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## THE SOURCE OF PHOSPHORUS IN A DIET OF 17-YEAR-OLDS

### ŹRÓDŁA FOSFORU W DIECIE 17-LETNIEJ MŁODZIEŻY

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#### Summary

**Introduction.** Phosphorus is an element which naturally occurs in food. However, much phosphorus is also added to food in the form of emulsifiers, stabilizers or raising agents. The growing popularity of highly processed foods is becoming a problem because of excessive phosphorus dietary intake by children and young people.

The purpose of this work was to estimate the consumption of phosphorus and identify its sources in daily food rations of 17-year-old schoolchildren from the Kuyavian-Pomeranian Province.

**Material and methods.** Information about the composition of ingested food ration was obtained by 24-hour recall. Based on the information on food consumption and the phosphorus content in 100 g of food products, the phosphorus content in a daily food ration was calculated. The values were compared with the norm for adolescents aged 16-18 years (EAR, Estimated Average Requirement = 1050 mg/person/day). Next, the percentage of phosphorus from six food groups in food rations for girls and boys were

calculated, defining the structure of the element consumed. Differences in the phosphorus intake structure between the genders were assessed with the Mann-Whitney U test. Statistical analysis was performed using Statistica.

**Results.** The analysis showed that young people's diets were characterized by a high content of phosphorus. The average content of phosphorus in the daily food ration of boys was  $1939.8 \pm 62.7$  mg/person/day, corresponding to 184.7% of the average demand for phosphorus (EAR). For girls, the phosphorus intake was significantly lower than for boys, i.e.  $1245.7 \pm 38.4$  mg/person/day, equal to 118.6% of the EAR. Over 80% of ingested phosphorus originated from 3 groups of food products. The main sources of phosphorus in the diet were grain products, potatoes and animal products (milk and dairy products, meat, sausages, fish and eggs).

**Conclusions.** Excessive intake of phosphorus was found in the diet of adolescents.

#### Streszczenie

**Wstęp.** Fosfor jest pierwiastkiem naturalnie występującym w żywności. Spora ilość tego związku dodawana jest również do żywności m.in. jako emulgatory, stabilizatory i spulchniacze. Rosnąca popularność żywności wysokoprzetworzonej staje się problemem, gdyż w dietach dzieci i młodzieży obserwuje się nadmiar spożycia fosforu.

**Celem pracy** była ocena spożycia fosforu i wyznaczenie głównych jego źródeł w całodziennej racji pokarmowej 17-letniej młodzieży z województwa kujawsko-pomorskiego.

**Materiał i metody.** Informacje o składzie spożytej racji pokarmowej uzyskano metodą wywiadu z 24

godzin. Na podstawie informacji o spożyciu oraz zawartości fosforu w 100 g produktów spożywczych obliczono zawartość fosforu w całodziennej racji pokarmowej. Uzyskane wartości porównano z normą dla osób w wieku 16-18 lat (Średnie zapotrzebowanie dla grupy, EAR ang. – Estimated Average Requirement = 1050 mg/osobę/dzień). Następnie obliczono procent fosforu z 6 grup żywności w racjach pokarmowych dziewcząt i chłopców, określając strukturę spożytego pierwiastka. Zróżnicowanie struktury spożytego fosforu związane z płcią przeprowadzono testem U Manna-Whitneya. Analizę statystyczną przeprowadzono przy pomocy programu Statistica.

Wyniki. Analiza wykazała, że dieta młodzieży charakteryzowała się wysoką zawartością fosforu. Średnia zawartość fosforu w całodiennej racji pokarmowej chłopców wynosiła  $1939,8 \pm 62,7$  mg/osobę/dzień, co stanowiło 184,7% średniego zapotrzebowania na fosfor (EAR). W grupie dziewcząt spożycie fosforu było istotnie niższe niż u chłopców i wynosiło  $1245,7 \pm 38,4$  mg/osobę/dzień, co

stanowiło 118,6% EAR. Źródłem ponad 80% spożytego fosforu były 3 grupy produktów spożywczych.

Głównymi źródłami fosforu w diecie były produkty zbożowe, ziemniaki oraz produkty pochodzenia zwierzęcego (mleko i produkty mleczne, mięso, wędliny, ryby i jaja).

Wnioski. Stwierdzono nadmierne spożycie fosforu w diecie młodzieży.

**Key words:** consumption phosphorus, sources of phosphorus, school children

**Słowa kluczowe:** spożycie fosforu, źródła fosforu, młodzież szkolna

## INTRODUCTION

Phosphorus is an element which naturally occurs in food. Bread and cereal products, milk and dairy products, meat and meat products as well as fish, eggs, legumes and nuts are a rich source of phosphorus in our diet [1]. In addition to the naturally occurring phosphorus in raw food, considerable amounts of this element originate from substances added to food. Phosphorus compounds are added to highly processed foods for technological, organoleptic and economic reasons, using emulsifiers, stabilizers, rising, clarifying, anti-caking and acidity regulating agents [1,2]. This particularly concerns meat and meat products, processed cheese, instant soup concentrates, confectionery products and sugary sodas [2]. The growing popularity of highly processed convenience foods, including fast food, alongside bad eating habits result in a high content of phosphorus in diets of children, adolescents and adults observed for many years now [3, 4, 5, 6, 7, 8, 9]. It has been demonstrated empirically that the problem of excessive consumption of phosphorus appears mainly among schoolchildren and students and that the highest content of this element is found in diets of boys and men aged 16-18 and 19-25 years and girls aged 13-15 and 16-18 years [4,8,10]. Excessive intake of phosphorus is a disturbing finding because it may cause disorders in the body's mineral economy with such consequences as reduced absorption of calcium, parathyroid gland stimulation, increased bone resorption and low calcium intake, which leads to bone demineralization [1]. This can be especially detrimental during the body's growth, which continues until the closure of epiphyses, i.e. about 20 years of age, when 80-95% of the peak bone mass is deposited. Therefore, it is important to monitor the intake of phosphorus in the diet of young people and raise awareness about the presence of phosphorus in food products.

The purpose of this study was to determine the phosphorus content in daily food rations of 17-year-old adolescents and to determine the structure (%) of this element in their diet.

## MATERIALS AND METHODS

The study was conducted in spring 2003 on a group of 232 persons (130 boys, 102 girls). They were 17-year-olds from secondary schools in the Kuyavian-Pomeranian Province. The information about the composition of ingested food rations was obtained by 24-hour recall, which relied on the Album of Products and Dishes.

Based on the information on consumption of all products, food and beverages, and the phosphorus content in 100 g of food products [11], the amount of phosphorus [mg/day] in the entire food ration for girls and boys was calculated. The values were compared with the norm for people aged 16-18 years, i.e. the average phosphorus demand of the group (level of Estimated Average Requirement = 1050 mg/person/day) [12]. Then, the percentage of phosphorus from 6 food groups: 1 cereals and potatoes; 2 milk and dairy products; 3 meat, sausages, fish and eggs; 4 fats; 5 vegetables and fruits; 6 sugar and sweets [13] in food rations for girls and boys was calculated, defining the structure of the element consumed. Differences in the phosphorus intake structure between the genders were assessed with the Mann-Whitney U test. Statistical analysis was performed using Statistica version 6.0 StatSoft.

## RESULTS

The phosphorus content in daily food rations of boys and girls is shown in Table 1. Statistically significant differences in the phosphorus content in the diets of boys and girls were demonstrated. The mean content phosphorus in the daily food ration of boys was  $1939.8 \pm 62.7$  mg/person/day, representing 184.7% of

the average requirement (EAR) for phosphorus. Among the girls, the phosphorus intake was significantly lower:  $1245.7 \pm 38.4$  mg/person/day, representing 118.6% of the average demand for phosphorus (EAR).

Table I. *The content of phosphorus in daily food rations of 17-year-old adolescents [mg/day]*

Tabela I. *Zawartość fosforu w racjach pokarmowych 17-letniej młodzieży [mg/dzień]*

	phosphorus content [mg/person/day] zawartość fosforu [mg/osobę/dzień]				P
	boys (n=130) chłopcy (n=130)		girls (n=102) dziewczęta (n=102)		
	X ± SEM	Me ± QD	X ± SEM	Me ± QD	
phosphorus content in food rations zawartość fosforu w racjach pokarmowych	1939.8 ± 62.7	1819.5 ± 849.0	1245.7 ± 38.4	1173.5 ± 532.0	<0.001
EAR - Estimated Average Requirement (%) EAR - średnie zapotrzebowanie grupy (%)	184.7 ± 6.0	176.2 ± 83.3	118.6 ± 3.7	111.8 ± 50.7	<0.001

X - mean value, SEM - standard error of mean, Me - median, QD - interquartile range (IQR)

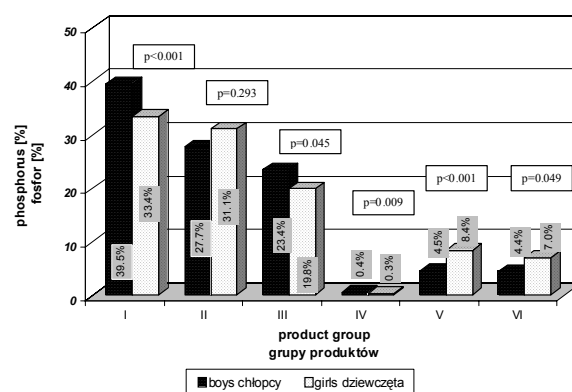
p - significance level - U Mann-Whitney test

X - wartość średnia, SEM - błąd standardowy średniej, Me - mediana, QD - rozstęp kwartylny,

p - poziom istotności - test U Manna-Whitneya

The amount of phosphorus consumed from different food groups was also assessed. Statistically significant differences between the two genders were demonstrated in the percentage of phosphorus from most of the analyzed food groups, except milk and dairy products ( $p = 0.293$ ). Among the 6 analyzed food groups, most phosphorus in the diet of most boys and girls was provided by cereals and potatoes: 39.5% and 33.4%, respectively (Fig. 1). Much phosphorus also originated from milk and dairy products (27.7% boys, girls 31.1%), less from meat, sausages, fish and eggs (23.4% boys, girls 19.8%). The two remaining groups of products (vegetables and fruits, sugar and sweets) proved to be a poor source of phosphorus, providing respectively 4.5% and 4.4% for boys and 8.4% and 7.0% for girls.

It was shown that most of phosphorus came from three groups of products (1 - cereals and potatoes, 2 - milk and milk products, 3 - meat, sausages, fish and eggs), bringing the total of 90.6% and 84.3% of this element into the food rations of boys and girls, respectively



I - cereal products & potatoes – produkty zbożowe i ziemniaki; II - milk & dairy products – mleko i produkty mleczne; III - meat, cold cuts, fish & eggs – mięso, wędliny, ryby i jaja; IV - fats - tłuszcze; V - fruit & vegetables – warzywa i owoce; VI - sugar and sweets – cukier i słodczyce

Print 1. *The structure of phosphorus [%] in daily food rations of 17-year-olds*

Rycina 1. *Struktura fosforu [%] w całodziennych racjach pokarmowych 17-letniej młodzieży*

## DISCUSSION

The excessive consumption of phosphorus by 17-year-old boys and girls from the Kuyavian-Pomeranian Province, as demonstrated in the present study, is confirmed by the research results presented in recent years. Attention is drawn to a higher intake of phosphorus by boys and men as compared to girls and women [4,8,14]. Szponar et al. (2003), who examined individual food consumption in households, determined the amount of dietary phosphorus in the Polish population within a wide range of ages (from 1 to 60 years of age and above) [8]. The recorded phosphorus intake was in excess of the average phosphorus demand in all age groups except children under 3 years of age [8]. The highest phosphorus content in daily diets was found in the group of boys aged 16-18 years ( $1661 \pm 607$  mg/person/day) and men aged 19-25 years ( $1758 \pm 565$  mg/person/day). In turn, the diets of girls and women had a slightly lower phosphorus content, and the highest values were observed in age groups 13-15 and 16-18 years ( $1147 \pm 435$  and  $1125 \pm 480$  mg/person/day) [8]. The phosphorus content of the diet of girls increased with age (up to 18 years of age). Among women aged 19-25 years and older, the content of this element was lower and remained on a similar level of about 1008-1016 mg/person/day [8]. Excessive intake of phosphorus in the diet of 16-17-year-old school students was also

observed Ostrowska et al. (2003). The demonstrated amount of phosphorus in the diets of boys and girls was  $1647 \pm 667$  and  $1053 \pm 390$  mg/person/day [4]. Also Maruszczyńska et al. (2005) reported a high intake of phosphorus in the diets of 16-19-year-old boys and girls:  $1709 \pm 850$  and  $1210 \pm 556$  mg/person/day, respectively [14]. A similar amount of phosphorus in the diet of a slightly older age group was reported Stefńska et al. (2005) [10].

Our study showed that three groups of products (cereals and potatoes, milk and dairy products, meat, sausages, fish and eggs) provided about 91% and 84% of phosphorus in the diets of boys and girls, respectively. In the study presented by Rutkowska et al. (1993), the above three groups of products, having added cereal products and potatoes, which they analyzed separately, also supplied much phosphorus, i.e. 87-91% [15]. However, grain products and potatoes added slightly less phosphorus (about 32-34%) than in our study (33.4-39.5%), whereas meat products introduced slightly more phosphorus (about 2.6-6.2%), although eggs were analyzed separately. A similar percentage of phosphorus in the whole diet was contributed by milk and dairy products [15]. Kunachowicz and Wojtasik (2005) indicated that grain products (25-35%), dairy (20-30%) and meat and meat products 20-25% are the main source of phosphorus [1]. These three product groups contributed slightly less phosphorus in the research presented by Dybkowska et al. (2004). Bread and cereal products, milk and dairy products and meat and meat products accounted for 22-27%, 24-26% and 22-23% of the phosphorus content in the diet of the Warsaw adult population [9].

Our study showed that food rations of 17-year-olds were too high in phosphorus. This was particularly evident in the diet of boys, in which the phosphorus content exceeded the norm by about 85%. Higher phosphorus content in processed foods leads to excessive consumption of this element, which may interfere with the body's mineral balance, impede the proper development of bone mass during adolescence and increase the risk of osteoporosis in later life.

## CONCLUSIONS

1. The diet of 17-year-old adolescents was characterized by an excessively high content of phosphorus, which may interfere with the body's mineral balance and impede the proper development of bone mass.

2. The main source of phosphorus in the diet of 17-year-olds was cereals and potatoes and animal products (milk and dairy products, meat, sausages, fish and eggs).

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