

INTAKES OF FOLIC ACID FROM DIETARY SUPPLEMENTS AND FORTIFIED PRODUCTS IN STUDENTS

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ABSTRACT

Background. A great variety of dietary supplements and fortified products, containing folic acid, are widely available to satisfy the market demand for supplementing the diet with this vitamin.

Objective. To assess folic acid intake from dietary supplements and fortified products in students.

Materials and methods. The study was performed between October 2010-April 2011 on 314 university students aged 19-34 years, excluding pregnant or lactating women. Self-administered questionnaire was used to collect information about health, lifestyle and use of dietary supplements during previous month (frequency and doses) and frequency and portion of the fortified products consumed.

Results. Diets were supplemented by folic acid by almost 13% of respondents; the average intake was 148 ± 99.7 $\mu\text{g}/\text{person}/\text{day}$, (range 10-400 μg). Products fortified with this vitamin were used by 89% students with an average intake of folic acid 83.7 ± 101 $\mu\text{g}/\text{person}/\text{day}$, (range 0.3-660 μg); about a quarter of these subjects were however unaware that they were consuming fortified products. Both product types were used together by 11% students. Among these subjects the average folic acid intake was the highest (233 ± 151 $\mu\text{g}/\text{person}/\text{day}$, range 12.3-678 μg); with 66% originating from supplements and 34% from fortified products. There were no instances of folic acid being consumed above the tolerable upper intake level (UL), of 1000 $\mu\text{g}/\text{day}$.

Conclusions. It is necessary to warn the public that overconsumption of folic acid, (through dietary supplements, enriched food), may be hazardous to health, since many people combine such multiple products.

Keywords: *intake, folic acid, dietary supplements, fortified products, students*

STRESZCZENIE

Wprowadzenie. Szeroki asortyment suplementów diety i produktów wzbogaconych w kwas foliowy na rynku powoduje, że uzupełnianie diety tą witaminą staje się powszechne.

Cel pracy. Oszacowanie spożycia kwasu foliowego w formie suplementów diety i produktów wzbogaconych przez wybraną grupę studentów.

Materiał i metody. Badanie przeprowadzono w okresie październik 2010r. – kwiecień 2011r. Wzięło w nim udział 314 studentów w wieku 19-38 lat. Respondenci wypełniali kwestionariusz, który zawierał pytania dotyczące zdrowia, stylu życia, stosowania suplementów diety w ciągu ostatniego miesiąca oraz częstotliwości spożycia produktów wzbogaconych wraz z wielkościami spożywanych porcji.

Wyniki. W badanej grupie studentów stosowanie suplementów diety zawierających kwas foliowy zadeklarowało prawie 13% osób, średnie spożycie wynosiło $148 \pm 99,7$ $\mu\text{g}/\text{os}/\text{d}$ (zakres 10-400 μg). Natomiast produkty wzbogacone tą witaminą spożywało 89% badanych, średnie spożycie było $83,7 \pm 101$ $\mu\text{g}/\text{os}/\text{d}$ (zakres 0,3 - 660 μg). Stwierdzono, iż ponad ¼ respondentów nie była świadoma faktu, że spożywa produkty wzbogacone. Jednocześnie suplementy diety i produkty wzbogacone kwasem foliowym stosowało 11% osób. Średnie pobranie witaminy w tej grupie było najwyższe (233 ± 151 μg , zakres 12,3 – 678 μg).

Wnioski. U żadnej osoby spożycie łącznie z obu źródeł nie przekroczyło górnego tolerowanego poziomu (UL). Istnieje potrzeba informowania społeczeństwa o zasadach prawidłowego stosowania dodatkowych źródeł składników odżywczych, aby nie dopuścić do nadmiernego ich spożycia.

Słowa kluczowe: *spożycie, kwas foliowy, suplementy diety, produkty wzbogacone, studenci*

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INTRODUCTION

Dietary intakes of folic acid are often found to be insufficient in many population groups. Supplementation with 400 µg/person/day or fortified product consumption has therefore been recommended in many countries like the UK, Ireland and Finland [9]. In Poland, the average folate intake in young women is low (127-315 µg/person/day) [17], and thus supplementation with this vitamin is recommended for women in child-bearing age in order to prevent neural tubes defects in offspring [20]. Indeed, there are about 50 countries in the world that make folic acid supplementation of cereal products obligatory, including the USA, Canada and Australia [4]. In Poland, as in the EU, manufacturers are allowed to voluntarily add this vitamin to their foodstuff products.

The increasing market availability and variety of dietary supplements and fortified products has meant that supplementation with this vitamin is widespread and not always resulting from making a conscious decision. At the beginning of the year 2011, there were more than 300 dietary supplements (containing 11-800 µg of folic acid in one dose) [16], and 200 products fortified with folic acid available on the market in Warsaw. The fortified products were mainly breakfast cereals, fruit juices and non-alcoholic beverages, sweets, different types of margarine, instant cocoa and tea; the greatest amounts of folic acid was found in margarines and sweets, ranging from 500 to 800 µg/100 g [18]. They wide offer of these products allow to overcome folate deficiency, but it also poses a risk of an excessive and uncontrolled intake leading, amongst other consequences, to masking undiagnosed vitamin B₁₂ deficiency. It is especially relevant because folate bioavailability from 'natural food' is about half less than from the synthetic form used in supplements (100%) and in fortified foodstuffs (~85%). In order to calculate total amount of this vitamin in the diet, the dietary folate equivalents (DFE) are used. It is thereby accepted that 1 µg of synthetic folic acid, present in fortified foodstuffs delivers 1.7 µg DFE while 1 µg of synthetic folic acid taken as dietary supplement on an empty stomach delivers 2 µg DFE [1, 7].

The presented study aims to assess folic acid consumption in a select group of students when taken in the form of dietary supplements or/and fortified products. Furthermore, the risk of intake exceeding the UL for this vitamin, was also addressed.

MATERIALS AND METHODS

The study was conducted between October 2010 and April 2011 on selected students of Warsaw University of Life Sciences (SGGW). Women who were either

pregnant or lactating were excluded, as their dietary requirements for folic acid are higher. Students who incorrectly completed the questionnaire, (n=6) were also excluded.

The survey questionnaire included socio-demographic conditions linked to health and lifestyle. Information for calculating the Body Mass Index (BMI) were also obtained. Subjects were asked about their intakes of the dietary supplements and fortified products over the previous month, giving a definition of fortified products. A food frequency questionnaire (FFQ) was used to collect the information about fortified products. Brand names of foodstuffs consumed by respondents were identified with the help of photo album of the fortified products available on the market, which have been previously developed. In order to facilitate establishing the amounts consumed the portion size photographs were used [19]. All subjects who reported consumption of any product from the album in FFQ were classified as a fortified food users.

The amounts of folic acid in the fortified products were obtained from information on the labels. Although the manufacturers are obliged to provide total amount of the vitamins and minerals in foodstuff (naturally and added) [5], nevertheless, it is a frequently seen working practice that only the fortified amounts are provided [8], so such an assumption was made in the study. Because most of the supplements users declared taking them during meals the intake of DFE was calculated with conversion factor 1.7. The individual intake of folic acid from dietary supplements and fortified products was compared to UL value to determine whether there was any risk of overdosing. Statistical analysis was performed using the 'Statistica 9.0' programme software. The variables' distribution was tested by the *Shapiro-Wilk* statistic and because the data were not normally distributed, the non-parametric *Mann-Whitney U* test was used to determine the significance of differences between medians. Qualitative differences were analysed by the *Chi²* test. The level of significance was set at $p \leq 0.05$ for all analyses.

RESULTS AND DISCUSSION

Study subjects were students aged 19-38 years, (mean 21.6 ± 1.96), of which an 82% were women. University courses chosen for study varied and the most popular ones were food technology, human nutrition and dietetics (84%). More than half the students (54%) evaluated their levels of physical activity as moderate and 10.5% of the respondents suffering from chronic diseases such as bronchial asthma, hypothyroidism, food allergy and diabetes. Medication for chronic diseases were taken by 15.3% of the subjects, 4 women decla-

red taking contraceptives and 17% smoked cigarettes. BMI results demonstrated that body weight of 81.7% respondents were in normal range, whilst 8.1% were underweight and 9.7% overweight.

Dietary supplements were used by nearly 30% students (n=91). Significantly more non-smokers took supplements than smokers (83 vs 8 subjects), and in similar fashion, more students of food technology and human nutrition faculties took supplements than those studying other fields (76 vs 15 subjects). There were however no gender differences observed in the using of folic acid supplements or fortified products.

In all, 13% of students, (n=40), took folic acid supplements in the previous month at doses of 10-400 µg/day of which the most popular were in the form of multi-vitamins-minerals (95%). Only two women took supplements containing just folic acid.

Previous studies in Canada from 2004 however showed different results. Among 3000 subjects, aged 19-30, it was observed that 18% men and 23% women took folic acid supplements [14]. The studies on female students from Warsaw and Bialystok (n=173) showed that 18% took this vitamin at daily doses of 200-400 µg [3]. A study on adults aged 21-70 yrs (n=60) and living in Warsaw, showed that 25% of them had been using these supplements over the previous year and that 85% had been consuming this vitamin in fortified products [10]. A later study in 2005, on female students, (n=445) demonstrated that 20% took folic acid supplements and 37.8% took products fortified with this vitamin [11].

The current study showed that products fortified with folic acid had been consumed by 89% students, even though a quarter of them did not realized the usage of such a foodstuffs. A somewhat similar finding was observed in a 2005-2009 study on fortified products, where 22% parents, (of n=743 children, aged 7-12), were unaware that their offspring had indeed consumed such products [12]. In addition, another survey from 2009 on 94 shop customers, aged 15-85 yrs, showed that only 48% of them correctly understood the concept of 'fortified products'. The most frequently fortified products were confused with organic products, vegetables, fruit and dietary supplements. Very often they were also described such a product as 'healthy products' or 'health foods' [15]. A study among child-bearing ages

women (n=120) revealed that only one fifth of them knew and bought products fortified with folic acid such as juice, breakfast cereals, flour and bread [2]. The presented study showed that in diet of fortified products consumers, the most folic acid came from juices and non-alcoholic beverages and from breakfast cereals i.e. 53.1 ± 88.7 µg/person/day and 35.5 ± 43.9 µg/person/day respectively (Table 1).

Table 1. The average intake of folic acid from the groups of fortified food products

Group of products	Number of people (n=279)	Intake of folic acid [µg/person/day] among those consuming fortified products		
		n*	x ± SD	median range
Wheat flour	45	21.7 ± 30.3	9.2	0.7 - 120
Breakfast cereals	204	35.5 ± 43.9	17.0	0.8 - 400
Yogurt	52	18.6 ± 20.0	11.2	3.5 - 103
Sweets	124	15.6 ± 21.7	7.5	1.3 - 131
Juices, nectars and non-alcoholic beverages	182	53.1 ± 88.7	20.4	2.0 - 600
Instant beverages	90	6.4 ± 9.4	2.8	0.2 - 61.9
Margarine	60	32.9 ± 50.4	15.4	0.5 - 300

* number of people do not add up to 279, some people consume products from different food groups

Over 90% of the whole group of respondents consumed additional amounts of folic acid in the form of dietary supplements and/or fortified products; their average total intake from these sources was 103 ± 118 µg/person/day (Table 2). Slightly higher amounts were however seen in a study on adults living in Warsaw i.e. 113 ± 169 µg/person/day for women and 116 ± 204 µg/person/day for men [10]. Returning to the current study, 47% of subjects that either took the dietary supplements or fortified products had low intakes of folic acid, (below 50 µg/day), which were really of little effect on their nutritional status. A larger amount (50-200 µg/day) was consumed by 37% respondents and 16% of them took over 200 µg/day of whom 8 subjects took more than 400 µg/day.

Only 35 subjects (11%) used both supplements and fortified products together, which constitutes a risk of overdosing and thereby resulting in health problems. According to experts from the Scientific Committee

Table 2. The average intake of folic acid from dietary supplements and/or fortified food products

Studied groups	Number of people		The folic acid intake [µg/person/day]			RDA* %
	n	%	x ± SD	median	range	
Whole studied group	314	100	93.1 ± 116	47.6	0 - 678	41.0
Persons using dietary supplements and /or products fortified with folic acid, including:	284	90.4	103 ± 118	53.7	0.3 - 678	43.7
- dietary supplements	40	12.7	148 ± 99.7	136.7	10 - 400	62.9
- fortified products	279	88.9	83.7 ± 101	47.8	0.3 - 660	35.6
- both, supplements and fortified products	35	11.1	233 ± 151	211.0	12.3 - 678	98.9

* RDA for adults 400 µg/person/day [1], % RDA calculated on the basis of intake of folic acid converted into DFE

on Food of the European Commission (SCF), the tolerable upper intake level for folic acid taken only from supplements or fortified products are 1000 µg/person/day [13]. The average intakes found from consuming these products together were 233±151 µg/person/day without accounting for natural dietary sources; this value representing 99% of the Recommended Dietary Allowance (RDA) (Table 2). The contribution of the supplements in the folic acid intake was 66% and the fortified food was 34%.

There were no individuals found in this group to exceed the UL for this vitamin; the highest found was 678 µg/person/day in a male student who took 13% of this amount as a supplement and 87% as fortified products (2-4 portion/day), that included breakfast cereals, juices and non-alcoholic beverages and sweets. These results were similar to a 2006 study, where likewise, there were no subjects found to exceed the UL and the highest intake was 800 µg/day [10]. Another similar study conducted among female students, however showed that one person exceeded the daily limit of 1000 µg/day [11] through consuming both of the product types. Results gathered from various EU countries did not show any exceedance of the aforementioned limit. The 95th percentile of supplemental intakes of folic acid among adults, were well below UL ie. it was 360 µg/person/day. This level increased to 400µg when including Irish data on consumption of fortified products [6]. Nevertheless, studies conducted in the USA (NHANES) during 2003-2006, where flour fortification with folic acid is mandatory from 1998, demonstrated that there exists a risk of over-consuming this vitamin whenever dietary supplements are taken in conjunction with fortified products. It was found that 2.7% out of the 8258 study subjects had in fact exceeded the UL. Of the group using dietary supplements at doses of >400 µg/person/day, 47.8% of subjects exceeded the UL, however in those consuming ≤400 µg/person/day only 1% exceeded the UL. It was concluded that at current fortification levels, US adults who do not consume supplements or who consume ≤400 µg/person/day folic acid from supplements are unlikely to exceed the UL [21].

Widespread use of supplements and/or fortified products provides the ability to quickly meet the requirements when diet is deficient in this vitamin. There is however a risk of overdosing which results in negative health effects. For this reason, taking dietary supplements and fortified products should always be considered in nutritional assessment of individuals and population groups.

CONCLUSIONS

1. Among university students 13% took folic acid in the form of dietary supplements whilst 89% did so

from fortified product sources; one quarter of the latter doing so unwittingly.

2. Folic acid was jointly consumed from dietary supplements and fortified product in 11% of cases, of which 66% was obtained from dietary supplements. The UL was never exceeded.
3. There is a need for informing the general public on the principles for the safe taking of additional sources of nutrients in order to prevent overdosing.

REFERENCES

1. *Bulhak-Jachymczyk B.*: Witaminy. W: Normy żywienia człowieka: podstawy prewencji otyłości i chorób niezakaźnych. Red. *Jarosz M., Bulhak-Jachymczyk B.* Wyd. Lekarskie PZWL, Warszawa, 2008, 172-232.
2. *Ehmke vel Emczyńska E., Kunachowicz H.*: Rola kwasu foliowego w zapobieganiu wadom cewy nerwowej – badanie własne wśród kobiet w wieku rozrodczym. I Krajowa Konferencja Naukowa „Rola żywienia w zapobieganiu chorobom dietozależnym”, Biała Podlaska 23-24 września 2010 Materiały konferencyjne, 16-17.
3. *Ehmke vel Emczyńska E., Wojtkielewicz S., Kunachowicz H., Wójcik Z.*: Supply trends of folic acid with diet and dietary supplements view of the factors impeding its absorption in a group of medical students universities from Warsaw and Białystok. *Brom. Chem. Toksykol.* 2011, 44, 3, 331-335 (in Polish).
4. EUROCAT European surveillance of congenital anomalies. Folic acid mandatory fortification. <http://www.eurocat-network.eu/>.
5. European Commission: Regulation (EC) No. 1925/2006 of the European Parliament and of the Council of 20 December 2006 on the addition of vitamins, minerals and of certain other substances to foods. *Official Journal of the European Union*, 2006, L404, 30.12.2006.
6. *Flynn A., Hirvonen T., Mensink G.B.M., Ocke M. C., Serra-Majem L., Stos K., Szponar L., Tetens I., Turrini A., Fletcher R., Wildemann T.*: Intake of selected nutrients from foods, from fortification and from supplements in various European countries. *Food Nutr. Res., Suppl 1*, 2009, 12, 1-53.
7. Joint FAO/WHO Expert Consultation. *Vitamin and Mineral Requirements in Human Nutrition*, Rome 2004, 289-302.
8. *Kunachowicz H., Nadolna I., Wojtasik A., Przygoda B.*: Żywność wzbogacana a zdrowie. *Wyd. IŻŻ*, Warsaw, 2004, 161-170.
9. *Lawrence M., Chai W., Kara R., Rosenberg I., Scott J., Tedstone A.*: Examination of selected national policies towards mandatory folic acid fortification, *Nutr. Rev.* 2009, 67 suppl. 1, S73-S78.
10. *Pietruszka B., Brzozowska A.*: Supplement and fortified food contribution to overall folate intake among adults living in Warsaw, Poland. *Pol. J. Food Nutr. Sci.* 2006, 15/56, 1, 97-102.

11. *Pietruszka B.*: The effectiveness of diet supplementation with folates relative to risk factors for folate deficiencies in young women. Ed. SGGW, Warsaw 2007 (in Polish).
12. *Rolf K., Januszko O., Bylinowska B., Sicińska E., Pietruszka B., Kaluża J.*: Influence of selected factors on fortified food intake by children. *Rocz Panstw Zakl Hig.* 2012, 63, 3, 339-346, (in Polish)
13. Scientific Committee on Food, Scientific Panel of Dietetic Products, Nutrition and Allergies. Tolerable upper intake levels for vitamins and minerals. European Food Safety Authority (EFSA), Brussels 2006.
http://www.efsa.europa.eu/EFSA/Scientific_Document/upper_level_opinions_full-part33.pdf
14. *Shakur Y.A., Garriguet D., Corey P., O'Connor D.L.*: Folic acid fortification above mandated levels results in a low prevalence of folate inadequacy among Canadians. *Am. J. Clin. Nutr.* 2010, 92, 4, 818-25.
15. *Sicińska E., Pelc A.*: Fortified food products as a potential source of folic acid in human nutrition]. *Rocz Panstw Zakl Hig* 2011, 62, 2, 209-214 (in Polish).
16. *Sicińska E., Wasik M.*: Dietary supplements as an additional source of folic acid. *Bromat. Chem. Toksykol.* 2012, 45, 2, 152–158 (in Polish).
17. *Sicińska E., Wyka J.*: Folate intake in Poland on the basis of literature from the last ten years (2000-2010). *Rocz Panstw Zakl Hig* 2011, 62, 3, 247-256 (in Polish).
18. *Sicińska E.*: Products fortified with folic acid. *Przem. Spoż.* 2011, 65, 12, 39-41 (in Polish).
19. *Szponar L., Wolnicka K., Rychlik E.*: Album fotografii produktów i potraw. Wyd. IZZ, Warszawa 2000.
20. The standpoint of the Experts Group of the Ministry of Health and Human Welfare regarding prevention of inbred defects of neural tube in children using folic acid. *Żyw. Człow. Metabol.* 1997, 1, 91-95 (in Polish).
21. *Yang Q., Cogswell M.E., Hamner H.C., Carriquiry A., Bailey L.B., Pfeiffer Ch.M., Berry R.J.*: Folic acid source, usual intake, and folate and vitamin B-12 status in US adults: National Health and Nutrition Examination Survey (NHANES) 2003-2006. *Am. J. Clin. Nutr.* 2010, 91, 64-72.

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