

SUPPLEMENT AND FORTIFIED FOOD CONTRIBUTION TO OVERALL FOLATE INTAKE AMONG ADULTS LIVING IN WARSAW, POLAND

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The aim of this study was to assess the supplement and fortified food contribution to total folate intake among adults in Warsaw in 2002. Out of 449 respondents of survey on supplementation practice, 60 individuals of both sexes accepted the invitation to folate intake study. The data on dietary folate intake was collected by the 3-day record method. Folic acid supplements usage over the year prior to the study was declared by 25% of respondents. The mean daily folate intake with a diet (natural product only) was 192 μg for women (80% of the Polish RDA) and 209 μg for men (76% of the Polish RDA). The amount of folates consumed with enriched products was approx. 68 μg of DEF/day for women and 103 μg of DEF/day for men. The use of supplements increased significantly the intake of folates only for women ($p < 0.01$) reaching the level of about 385 $\mu\text{g}/\text{day}$ (109% of the RDA with natural and fortified products vs. 162% of the RDA as total intake). Even taking all sources of folates into consideration, the folate intake of 14% of women and 21% of men was still below 66.7% of the Polish RDA. The mean daily folic acid intake with enriched products and supplements together was approx. 115 $\mu\text{g}/\text{day}$. None of the subjects took folic acid from these sources in the amounts exceeding UL, *i.e.* 1000 $\mu\text{g}/\text{d}$. There is a need to improve the respondents' diet and since people may combine multiple products containing high amounts of folic acid (supplements, enriched food), there is a need to make them aware that its excessive intake may pose health problems.

INTRODUCTION

Many people are at a risk of folate deficiency because of inadequate dietary intake. Moreover, other factors like genetic polymorphisms, use of some antifolate medicines, gastrointestinal disorders *etc.* are associated with a low status of this vitamin in the human body. It was demonstrated that inadequate folate status during periconceptional period and during the first weeks of pregnancy increases the risk of neural tube birth defects such as spina bifida or anencephaly [Fairfield & Flecher, 2002]. Moreover, a low folate status is associated with hyperhomocysteinemia, an independent risk factor for cardiovascular diseases [Lökk, 2003]. A high plasma homocysteine level is also associated with mental disorders and possibly cancer [Refsum *et al.*, 1998; Kim, 1999]. The other disease related to folate deficiency is megaloblastic anemia [Bässler *et al.*, 2002].

Among strategies undertaken to improve the folate status on a population level there are nutritional counseling to consume folate-rich foods, food fortification and use of supplements. For example, in the USA, the fortification with folic acid is required for all cereal-grain products enriched with other nutrients [Choumenkovitch *et al.*, 2002]. In Poland, some food products fortified with folic acid, like breakfast cereals, fruit juices, some milk products, wheat flour, some dietetic food and selected products for infants and young children, have been introduced recently [Kuna-

chowicz *et al.*, 2004]. Moreover, diet supplementation is relatively common practice with an increasing trend (from 8.8% in 1993 to 26% in 1999 of folic acid supplement users among elderly people) [Pietruszka & Brzozowska, 2002]. This is a result of strong advertising concerning the health benefits and growing market of dietary supplements and pharmaceutical preparations containing nutrients.

The aim of this study was to assess the supplement and fortified food products contribution to the total folate intake among adults living in Warsaw. All possible sources of this nutrient were included, *i.e.* natural dietary folates, food products fortified with folic acid, pharmaceutical preparations and dietary supplements containing folic acid.

MATERIALS AND METHODS

The study was conducted in Warsaw in 2002 as a part of the project on supplementation practice among adults living in Warsaw, with special concern of folic acid [Pietruszka & Brzozowska, 2004]. The whole population under study consisted of 449 respondents aged 18 and over, randomly selected and stratified for age. Out of them, 60 individuals of both sexes accepted the invitation to folate intake study.

Demographic data, information related to health status, supplemental practice, use of food products enriched with folic acid were collected by a questionnaire method. All the products in the form of tablets, drops, powder *etc.* (pharma-

ceutical preparations and dietary supplements) containing folic acid and available on the market were regarded as folic acid supplements. Respondents were asked about folic acid supplements usage over the year prior to the study, *i.e.* about type and brand of products, doses, frequency and duration of supplement usage as well as by whom such a practice was advised. Daily supplemental folic acid intake was calculated on the basis of the producer declaration on labels of preparations containing folic acid.

The data on dietary folate intake was collected by the 3-day records. One day out of the 3 analysed was always a weekend day. The album of photographs of food products and dishes [Szponar *et al.*, 2000] was used to assess portion sizes. The daily folate intake was calculated on the basis of the Polish food composition tables [Nadolna *et al.*, 2000] with reduction of 40%, as suggested by Müller's data related to losses during a typical meal preparation [Müller, 1995]. The amounts of folic acid in fortified products were taken from producer declarations on the labels. The folic acid intakes with the enriched products for 3 consecutive days and with supplements were multiplying by 1.7 in order to convert them into DFE (Dietary Folate Equivalent) and added to the dietary data [Dietary Reference Intakes for..., 1998].

The folate intake (as DFE) with the diet, fortified products and in supplemental form were compared to Polish RDA [Ziemlański, 2001]. Moreover, the intake of folic acid with enriched products and with supplements together was compared to the Upper Tolerable Level of Intake – UL (1000 µg) to assess the risk of overdosage [Dietary Reference Intakes for..., 1998].

A statistical analysis was performed with StatPL version 6.0. Continuous independent variables were compared by Student t-test and in the case of skewed distribution – by Krauskall-Wallis test, whereas the dependent variables were compared by Mann-Whitney U-test. Categorical variables were compared using χ^2 analysis. Statistical significance was set at $p \leq 0.05$.

RESULTS AND DISCUSSION

The characteristics of the group under study are presented in Table 1. The sample consisted of 68% of women and of 32% of men, with an average age of 41.6 ± 12.6 (range 21–70 years). Almost all the subjects completed secondary or higher schools, most of them considered their financial status as average and their health status as good or average. Almost half (47%) the individuals were overweight, while the BMI of 38% of the respondents was within reference range. Vitamin/mineral supplements usage during a year before the study was declared by 53% of respondents and folic acid supplements were taken by 25% of subjects. For the whole group (449 respondents) included in the survey on supplementation practice these numbers were 60.4% and 28.7%, respectively [Pietruszka & Brzozowska 2004]. Similar percentage of folic acid supplement users was reported in NHANES III survey, *i.e.* approx. 29% of subjects took at least one product containing folic acid any time in a period of one month before the study [Balluz *et al.*, 2000]. Also the similar prevalence of folic acid supplement usage was shown

TABLE 1. Characteristics of the respondents.

		Respondents	
		N = 60	%
Gender	female	41	68.3
	male	19	31.7
Age (years)	18–29	16	26.7
	30–44	15	25.0
	44–59	26	43.3
	60+	3	5.0
Education level	primary	1	1.7
	technical secondary	1	1.7
	general secondary	19	31.7
	higher (university type)	39	65.0
Financial status	poor	6	10.0
	average	33	55.0
	good	18	30.0
	very good	3	5.0
Self reported health status	average	24	40.0
	good	28	46.7
	very good	8	13.3
BMI ¹	underweight	3	5.0
	normal weight	23	38.3
	overweight	28	46.7
	obesity	6	10.0
Overall supplement usage	yes	32	53.3
	no	28	46.7
Folic acid supplement usage	yes	15	25.0
	no	45	75.0
Fortified products usage ²	yes	51	85.0
	no	9	15.0

¹ based on self reported weight and height, ² fortification with folic acid

in the USA among women in childbearing age [Gates & Holmes, 1999]. In earlier study it was found that among adults living in the central and eastern regions of Poland during the years 1993–1995 such supplements were taken by 7% of subjects [Pietruszka & Brzozowska, 1999].

Data on dietary folate intake are presented in Table 2. The mean daily folate intake with a diet (natural product only) was 192 µg for women (80% of the Polish RDA) and 209 µg for men (76% of the Polish RDA). The results did not differ significantly between genders. Our data on folate intake from “natural” sources are in accordance with the results obtained on the basis of households budget surveys conducted annually in Poland, in which the amounts from fortified products are not included. The calculations indicated that average Polish diet in 1999 covered Polish RDA in approx. 74% with the range from 65 to 88%, depending on the income level [Troszczyńska *et al.*, 2004].

The mean folate dietary intake (215 µg/day, median 189 µg) by American women aged 11–50 years was slightly higher than among women in our study [Gates & Holmes, 1999], whereas the average daily folate intake among Hungarian women in periconceptional age (160 µg) was lower [Czeizel & Susánszky, 1994].

In our study, the average daily dietary (natural and fortified products) folate intake was 260 µg/day (109% of the RDA) for women and 311 µg/day (112% of the RDA) for men and did not differ significantly according to gender. The intake of about one-fourth of women and 21% of men was still below 66.7% of the Polish RDA. So those subjects were at risk of deficit of this vitamin.

TABLE 2. Folate intake among subjects under study (women n=41; men n=19).

Parameter	Folate intake ¹			
	Female	Male	Female	Male
	$\mu\text{g DFE/day}$		% of Polish RDA	
	A. with diet – natural ² products only			
Mean \pm SD	192 \pm 85	209 \pm 52	80.1 \pm 26.4	75.6 \pm 26.4
Median	174	195	72.7	72.2
Range	81–594	107–416	31.3–228	36.8–149
First quartile (Q ₁)	143	149	63.9	53.0
Third quartile (Q ₃)	236	248	98.6	92.6
	B. with fortified products only			
Mean \pm SD	68 \pm 74	103 \pm 113	29.0 \pm 32.7	36.9 \pm 39.9
Median	43	96	19.7	34.2
Range	0–303	0–428	0–138	0–148
First quartile (Q ₁)	0	0	0	0
Third quartile (Q ₃)	146	128	42.1	45.5
	C. with a diet – natural and fortified products			
Mean \pm SD	260 \pm 123	311 \pm 138	109 \pm 52.6	113 \pm 49.7
Median	249	305	106	109
Range	81–612	107–602	31.3–245	36.8–208
First quartile (Q ₁)	162	212	67.5	73.6
Third quartile (Q ₃)	321	407	134	149
	Difference between A and C			
p value	<0.0001	0.0009	<0.0001	0.0008
	D. total intake (diet plus supplements)			
Mean \pm SD	385 \pm 301	405 \pm 359	162 \pm 131	144 \pm 123
Median	278	305	111	109
Range	93.1–1476	107–1452	38.8–671	36.8–501
First quartile (Q ₁)	212	212	90	81.5
Third quartile (Q ₃)	466	416	209	149
	Difference between C and D			
p value	0.0076	NS	0.0089	NS

¹ there were no statistically significant difference in folate intake between genders, ² means not fortified, Ns – no significant difference, $p > 0.05$

Rogalska-Niedźwiedz *et al.* [2000] found that the mean folates content in the diets of women aged 18–36 years living in Warsaw was 315 $\mu\text{g/g}$ with the range of 111–548 $\mu\text{g/day}$. But the authors did not mention if they had taken fortified products into consideration as well.

In our study, the amount of folates taken from enriched products was approx. 68 μg of DEF/day for women (approx. 26% of “natural” folate intake) and 103 μg of DEF/day for men (approx. 33% of “natural” folate intake). The increase in the folate level in the diet after taking enriched products into consideration was statistically significant for both genders ($p < 0.0001$). On the basis of households budget surveys Przygoda *et al.* [2001] made a simulation as to much the intake of folates would increase if natural products were replaced by the enriched ones. The authors confirmed that the folate intake increased up to 85–127% of Polish RDA, depending on the type of household, hence our findings are within the same range. Another calculation indicates that the introduction of fortified products instead of natural ones into an average Polish diet can increase folate intake up to 26% of RDA [Przygoda *et al.*, 2001].

In contrast, in the US study of 1996, it was found that the increase in folic acid intake, associated with fortification, was about 200 $\mu\text{g/day}$ [Choumenkowitz *et al.*, 2002]. Also in the study conducted among women by Boushey *et al.* [2001] the fortification was estimated to increase folic acid intake by 170 $\mu\text{g/day}$ on average. In Poland until the year

2003, folic acid was added mainly to fruit juices, breakfast cereals, selected products for infants and young children and to some other products, less important considering their share in total diet. We would expect that folate intake with fortified products would be higher due to new products with folic acid added, *i.e.* wheat flour and milk products that have recently been introduced on the Polish market.

Our findings related to total dietary intake are similar to those obtained by Brussaard *et al.* [1997] in the Netherlands, among 20–49 years old subjects (women – 270 $\mu\text{g/d}$, men – 325 $\mu\text{g/d}$) and by Bates *et al.* [1997] in the United Kingdom, among subjects aged over 65 years (women – 253 $\mu\text{g/d}$, men – 307 $\mu\text{g/d}$).

In our study, the use of supplements significantly increased the intake of folates only for women ($p < 0.01$) and their total intake was about 385 $\mu\text{g/day}$ (109 vs. 162% of the RDA). This was not the case for men. After taking into consideration all sources of folates, there was no significant difference in total folate intake between women and men, but still the intake of folates of 14% of women and 21% of men was below 66.7% of the Polish RDA. Thus, those subjects could be at risk of folate deficiency.

The mean folate intake with a diet and supplements among women living in Warsaw [Rogalska-Niedźwiedz *et al.*, 2000] was higher, *i.e.* 478 $\mu\text{g/day}$ (authors did not convert folic acid in supplements to folate, hence this value is a sum of folate from diet and folic acid from supplements).

As the tolerable upper intake level (UL) for adults is set for folate from fortified food and/or supplements only and does not include food folates [Dietary Reference Intakes for..., 1998], the intake from fortified food and supplements was calculated as well (Table 3). The mean daily folic acid intake with enriched products and supplements together was similar for women (113 $\mu\text{g}/\text{d}$) and for men (116 $\mu\text{g}/\text{d}$). None of the subjects took folic acid from these sources in amounts exceeding UL, *i.e.* 1000 $\mu\text{g}/\text{d}$. The highest dose for women was 800 $\mu\text{g}/\text{d}$ and for men – 751 $\mu\text{g}/\text{d}$.

TABLE 3. Folic acid intake with fortified food and supplements (women n=41; men n=19)

Parameter	Folic acid intake ($\mu\text{g}/\text{day}$) ¹	
	Female	Male
Mean \pm SD	113 \pm 169	116 \pm 204
Median	50	61
Range	0–800	0–751
First quartile (Q ₁)	11	0
Third quartile (Q ₃)	112	101

¹ there were no statistically significant difference in folic acid intake between genders

To assess the need of supplements and/or fortified products usage the population under study was divided into quartiles according to total folate intake (as % of the RDA) (Figure 1). Individuals in the first quartile (Q₁) with the lowest dietary folate intake (median 61% of the RDA) had also

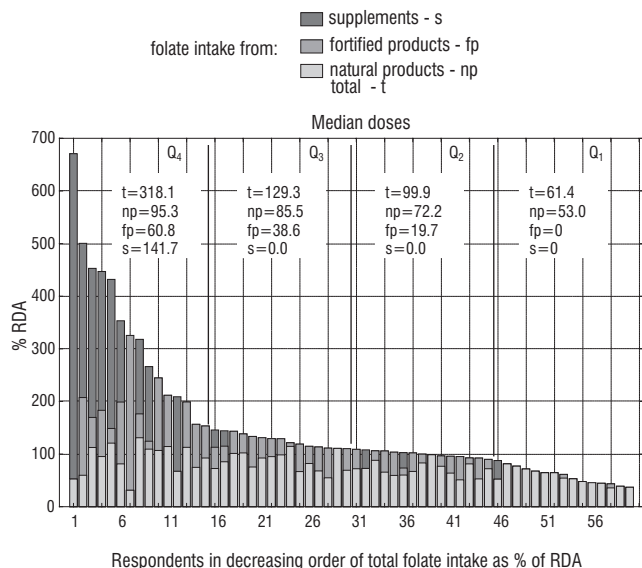


FIGURE 1. Individual folate (DEF) intake as % of the Polish RDA (differences between quartiles – p value for: total intake <0.0001; intake from natural products =0.0001; intake from fortified products <0.0001; intake from supplements <0.0001).

TABLE 4. The contribution of different sources in folate intake by quartiles of total intake.

Type of product	Contribution in total folate intake (%)				
	Q ₁	Q ₂	Q ₃	Q ₄	whole population
Natural ¹ foods	94.2	71.1	68.0	27.6	49.4
Fortified foods	1.7	24.6	28.7	19.5	20.5
Supplements	4.1	4.3	3.2	52.9	30.1

¹ means not fortified

the lowest folate intake from other sources (fortified products and supplements). In contrast, dietary folate intake among people from the fourth quartile (Q₄) and the third quartile (Q₃) was similar (95 and 86% of RDA, respectively) while the folate intake with fortified food and supplements was the highest (142% and 61% of RDA, respectively) in the fourth quartile (Q₄). It means that people with the highest dietary folate consumption took nutrients from additional sources in higher amounts than those respondents with a lower dietary intake. Such a situation was confirmed in other surveys [Pietruszka & Brzozowska, 2002]

For the whole population under study natural products were the main source of folate (approx. 50% of total intake) (Table 4). The contribution of fortified foods in total folate intake was considerable in Q₂–Q₄ (24.6, 28.7 and 19.5%), while that of supplements – only in Q₄ (53%).

CONCLUSIONS

1. Average folate intake from natural products did not meet the Polish RDA. Additional nutrient sources, *i.e.* folate fortified food and folate dietary supplements, were used mainly by people with the highest folate intake from natural products. Such situation poses the risk of folate deficiency among respondents with the lowest folate intake, on the other hand – the risk of overdose among those with the highest folate intake from natural products.

2. There is a need to improve the respondents' diet mainly through including more foods naturally rich in folate. In case when this is impossible, they should eat more folate fortified products. As people can combine a number of products containing high amounts of folic acid (supplements, enriched food), there is a need to make them aware that its excessive intake may pose health problems.

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UDZIAŁ SUPLEMENTÓW I PRODUKTÓW WZBOGACANYCH W SPOŻYCIU FOLIANÓW PRZEZ OSOBY DOROSŁE Z WARSZAWY

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Celem pracy było określenie udziału suplementów i produktów wzbogacanych w całkowitym spożyciu folianów przez osoby dorosłe zamieszkałe w Warszawie. Badanie, w którym wzięło udział 60 osób, spośród 449 respondentów uczestniczących w projekcie dotyczącym rozpowszechnienia stosowania suplementów, przeprowadzono w 2002 roku. Dane o spożyciu żywności zebrano metodą 3 dniowego bieżącego notowania. Stosowanie suplementów kwasu foliowego w roku poprzedzającym dzień badania deklarowało 25% respondentów (tab. 1). Średnie dzienne spożycie folianów z produktów naturalnych wynosiło w grupie kobiet 192 μg (80% normy na poziomie bezpiecznym), a w grupie mężczyzn 209 μg (76% normy) (tab. 2). Produkty wzbogacone dostarczały ok. 68 μg DEF/dzień w przypadku kobiet i 103 μg DEF/dzień u mężczyzn. Stosowanie suplementów przyczyniło się do istotnego wzrostu spożycia tylko w grupie kobiet (109 vs. 162% normy). Po uwzględnieniu wszystkich źródeł folianów w diecie zbyt małe spożycie (<66,7% normy) stwierdzono u 14% kobiet i 21% mężczyzn). U żadnej osoby łączne spożycie kwasu foliowego dodanego do produktów wzbogacanych i z suplementów nie przekroczyło górnego tolerowanego poziomu spożycia tj. 1000 μg /dzień. Istnieje potrzeba korekty sposobu żywienia badanych oraz ze względu na fakt łącznego stosowania suplementów i produktów wzbogacanych informowania społeczeństwa o zasadach prawidłowego stosowania dodatkowych źródeł składników odżywczych.