

## FLAVONOIDS INTAKE AMONG POLISH AND SPANISH STUDENTS

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### ABSTRACT

**Background.** Flavonoids are a group of bioactive compounds that are extensively found in foodstuffs of plant origin. Their regular consumption plays an important role in the prevention of degenerative diseases, particularly cardiovascular disease, and cancer.

**Objective.** The purpose of the study was to estimate dietary flavonoid intake among Polish and Spanish students and to establish the main dietary sources of flavonoids.

**Material and Methods.** This study included 91 Polish and 60 Spanish students.

Dietary data were collected using a food frequency questionnaire. The dietary USDA Database for the flavonoid content of selected foods was used to calculate daily and weekly flavonoid intakes by the subjects.

**Results.** The average flavonoid consumption in the Polish students was 801 mg/day, and in Spanish students 297 mg/day. Food categories such as beverages, vegetables and fruits were found to be significant sources of flavonoids, of which tea, oranges, orange juice, dried parsley and oregano were the main contributors among Polish students and oranges, tea, chick-peas, orange juice and dried parsley were the main sources of flavonoids among Spanish students.

**Conclusions.** Flavonoid consumption in Polish students was more than two times higher than in Spanish students. Compared to other population studies consumption of flavonoids in both students groups was adequate.

**Key words:** *flavonoids, flavonoid intake, patterns of consumption*

### STRESZCZENIE

**Wprowadzenie.** Flawonoidy to grupa antyoksydantów występująca powszechnie w roślinach. Substancje te wykazują wielokierunkowe działanie protekcyjne na organizm człowieka, budząc tym samym zainteresowanie naukowców, którzy w licznych pracach badają pobranie tych związków u ludzi.

**Cel.** Celem badań była ocena spożycia wybranych flawonoidów spożywanych wraz z dietą przez polską i hiszpańską młodzież akademicką oraz wskazanie głównych źródeł tych substancji w diecie badanych.

**Material i Metody.** W badaniach wzięło udział łącznie 151 osób: 91 Polaków oraz 60 Hiszpanów. Studenci zostali poproszeni o podanie tygodniowego spożycia produktów spożywczych będących istotnym źródłem flawonoidów. Spożycie tych związków obliczono na podstawie informacji zawartych w bazie danych opracowanej przez Departament Rolnictwa USA (USDA United States Department of Agriculture).

**Wyniki.** Średnie spożycie flawonoidów przez polskich studentów wynosiło około 801 mg/dzień, podczas gdy wśród hiszpańskich studentów wyniosło około 297 mg/dzień. Napoje, warzywa, oraz owoce były głównymi grupami produktów dostarczających flawonoidów wśród badanych z obydwu grup. Najistotniejszym źródłem tych związków wśród polskich ankietowanych była czarna herbata, a wśród hiszpańskich pomarańcze.

**Wnioski.** Analiza udzielonych odpowiedzi wykazała, że polscy studenci spożywali ponad dwukrotnie więcej flawonoidów niż hiszpańscy badani. Konsumpcja flawonoidów w obu grupach była zadowalająca, na tle danych z innych badań populacyjnych.

**Słowa kluczowe:** *flawonoidy, spożycie flawonoidów, wzory konsumpcji*

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## INTRODUCTION

Flavonoids are one of the most abundant group of biochemical substances found in plants. Several reviews about flavonoids have shown a wide spectrum of potential health benefits, such as antioxidant, anticarcinogenic, anti-inflammatory and cardiovascular disease prevention [7, 8, 9, 10, 11, 16]. Molecular mechanisms of these substances have not been fully understood [11]. Their beneficial effects on the cardiovascular system are suspected to involve the inhibition of low-density lipoprotein (LDL) oxidation, reduction of atherosclerotic lesion formation, inhibition of platelet aggregation, reduction of vascular cell adhesion molecule expression, amelioration of endothelial function and reduction of the blood pressure [7, 16]. The consumption of flavonoids in a plant-based diet can be several times higher than the consumption of other phytochemicals and vitamins, including ascorbic acid (vitamin C),  $\alpha$ -tocopherol (vitamin E) or carotenoids [9].

The eating habits of populations living in the Mediterranean region, including the Spanish population, arouse the interest of many researchers. The typical Mediterranean diet is characterized by high consumption of plant products rich in flavonoids [2, 14, 18]. It is estimated that inhabitants of the Western Europe consume on average 100-1000 mg flavonoids/day/person [10, 17]. This study aimed to estimate the level of intake of these compounds by people living in different countries, with different dietary habits and with different availability of specific foods.

Winter-spring period is characterized by the limited access to certain foodstuffs. Interesting is the level of flavonoid consumption at that time. The populations for which it is important are not only people with chronic diseases, but also other groups – e.g. young people, including students. The purpose of the study was to estimate dietary flavonoid intake among Polish and Spanish students and to establish the main dietary sources of flavonoids.

## MATERIALS AND METHODS

Information about food intake during February, March and April 2013, was collected in the anonymous on-line survey in Polish and Spanish academic students. Both groups received the same questionnaire including questions about flavonoid-rich foods intake during 7 preceding days. The questionnaire aimed to the Spanish students was translated into Spanish.

The selection of food items that were included in the questionnaire was based on the database of flavonoid and flavonoid subclasses content of foods that was published by the US Department of Agriculture (USDA) in 2011 [1]. From among more than 500 specified products, 126 considered as effective flavonoid sources have been selected. In the case of several varieties of a product, contents of flavonoids were averaged. When the content of flavonoids in related products was similar, respondents were asked to report the total size of their consumption, e.g. the total amount of consumption red/black grapes in the preceding week.

To analyze the results the participants were grouped according to students' nationality: Polish (P) and Spanish (H) students. One hundred and sixty persons, 97 Poles and 63 Spaniards, signed in the website survey. Due to the incorrect filling a total of 9 questionnaires were excluded: 6 Polish and 3 Spanish. The final statistical analysis involved 91 questionnaires completed by Polish and 60 by Spanish students. In the group of Polish students there were 74 women and 17 men. In the Spanish group there were 36 women and 24 men. Among both groups dominated the female respondents. The differences in the percentage of men and women surveyed were statistically significant ( $P < 0.05$ ). Polish respondents were 21-28 years old, their average age was 23.5 years. Spanish students were 19-46 years old, their average age was equal to 22.73 years. One of Spanish respondents did not specify her age. The average age of men and women did not show statistically significant differences within the groups surveyed and between them.

Table 1. Mean weekly flavonoid, flavone and flavonol intakes in Spanish and Polish students (mean, SD, median, minimal, 25%, 75% and maximum)

Class of flavonoids		Mean (mg)	SD	Min.	25%	Median	75%	Max.	P-value
Total flavonoids	P	5605.26	4150.77	328.80	2003.69	4706.63	8667.72	18220.13	P<0.001
	H	2080.26	1851.83	145.12	973.81	1563.90	2530.42	10970.94	
Flavones	P	115.99	153.71	0.1	24.14	59.07	143.74	923.91	NS
	H	133.20	153.51	0.31	42.22	70.09	152.25	626.52	
Flavonols	P	302.32	189.12	29.72	147.20	267.80	414.09	844.09	NS
	H	213.26	196.08	7.89	97.19	141.02	242.44	1056.92	

P – Polish students, H – Spanish students, SD – standard deviation

Statistical analysis was performed using Statistica and Epi Info programmes (Student's t-test, Fisher's exact test, ANOVA). The level of statistical significance was  $P < 0.05$ .

### RESULTS

The weekly flavone, flavonol, and total flavonoid intakes in the both groups under study are shown in Table 1. Statistical analysis showed statistically significant differences between the two groups ( $P < 0.001$ ) in the average amount of total flavonoids consumed with the diet. No differences were found between consumption of two subclasses of flavonoids: flavones and flavonols.

Polish students consumed more than twice the amount of total flavonoids compared to the respondents from Spain. The mean and median of the total flavonoid intakes among Polish students were 5605 and 4707 mg/week respectively. The mean and median of total flavonoid intakes among Spanish students were 2080 and 1564 mg/week respectively. The average daily flavonoid consumption among Polish students was 801 mg, and among Spanish students 297 mg. The daily intake of flavonoids exceeding 1.2 g were found in 25% of Polish respondents. The maximum weekly intake of these substances in the group P was about 18.2 g, while in the group H about 11 g. The minimum weekly intake in Spanish students was a little over 145 mg and in Polish students almost 329 mg.

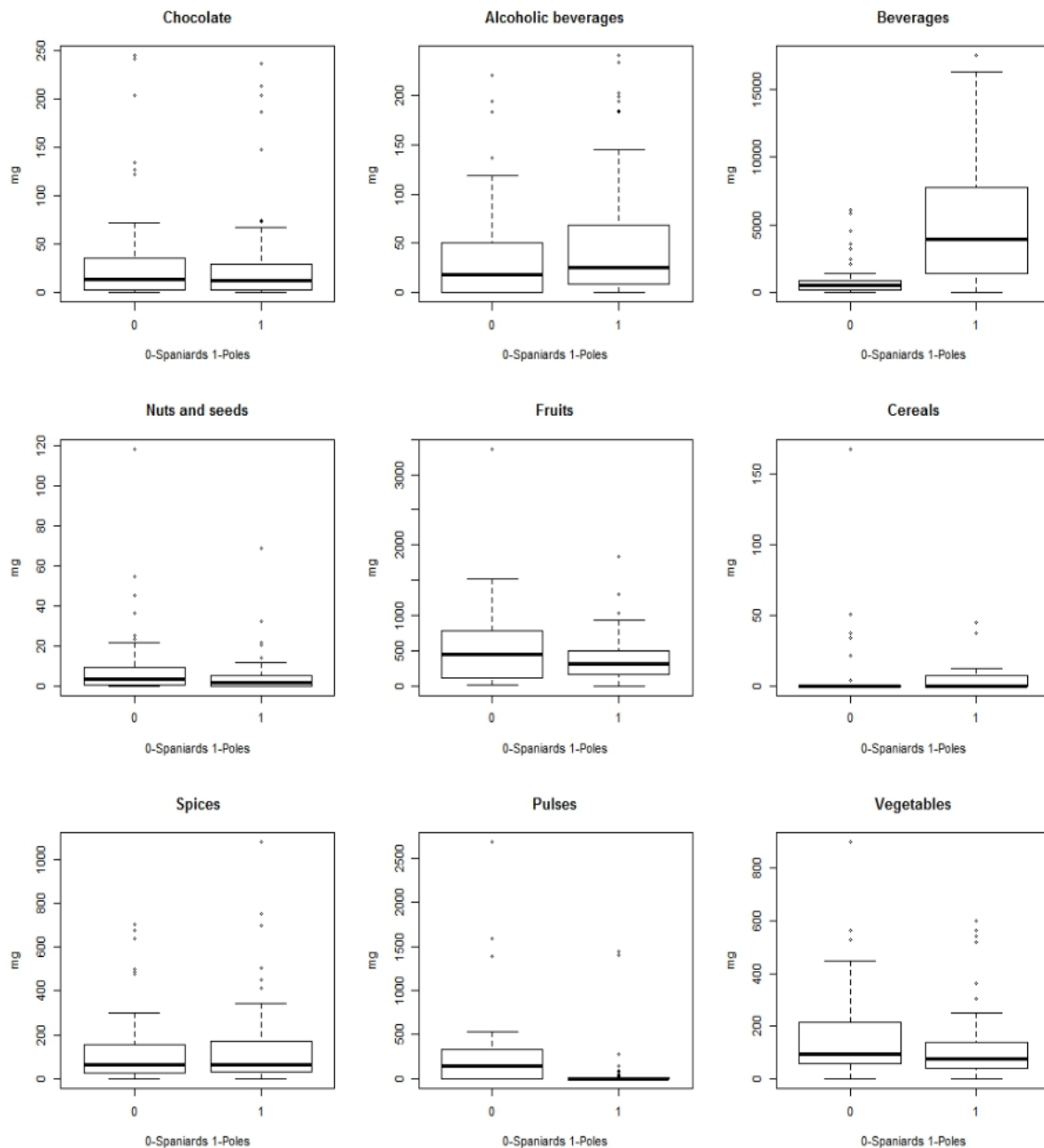


Figure 1. Mean weekly flavonoid intakes with different kinds food in Polish and Spanish student groups

Table 2. Mean weekly flavonoid intakes with different food categories in Polish and Spanish student groups

Food categories	Mean weekly flavonoid intake (mg ± SD)			P-value
	Poles (N=91)	Spaniards (N=60)	Both (N=151)	
Chocolate	29 ± 46	34 ± 55	31 ± 49	0.521
Alcoholic beverages	52 ± 67	36 ± 51	46 ± 61	0.110
Non- alcoholic beverages	4855 ± 4026	906 ± 1298	3286 ± 3761	<0.001
Nuts and seeds	3.9 ± 8.6	9.2 ± 18.1	6 ± 13.4	0.017
Fruit	371 ± 304	533 ± 553	436 ± 427	0.022
Cereals	3.6 ± 6.9	5.6 ± 23.4	4.4 ± 15.7	0.443
Spices	130 ± 176	130 ± 171	130 ± 174	0.993
Pulses	49 ± 212	270 ± 459	137 ± 349	<0.001
Vegetables	113 ± 118	156 ± 166	130 ± 140	0.061

SD – standard deviation

### THE MAIN SOURCES OF FLAVONOIDS IN POLISH AND SPANISH STUDENTS' DIET

The main food categories related to the flavonoid intake were also studied (Figure 1, Table 2). There were statistically significant differences between consumption of flavonoids from such groups of products as beverages, nuts and seeds, fruits and pulses. The Poles consumed higher amounts of flavonoids than the Spaniards with non-alcoholic beverages. On the other hand, the Spaniards consumed higher amount of these substances with nuts and seeds, fruits and pulses.

Table 3 illustrates the main flavonoid sources in the Polish group of participants. The main sources of total flavonoid intake were: black tea (~2901 mg/ week) green tea (~1520 mg /week), followed by oranges (~164 mg / week), orange juice (~160 mg/ week) and fruit tea (~100 mg /week). Dried parsley and oregano effectively enriched the diet of Polish students with these substances. The declared amount of consumption of dried parsley, supplied weekly about 56 mg of these compounds, and dried oregano about 52 mg, both altogether slightly more than 100 mg. Alcoholic beverages, such as beer, provided

43 mg of these substances. The average of 30 mg of total flavonoid consumption was derived from the following sources: white tea, blackcurrant juice, onion and lemon.

The analysis of the answers given by the Spanish academic youth enabled to identify the main products being a source of flavonoids in their weekly diet (Table 4). The main contributors were oranges (~270mg/ week) and green tea (~265 mg/week). In the vegetable group chickpeas (~250 mg/week) were by far the richest source of flavonoids.

The main sources of flavonoids in Spanish and Polish diets were different. For example, black tea in the Spanish group provided weekly about 236 mg of flavonoids, over 12 times less than in the Polish group. On the other hand, the Spaniards' diet was richer than Poles' diet in such sources of flavonoids as oranges, chickpeas, dried parsley, onions, strawberries, almonds or pomelo (Table 3, Table 4).

### DISCUSSION

Flavonoids exert beneficial effects on human health. Their regular consumption is associated with reduced

Table 3. The main flavonoid sources in the Polish group of participants

Product	Mean weekly flavonoid intakes (mg)	SD	Min.	25%	Median	75%	Max.
Black tea	2901.05	3006.05	0	447.45	1789.8	6562.6	8352.4
Green tea	1520.85	2699.31	0	0	454.75	909.51	9398.27
Orange	164.49	200.87	0	0	88.05	220.12	1232.7
Orange juice	160.10	325.13	0	0	76.28	228.84	2135.84
Fruit tea	99.57	170.07	0	0	20.5	123.0	574.0
Parsley, dried	56.55	128.90	0	0	0	97.09	728.17
Oregano, dried	52.16	56.90	0	0	30.92	61.84	293.74
Apple	46.64	57.31	0	0	22.88	57.2	286.0
Beer	43.17	64.63	0	0	12.52	50.10	233.8
Chickpeas	41.15	208.30	0	0	0	0	1387.05
White tea	37.91	243.55	0	0	0	0	2238.0
Blackcurrant juice	33.23	94.49	0	0	0	0	585.3
Onion	30.45	40.10	0	6.77	27.1	27.1	243.9
Lemon	30.26	45.69	0	0	21.35	42.7	277.55
Banana	24.18	29.36	0	0	14.42	41.05	147.78

Table 4. The main flavonoid sources in the Spanish group of participants

Product	Mean weekly flavonoid intake (mg)	SD	Min.	25%	Median	75%	Max.
Orange	270.75	337.03	0	0	88.05	396.22	1232.7
Green tea	265.27	699.75	0	0	0	303.17	3638.04
Chickpeas	249.68	445.12	0	0	138.7	277.41	2635.39
Black tea	236.15	667.75	0	0	0	298.3	3579.6
Orange juice	218.67	272.50	0	0	114.42	457.68	915.36
Parsley, dried	72.82	128.75	0	0	0	97.09	533.99
Onion	58.38	79.14	0	10.16	27.1	67.75	379.4
Strawberries	55.13	68.38	0	0	49.22	88.60	344.57
White tea	49.73	205.64	0	0	0	0	1119.0
Oregano, dried	48.96	60.53	0	0	30.92	61.84	293.74
Banana	39.81	45.77	0	0	41.05	41.05	229.88
Almonds	36.38	6.03	0	0	0	3.3	29.70
Apple	34.51	57.39	0	0	17.16	57.2	320.32
Pomelo	28.15	167.75	0	0	0	0	1291.68
Beer	26.92	45.87	0	0	12.52	25.05	183.7

risk of a number of chronic diseases, including cancer, cardiovascular disease (CVD) and neurodegenerative disorders. Our study showed the estimated level of flavonoid intake and the main food sources of total flavonoids and also flavones and flavonols subgroups among Spanish and Polish students. There are few investigations aimed at assessment of flavonoid consumption in the Polish population. One of such studies included 13545 subjects aged 20 to 74 years from the whole Poland as a part of the Polish Multicenter National Health Survey (WOBASZ) that was performed in 2003-2005 [19]. Another study was carried out in 2005-2007 and included students from the Medical University of Wroclaw [6]. There are also data on consumption of flavonoids in the Spanish [18], Greek [3], American [5] and Dutch female populations [12].

The average estimated flavonoid intake in a group of 398 students of the Medical University of Wroclaw was 639.1 mg/ day. This amount compared to our own results was lower than that in Polish students (about 801 mg/ day) and higher than in Spanish students (about 297 mg/ day) [6].

Based on the data from the WOBASZ study, the average estimated intake of flavonoids in Poles aged 20-74 years was 1172 mg/ day in males and 1031 mg/ day in females. Men aged 20-40 years consumed about 1251 mg of flavonoids per day, while women in the same age range 1054 mg [19]. Consumption of flavonoids in the WOBASZ study was higher than in our study. However, the main sources of flavonoids were similar: beverages, fruits and vegetables.

It is estimated that inhabitants of the Western Europe consume on average 100 to 1000 mg of flavonoids/day [10, 17]. Results of the European Prospective Investigation into Cancer and Nutrition (EPIC) study showed a lower intake of these substances among inhabitants of Greece and Spain compared with results of our own

study [3,18]. The median daily intake of flavonoids by Greek and Spaniard subjects equaled to 93 mg (n ~ 28000) and 126.1 mg (n = 40683) per person, respectively. The Greek survey was performed in 1992-1996 and thus the results may be underestimated as the database concerning flavonoid levels in foodstuffs was incomplete at that time [3,18].

The authors of another study, published in 2008, which covered a much smaller group of respondents (45 Dutch women) estimated that the daily average intake of flavonoids with diet was 166 mg, which also indicates a relatively large supply of these substances by Polish and Spanish students that took part in our study [12]. It should be emphasized that the information about the diet of our subjects was collected in the winter-spring period when the access to certain fruit and vegetables is limited.

The data collected in 2001-2002 by the US Department of Agriculture showed that Americans consumed about 132 mg of flavonoids per day, which is much less than in our own participants [5]. On the other hand, it is assumed that inhabitants of countries in the Far East, such as Japan, because of high intake of legumes, soy and tea, may consume up to 2 g of flavonoids daily [17].

The main sources of flavonoids in the diet of Spaniards, according to the data from the European Prospective Investigation into Cancer and Nutrition (EPIC) study, were successively: apples, red wine, oranges, beans, pears and peaches [18]. However, the main food contributors to the total flavonoid intake among the Spanish students who took part in our study were: oranges, green tea, chickpeas, black tea, orange juice and dried parsley. Different sequence of products which are the main source of flavonoids in adult Spaniards in the EPIC study and our group of Spanish students may indicate a change in eating habits which took place in Spain during the last 17 years. We should emphasize that in the group of 6 products which are the main



sources of flavonoids in the diet of Spanish students there was no red wine. Moreover, low consumption of this drink caused this product to be outside of the 15 the most important foods that supply flavonoids. An alcoholic beverage which provided the highest amount of flavonoids in the diet of Spanish students was beer. It should be emphasized that beer contains much less of these substances than red wine.

Black tea was a product which was the main contributor of flavonoids in students of the Medical University of Wrocław. In the daily diet it supplied as much as 93% of these compounds [6]. The results of our study are similar. Black tea supplied the Polish students with over 81% of these substances. Similarly, it is estimated that in the diet of Americans about 83% of flavonoids were derived from this source [15]. The authors of the Spanish study indicate that inhabitants of the Northern European countries and the United States habitually drink more tea than those living in the Mediterranean countries [18]. The results of the study concerning consumption of black and green teas by Polish inhabitants of the Mazovian Region show that black tea was drunk by 80% of them, of whom 39% did so daily [4].

The average consumption of spices in Europe is estimated to be 0.5 g/person/day, which is significantly less than in the inhabitants of the North Africa and Asia. These products are good sources of flavonoids. It is worth noting that in the recent years in Poland, there was an increase in the consumption of spices. A review describing the sources of natural antioxidants, published in 2008, pays attention to changes in the Polish diet. According to the authors, the growth in consumption of spices is probably due to increased availability of these food items and the possibility of buying them in fresh form and also popularity of cuisines from different parts of the world. This conduces to increasing supply of antioxidants with a daily diet [13]. In the present study, both Polish and Spanish students declared consumption of spices, which had a favorable impact on the level of consumption of flavonoids with their diet.

## CONCLUSIONS

1. Flavonoids intake by Polish and Spanish students was similar or higher than in other Western populations studied by other authors.
2. Polish students consumed more than two times higher amount of flavonoids than Spanish students.
3. The main contributors of flavonoids in the diet was black tea in Polish, and oranges in Spanish students.
4. There is a need for further research on dietary intake of flavonoids among these groups taking into account the variability of consumption of these compounds in different seasons.

## Conflict of interest

*The authors declare no conflict of interest.*

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