: [https://commons.wikimedia.org/wiki/File:POLSKA_mapa_gminy.png?uselang=en], [Aotearora], license: [CCBY-SA 3.0 Deed] (<http://creativecommons.org/licenses/by-sa/3.0/>)

DISCUSSION

Decentralization of public authority assumed that the structure responsible for recognizing the local needs (including health needs) of citizens are local government units. Both the number and the quality of PPZ depends mainly on budget resources of the organizer [9]. This could explain discrepancy in implementation PPZ by self-governments. Due to facultative nature of PPZ, activity in this field is show only by those JST, that have at their disposal appropriate resources or take effective actions to obtain funding. Small municipalities below 5,000 residents can get up to 80% funding from the National Health Fund for the implementation of the PPZ, and the remaining - 40%.

However, the problem of responsibility for personal and others health is complex and also depends on a consistent, social strategy in favor of health, its protection and enhancement. All members of a given community have a significant share in this process [6]. A necessary condition for the proper implementation of local government units actions for the rational introducing health policy programs and for satisfying the health needs of residents is the compatibility of legal provisions and initiatives undertaken [10]. In accordance to the relevant constitutional regulations, public tasks of JST include, among others, actions in the field of promotion and health protection. Instruments for the implementation of these tasks are indicated, in particular, in the acts: on health care activities and on health care services financed from public funds, and include, among others, the possibility of financing health policy programs and the purchase of medical equipment.

The amendment to the Act extends only the scope of instruments, based on which local governments will be able to implement their systemic tasks in the field of health protection. The choice of the appropriate instrument in this respect will be, as in the previous legal structure, dependent on JST.

Act of June 10th, 2016 on amendment on medical activities and some other acts provides attributing JST with the possibility of financing of health care services. Referring to the lack of competence and appropriate tools to correctly assess health needs and make decisions about financing benefits, it should be noted that the Act provides that, when making the decision, local government units take into account the regional map of health needs, priorities for regional health policy and the state of access to health care services in the area of the voivodship.

Local government units are also covered by legal regulations regarding lobbying activities conducted in relation to them, despite the common belief that these regulations cover only public authorities at the central level [15]. Also the draft act on life transparency

will concern local self-government units (according to the definition included in art. 2 section 1 point 3 of the draft act, not only the municipality, poviát or voivodship should be understood as a self-government unit relationship). According to art. 2 section 1 point 6 of the draft act, lobbying is every action of entities that are not public authorities or representatives authorized by these bodies, carried out by legally permitted methods, not regulated under statutory proceedings before public authorities, aimed at influencing the decision of a public authority in the certain way [7].

In practice, we encounter the following forms of lobbying: protests of citizens, non-governmental organizations by demonstrations of the commune residents, establishment of a protest camp by the non-governmental organization or strike of hospital staff, appeals and petitions, happenings, gaining media support and cooperation with councilors, founding an association, use of experts knowledge and lawyers skills, and finally direct lobbying in the form of meetings and written correspondence. The essence of lobbying is to influence – within the law – the decisions of public authorities (except for judicial authorities) in the direction desired by specific groups (usually called interest or pressure groups) or individuals, so the phenomenon of lobbying can have a significant impact on the development of local programs health policy.

Supreme Audit Office in the report from 2016 evaluated PPZ implemented by self-governance as actions with limited effectiveness, consolidating inequalities in access to health services. A serious systemic drawback is the limitation of access to PPZ to residents of low-income municipalities. Ministry of Finance and Statistics Poland data, developed by Supreme Audit Office shows that the amounts spent by local self-government are characterized by a large discrepancy depending on the voivodship: average annual expenditure of local governments per PPZ per capita in 2010–2015 ranged from 0.3 PLN (Warmińsko-Mazurskie Voivodeship) to 4.3 PLN (Mazowieckie Voivodeship) [9].

Further concerns relate to the reliability and consistency of the AOTMiT opinion – for example in relation to the Legionowo poviát “Childbirth classes” in 2013 the agency issued a positive opinion, while in 2014 the health campaign with a similar content was given a negative opinion, justifying the decision with its modest financial resources for the implementation [9].

The criterion that the Agency takes into account when assessing the desirability of the implementation of PPZ is the ratio of potential benefits to health risk. When deciding on the distribution of funds for the implementation of health policy programs, it is worth to look systemic at what effects the intervention may bring. Local governments are the most willing to report

vaccination programs. The introduction of population vaccination increases immunity also in unvaccinated groups as part of an indirect effect, i.e. environmental immunity.

System effects can include reducing the number of hospitalizations, reducing the absenteeism of employees caused by sick leave (as a consequence, reducing the employers' and social security institutions costs). Population vaccination programs are characterized by high efficiency and relatively low costs: they can be more cost-effective than the treatment of the disease itself and its complications.

Programs with missing data on health risks should not be funded, or existing data suggest that the risk far exceeds the health implications. An example of how important it is to consider information about the risks and benefits can be programs for the early detection of prostate cancer. The agency often gave negative opinions, indicating an insufficient number of clinical trials confirming the validity of the procedure applied (PSA and prostate ultrasound examinations). Moreover, when performing screening tests, the possibility of false positive results should be taken into account – in numerous projects such circumstances have not been taken into account and there are no ways to minimize patient exposure to unnecessary stress.

Literature indicates factors that may have an adverse effect on the assessment of PPZ: the presence of informal decision-making processes that may lead to non-optimal decisions reflecting the strength of specific interest groups [3]. Difficulties in optimizing decisions taken at the stage of assessing and accepting PPZ may also result from psychological or behavioral problems of decision-making bodies. The new paradigm in the field of behavioral economics, honored with the Nobel Prize in the field of econometrics, is based on the belief that people make decisions rationally to a small extent; not reason, but above all, emotions influence people's decision making [8]. In the management of medical facilities, as well as other subjects of the health sphere or projects in the area of health, efficiency and ability to cooperate in order to achieve a common goal as well as extremely difficult strategic management are crucial, which may be crucial in assessing the long-term effects of the PPZ. In the recent years a big improvement in the quality of planned self-government health programs is observed. As new data is acquired and new solutions are found, local government units optimize their operations. It is suggested that due to the regulation defining the model of the health policy program and the model of the final report, this trend will continue.

Widely adopted tools for the creation and evaluation of health policy will certainly not solve all the problems raised, but will nevertheless contribute to facilitating the preparation and evaluation of PPZ.

CONCLUSIONS

1. Since 2010 increase in number of developed health policy programs can be noticed.
2. In the recent years an increase in the number of positively evaluated self-government health programs is observed. Regulation defining the model of the health policy program and the model of the final report is focused on improving their quality.
3. The most of positively evaluated PPZ submitted by local government units referred to prevention of infectious diseases by vaccines, considered as a highly cost-effective intervention.
4. Significant differences were observed in the implementation of the PPZ in various regions of Poland (regional stratification).

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Agencja Oceny Technologii Medycznych i Taryfikacji. Komunikat o zmianach w ustawie dot. PPZ [The Agency for Health Technology Assessment and Tariff System. Announcement on changes in the PPZ Act] <http://www.aotm.gov.pl/www/komunikat-o-zmianach-w-ustawie-dot-ppz/> (Accessed 25.01.2018) (in Polish).
2. Biuletyn Informacji Publicznej Agencji Oceny Technologii Medycznych i Taryfikacji [Bulletin of Public Information of the Agency for Health Technology Assessment and Tariff System] <http://bipold.aotm.gov.pl/> (Accessed 25.01.2018) (in Polish).
3. Buse K.: Addressing the theoretical, practical and ethical challenges inherent in prospective health policy analysis. *Health Policy Plan* 2008; 23:351-360.
4. Dudzik K., Cianciara D., Zalewska E., Lewczuk-Wesołowska A., Piętka S., Grudziąż-Sękowska J., Rdzany R, Brzezińska A.: Planowanie samorządowych programów zdrowotnych. Część I. Problem zdrowotny, adresaci [Planning of community health programs. Part I. Health problem, target population]. *Hygeia Public Health* 2015; 50:84-89 (in Polish).
5. Głanowski G.: Kontrowersje wokół realizacji samorządowych programów zdrowotnych [Regulation of health programs executed by local government]. *Medycyna ogólna i nauki o zdrowiu* 2015; 21:146-151 doi: 10.5604/20834543.1152911 (in Polish).
6. Głowacka M.D.: Odpowiedzialność za zdrowie własne i innych [Responsibility for health: personal and social]. In: Głowacka M.D., Mruk H. eds. *Odpowiedzialność za zdrowie* [Responsibility for health]. Poznań: Polskie Towarzystwo Nauk o Zdrowiu; 2017. p. 13-36 (in Polish). <http://legislacja.rcl.gov.pl/docs/516/12305154/12471189/dokument323516.pdf> (Accessed 25.01.2018) (in Polish).

7. KPRM. Projekt ustawy o jawności życia publicznego [Draft law: The Act on transparency in public life] <https://bip.kprm.gov.pl/kpr/form/r83905103,Projekt-ustawy-o-jawnosci-zycia-publicznego.html> (Accessed 25.01.2018) (in Polish).
8. *Mruk H.*: Zarządzanie placówką medyczną a ekonomia behawioralna [Management of a medical facility and behavioral economics]. *Biuletyn Głównej Biblioteki Lekarskiej* 2018 [ahead of print] (in Polish).
9. NIK. Realizacja programów polityki zdrowotnej przez jednostki samorządu terytorialnego. Najwyższa Izba Kontroli 2016 [Implementation of health policy programs by local government units. Supreme Audit Office; 2016] <https://www.nik.gov.pl/plik/id,12140,vp,14521.pdf> (Accessed 25.01.2018) (in Polish).
10. *Nowakowska I., Rasińska R., Bańkowska A.*: Programy polityki zdrowotnej jako działania samorządów [Health policy programs as local government act] In: *Głowacka M.D., Mruk H.* eds. *Odpowiedzialność za zdrowie* [Responsibility for health]. Poznań: Polskie Towarzystwo Nauk o Zdrowiu; 2017. p. 127-138 (in Polish).
11. Rozporządzenie Ministra Zdrowia z dnia 22 grudnia 2017 r. w sprawie wzoru programu polityki zdrowotnej, wzoru raportu końcowego z realizacji programu polityki zdrowotnej oraz sposobu sporządzenia projektu programu polityki zdrowotnej i raportu końcowego z realizacji programu polityki zdrowotnej [Regulation of the Minister of Health of December 22, 2017 on defining the model of the health policy program, the final report on the implementation of the health policy program and the method of preparing the health policy program draft and the final report on the implementation of the health policy program]. *Dz.U.* 2017 poz. 2476.
12. Sejm Rzeczypospolitej Polskiej: Kadencja VIII. Sprawozdanie Stenograficzne z 48. posiedzenia Sejmu Rzeczypospolitej Polskiej w dniu 29 września 2017 r. (trzeci dzień obrad) [Sejm of the Republic of Poland: 8th cadence. Statements at Parliament meetings. Meeting no 48 of September 29, 2017 (3rd day of the meeting)]. Warszawa: Sejm Rzeczypospolitej Polskiej; 2017. p. 310-313 http://orka2.sejm.gov.pl/StenoInter8.nsf/0/95D10368FC54F75BC12581AA0062FACD/%24File/48_c_ksiazka_bis.pdf (Accessed 25.01.2018) (in Polish).
13. Ustawa z dnia 27 sierpnia 2004 r. o świadczeniach opieki zdrowotnej finansowanych ze środków publicznych (Dz.U. 2017 poz. 1938 z późn. zm.) [Act of August 27, 2004 on healthcare services financed from public funds]. *Dz.U.* of 2017 item 1938, with subsequent amendments] (in Polish).
14. Ustawa z dnia 29 września 2017 r. o zmianie ustawy o świadczeniach opieki zdrowotnej finansowanych ze środków publicznych oraz niektórych innych ustaw (Dz.U. 2017 poz. 2110) [Act of September 29, 2017 on amendment on healthcare services finance from public funds and certain other acts *Dz.U.* of 2017 item 2110] (in Polish).
15. Ustawa z dnia 7 lipca 2005 r. o działalności lobbingsowej w procesie stanowienia prawa (Dz.U. 2005 Nr 169 poz. 1414 z późn. zm.) [Act of July 7, 2005 on lobbying in the law-making process. *Dz.U.* of 2005 No. 169, item 1414 with subsequent amendments] (in Polish).

Received: 21.02.2018

Accepted: 31.03.2018

INSTRUCTION FOR AUTHORS

Quarterly *Roczniki Państwowego Zakładu Higieny* / *Annals of the National Institute of Hygiene* is the peerreviewed scientific journal that publishes original articles, reviews, short communications, letters to the editor and book reviews.

Journal is devoted to the studies concerning scientific problems of food and water safety, nutrition, environmental hygiene, toxicology and risk assessment, public health and other related areas.

Since 2013, Volume 64, number 1 all the papers are published in English.

All articles for publication in *Roczniki Państwowego Zakładu Higieny* / *Annals of the National Institute of Hygiene* (Rocz Panstw Zakl Hig) should be submitted electronically via e-mail: roczniki.pzh@pzh.gov.pl

Fees

Since 1st January 2018 a fee of 650 PLN for Polish Authors (including VAT) and 150 EUR for foreign Authors is introduced for publication of paper in *Roczniki Państwowego Zakładu Higieny* / *Annals of the National Institute of Hygiene*. The fee will be charged after acceptance of the manuscript for publication.

Payment information

National Institute of Public Health – National Institute of Hygiene, 24 Chocimska street, 00-791 Warsaw, Poland
Payment from Poland: Bank PKO B.P.S.A. 98 1020 1042 0000 8302 0200 8027

Payment from other countries: IBAN PL98 1020 1042 0000 8302 0200 8027, SWIFT: BPKOPLPW

Title of the payment: Fee for publication of the article: article number, name of the first Author, title of the article.
The cost of bank charges is covered by the Authors.

The invoice is issued by the publisher: National Institute of Public Health – National Institute of Hygiene, after the fees have been transferred on the publisher's bank account.

RULES FOR THE ACCEPTANCE OF THE MANUSCRIPTS

Editorial policy and basic information

Only high scientific quality articles complying with the scope of the journal will be considered for the publication.

Copyright. All the copyrights to the articles published in the *Roczniki Państwowego Zakładu Higieny* are reserved for the publisher: the National Institute of Public Health – National Institute of Hygiene. It means that after article is published the authors transfer the copyright to the publisher and cannot publish this article or its parts elsewhere for commercial purposes without the written permission from the publisher.

License Creative Commons. Submitting the manuscript to Editorial Office means that the Authors declares that they have read the full text of the Creative Commons Attribution – Non Commercial 3.0 Poland license (CC-BY-NC) available at: <http://creativecommons.org/licenses/by-nc/3.0/pl/deed.en>.

Ethics. Clinical articles should comply with the generally accepted ethical standards and the Helsinki Declaration. For animal experiments reported in the articles the author(s) must obtain the acceptance by the relevant local Ethics Commission.

Conflict of interest. Conflict of interest exists if authors or their institutions have financial or personal relationships with other people or organizations that could inappropriately influence their actions. Such relationships should be disclosed to the publisher. All authors should provide a signed statement of their conflict of interest as a part of the author's statement form.

Transparency. Openness of information on any party contributing to preparation of a publication (content related, financial, etc. input) is proof of ethical attitude of a researcher and of high editorial standards.

“Ghostwriting” and “guest authorship” are indications of scientific dishonesty and all cases will be exposed and adequate institutions will be informed. “Ghostwriting” is a situation where a person contributes significantly to a publication and is not disclosed as one of the authors or named in the acknowledgments and “guest authorship” is a situation where an author’s contribution is insignificant or nonexistent and he is still listed as author/ co-author of a publication.

The editor requires from the authors of the articles that they reveal the contribution of individual authors to the manuscript, i.e. who is the author of the concept and study design, data/material collection, study/analysis, performance, statistical analysis, interpretation of the results, manuscript development etc. Authors of the manuscript should provide “Authors’ statement” form signed by the all authors. Also the information concerning the sources of financial support to the study presented in the submitted manuscript should be provided.

Peer review procedure for manuscripts

1. The manuscripts submitted to the *Roczniki Państwowego Zakładu Higieny* undergo preliminary evaluation in the editorial office to determine whether the topic is within the scope of the journal and to evaluate the adherence to the journal format, as well as to the rules of acceptance. In cases when the above prerequisites are not met the manuscript is not qualified, and the corresponding author is informed.
2. Following the positive preliminary evaluation the paper is directed for peer review to at least two independent and recognized experts representing the scientific experience in the field covered by the manuscript and affiliated in the different institution than the institution(s) where the authors have been affiliated. The reviewers must ensure independence and lack of conflict of interests.
3. During the entire reviewing the double-blind review process is maintained.
4. The review in the written form is forwarded to the corresponding author with the accompanying statement suggesting status of the paper as: “accepted”, “accepted after revisions” or “not accepted”. The **Review form** is available on the journal’s website: http://wydawnictwa.pzh.gov.pl/roczniki_pzh/ for-reviewers.
5. The list of reviewers is published once a year in the fourth issue of each volume and is available on the journal’s website: http://wydawnictwa.pzh.gov.pl/roczniki_pzh/reviewers

Submission of manuscripts

For the publication the following attachments must be submitted:

1. **Cover letter**, in which the corresponding author applies for the publication of the paper in the *Roczniki Państwowego Zakładu Higieny*. The cover letter, signed by the corresponding author, should contain the name of the institution where he is affiliated, address, phone and fax numbers, e-mail. The corresponding author is requested to suggest two or three potential reviewers (including their affiliations and e-mails) from institutions other than the author’s one.
2. **Author(s)’ statement**, signed by all authors, stating that the manuscript complies with the general rules set for the scientific articles and was not published and/or submitted for publication elsewhere and will not be send for publication to the other journal, and there is no infringement of property rights to any interested third parties. In the case of experiments on animals the approval of the relevant ethics commission is required. The clinical studies must be accompanied by the written statement, signed by the authors confirming that the research was conducted in accordance with the Helsinki Declaration. The contribution of the individual authors to preparation of a publication should be specified. All authors are required to sign the statement of their conflict of interest as a part of the author’s statement form. **Author’s statement form** is available on the journal’s website: http://wydawnictwa.pzh.gov.pl/roczniki_pzh/media/Authors_statement.pdf
3. **Manuscript**. Text of the manuscript, tables and figures (in the separate files) should be sent by the e-mail: roczniki.pzh@pzh.gov.pl.

Arrangement of manuscripts

Manuscripts submitted for publication should be typed by the editor Microsoft Word using Times New Roman 12 font and 1.5 space between lines on A4 paper size.

Title page. It should contain the title of the paper in English and, the name(s) and surname(s) of the author(s), the complete name(s) of the institution(s) where the work was performed, address of the corresponding author's institution, phone and/or fax numbers and the e-mail inserted at the bottom of the title page. If appropriate, the number and the title of the project under which the study has been carried out should also be given on this page as a footnote.

Abstract. It should contain 250-300 words and consist of the following sections: Background, Objective, Material and methods, Results, Discussion and Conclusions. The abstract of a review should not be divided into sections.

Keywords. Should be placed after the abstract. 3-6 words or short phrases according to the MeSH (*Medical Subject Headings Index Medicus*) catalogue available at www.nlm.nih.gov/mesh/meshhome.html
Polish authors are asked to attach the abstract and keywords also in Polish language.

Text. The text of the manuscript should be divided into the following sections: Introduction, Material and methods, Results, Discussion, Conclusions, Acknowledgements, References.

Introduction. It should contain the scientific rationale and the aim of the study or in the case of a review the purpose of the article. Only references related to the paper should be cited.

Material and methods. This section should provide detailed information on the subject of the study, methods, chemicals, apparatus and techniques used in sufficiently exhaustive way to enable readers to repeat the experiments or observations. For generally known methods references should be given together with name of the methods or statistical analysis used in the study. For new or substantially modified methods detailed descriptions are to be added. In the case of experimental studies on laboratory animals, the information should be provided on the approval by a local Ethics Commission, or in the case of clinical studies that they have been performed with the ethical standards according to the Helsinki Declaration.

Results. These should be presented in a logical sequence in the text, the same applies to the tables and figures. The data from the tables and figures should not be repeated in the text, where only the most important observations from the studies are to be summarized. The place where the tables, figures or photographs should appear in the text should be indicated.

Discussion. Emphasize the new and important aspects of the results and a comprehensive interpretation of the results obtained against the background of results obtained by other authors. Quotations should be restricted to those with immediate relevance to the author's findings.

Conclusions. They should be stated precisely in points or descriptively and should be logically connected with the aims stated in the introduction. Statements and conclusions not derived from own observations should be avoided. If a hypothesis is proposed it must be stated clearly.

Acknowledgements. These should be placed directly after the Conclusion section. One or more statements should specify: (1) persons who contributed substantially to the study but cannot be regarded as authorship, such as technical assistants, statisticians, data collectors etc. Their assistance should be acknowledged for the sake of transparency. It must be clear that they are not responsible for the final version of the article. You must ensure you have the consent of all the persons named in the acknowledgements; (2) all sources of financial and material support, which should specify the nature of the support. The recommended form is: "This work was supported by: (name of the organization, project number etc.)"; (3) relationships that may pose the conflict of interest.

References. References should be presented in alphabetical order, according to author's names. Each position in the list of references should start from the new line and contain: consecutive number, author's (authors') surname(s) and initials of name(s) (written in italic), full title of the paper, official journal title abbreviation (according to the List of Journals Indexed in *Index Medicus*), year, volume, the first and the last page number of the paper. When quoting them in the text only the number of the reference should be given in square brackets. If the article or book has a DOI number ('Digital Object Identifier' number unique to the publication), it should be included in the references. The titles of the cited papers in other language than English should be also translated

into English [and given in square brackets]. The information on the original language should be given in the brackets after the page numbers, for example: (in Polish). The examples of reference style are given below:

Article in a periodical:

1. *Snopczyński T., Struciński P., Góralczyk K., Czaja K., Hernik A., Korcz W., Kucharska A., Ludwicki J.K.*: Zastosowanie metody QuEChERS w połączeniu z chromatografią gazową z detektorem wychwytu elektronów (GC-ECD) w analizie pozostałości pestycydów w żywności [Application of the QuEChERS method coupled with gas chromatography with electron capture detection (GC-ECD) in analysis of pesticide residues in food]. *Rocz Panstw Zakl Hig* 2011;62(2):145-151 (in Polish).
2. *Lopes M.C., Giudici K.V., Marchioni D.M., Fisberg R.M., Martini L.A.*: Relationships between n-3 polyunsaturated fatty acid intake, serum 25 hydroxyvitamin D, food consumption, and nutritional status among adolescents. *Nutr Res* 2015;35(8):681-688.
3. *Shridhar G., Rajendra N., Murigendra H., Shridevi P., Prasad M., Mujeeb M.A., Arun S., Neeraj D., Vikas S., Suneel D., Vijay K.*: Modern diet and its impact on human health. *J Nutr Food Sci* 2015;5:6 doi:10.4172/2155-9600.1000430.
4. *Wu M., Yu G., Cao Z., Wu D., Liu K., Deng S., Huang J., Wang B., Wang Y.*: Characterization and human exposure assessment of organophosphate flame retardants in indoor dust from several microenvironments of Beijing, China. *Chemosphere* 2015, doi:10.1016/j.chemosphere.2015.12.111.

Books and chapter in a book:

5. *Riley D.M., Fishbeck P.S.*: History of methylene chloride in consumer products. In: *Salem H., Olajos E.J.* (eds.). *Toxicology in Risk Assessment*. London, Taylor & Francis, 2000.

Legislative acts:

6. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. *Off J EU L* 364, 20.12.2006.

Internet source:

7. The Rapid Alert System for Food and Feed (RASFF) Portal. Available <https://webgate.ec.europa.eu/rasff-window/portal> (accessed 18.10.2010)

Tables. These should be printed on separate sheets and numbered using Arabic numerals. The title should be placed directly above each table. Tables should always be cited in the text in consecutive numerical order. Each column in tables should have a brief heading, more extensive explanation should be given below the table, if necessary. The number of tables should be limited to indispensable for the documentation of results.

Figures and photographs. These should be numbered in Arabic numerals according to the sequence of their appearance in the text. Figures should be made by computer technique and the titles should be placed below the figures. Photographs must be of high quality, digital format is preferred.

Tables, figures or photographs should be cited in the text in consecutive numerical order in the following way: (Table 1), (Figure 1), (Photo 1).

Abbreviations, symbols, units. Generally known and used abbreviations may be left unexplained, others must be explained at the first use in the text. Metric SI units are recommended, however also other generally used units are accepted.

General information

The editor reserves the right for introducing the editorial corrections in the manuscript which will not influence the scientific contents of the article without prior informing the author.

SUBSCRIPTION

The subscription information is available at:

Library of the National Institute of Public Health - National Institute of Hygiene
24 Chocimska street, 00-791 Warsaw, Poland

Phone: +48 22 54 21 262 or +48 22 54 21 264
e-mail: biblioteka@pzh.gov.pl

Roczniki Państwowego Zakładu Higieny - Annals of the National Institute of Hygiene
may be ordered through Library of the National Institute of Public Health - National Institute
of Hygiene mailing address: biblioteka@pzh.gov.pl

Payment

The payment should be made after invoice receipt to the following account:

Bank PKO BP S.A. 98 1020 1042 0000 8302 0200 8027

National Institute of Public Health - National Institute of Hygiene
24 Chocimska street, 00-791 Warsaw, Poland

Annual subscription in Poland in year 2018 (Vol. 69, 4 issues): 120,00 PLN

ROCZNIKI PAŃSTWOWEGO ZAKŁADU HIGIENY

[ANNALS OF THE NATIONAL INSTITUTE OF HYGIENE]

Volume 69

2018

Number 2

REVIEW ARTICLES

Furan in roasted, ground and brewed coffee.

E. Gruczyńska, D. Kowalska, M. Kozłowska, E. Majewska, K. Tarnowska 111

Garden nasturtium (*Tropaeolum majus* L.) - a source of mineral elements and bioactive compounds.

K. Jakubczyk, K. Janda, K. Watychowicz, J. Łukasiak, J. Wolska 119

ORIGINAL ARTICLES

Analysis of acrylamide, 3-monochloropropane-1,2-diol, its esters and glycidyl esters in carbohydrate-rich products available on the Polish market.

A. Sadowska-Rociek, M. Surma, E. Cieślak 127

The influence of preschool children's diets on the risk of lifestyle diseases. A pilot study.

M. Kostecka 139

Food aversions and dietary preferences in pre-school children from Olsztyn.

J. Ciborska, J. Kłobukowski, I. Pierzchała 147

Analysis of the choice of food products and the energy value of diets of female middle- and long-distance runners depending on the self-assessment of their nutritional habits.

D. Głąbska, M. Jusinska 155

Analysis of nutrition and nutritional status of haemodialysis patients.

A. Bogacka, A. Sobczak-Czynsz, E. Kucharska, M. Madaj, K. Stucka 165

Dietary practices and nutritional status in survivors of breast cancer.

E. Kaładkiewicz, D. Szostak-Węgierek 175

The assessment of the nutritional value of meals consumed by patients with recognized schizophrenia.

E. Stefańska, A. Wendolowicz, M. Lech, K. Wilczyńska, B. Konarzewska, J. Zapolska, L. Ostrowska 183

Eating behaviours of primary school pupils from Śląskie, Malopolskie and Opolskie Voivodeships in Poland.

A. Dolipska, M. Majerczyk, A. Góra, K. Janion, E. Szczepanska 193

Evaluation of health status of children attending primary schools with different organization of physical education lessons.

O.S. Kondratiuk, M.M. Korshun, S.I. Garkavyi, S.S. Garkavyi 203

Health policy programs realised in Poland in 2016-2017.

P. Kurowska, A. Królak, W. Giermaziak 209

Instruction for authors 219