

EVALUATION OF THE MINERAL COMPOSITION OF BREADSTUFF AND FREQUENCY ITS CONSUMPTION

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Background. The aim of the study was to assess some selected minerals (Ca, Mg, Na, K, P, Fe, Zn, Cu, Mn) in different types of breadstuff. Moreover, the frequency of breadstuff consumption was determined in a selected group of students at one of Lublin universities.

Material and methods. The material for the study was breadstuff available on the consumer market, produced from wheat and rye flour, of varied degree of grinding. In the samples the content of dry matter, crude ash and minerals (Ca, Mg, Na, K, P, Mn, Cu, Fe and Zn) was determined. A questionnaire investigation was performed in a group of 100 university students in Lublin. The questionnaire included questions which were helpful in determining the frequency of the consumed breadstuff.

Results. The content of mineral elements in breadstuff depended on its recipe's composition and their higher share was noted in rye and mixed-flour bread. Whole wheat bread was richer in minerals in comparison with white bread. Assuming that a statistical Pole consumes daily 166 g of bread, it may be calculated that the men consumes daily with bread 512 mg of P (73% of RDA) and 0.7 mg of Cu (ca. 78% of RDA), ca. 20 mg of Ca (1.6-2.0% of AI), 93 mg of Mg (ca. 22-30% of RDA), 602 mg of Na (40-50% of AI), 183 mg of K (3.9% of AI), 4.5 mg of Fe (25-45% of RDA) and 3 mg of Zn (29-40% of RDA).

Conclusion. Bread is an important source of minerals, especially phosphorus and copper. Among students an excessive consumption of white bread should be noted contrasting with a low intake of whole wheat or whole meal bread.

Key words: breadstuff, microelements, macroelements

INTRODUCTION

Breadstuff makes the basic component of people's everyday diet, no matter where they live or what culture they represent. It is estimated that a statistical Pole will consume 5.06 kg of bread each month [Concise Statistical Yearbook of Poland 2009],

which gives slightly more than 166 g per day. According to Goryńska-Goldmann [2010] the market of bread in Poland is saturated, the overall consumption of bread will not increase. Research has shown that people in our country definitely prefer white bread [Szczęsna et al. 2005].

The exceptional role of breadstuff in human nutrition results from three basic factors: its high share of starch, the presence, to a higher or lower degree, of almost all nutrients and the presence of numerous flavouring substances. Breadstuff, particularly its brown and whole meal types, is a more beneficial component of our diet because it is a much richer source of elements which counteract civilization diseases (mainly neoplastic diseases and cardio-vascular conditions), in comparison with white bread produced from highly ground flour [Arvola et al. 2007, Kadan and Phillippy 2007, Leitzmann and Watzl 2002]. Moreover, bread is an excellent source of numerous vitamins and minerals whose abundance depends on the degree of grinding [Grembecka et al. 2007, Isserliyska et al. 2001]. Additionally, Polish bread may be enriched with substances which are supposed to improve its flavor and/or nutritional value, such as fiber additives [Korus and Achremowicz 2004], dried vegetables [Tańska et al. 2007], grain bran [Różyło 2007] or different types of seeds [Lebiedzińska et al. 2006]. Also, an addition of durum wheat (*Triticum durum*) is often used as a bread improver [Rachoń and Kulpa 2004]. From the nutritional viewpoint, it is particularly vital to enrich breadstuff produced from white flour because of losses in nutrients occurring in the process of grinding. Some authors [Karadzhev and Isserliyska 2003] claim that enriching bread with mineral elements has a beneficial effect on its quality.

Research has shown that the diet of the Poles does not fully meet their requirements concerning micro- and macroelements [Bronkowska et al. 2009, Ustymowicz-Farbiszewska et al. 2008]. Bearing in mind the high consumption of breadstuff in Poland, it should be treated as one of the basic sources of mineral elements in the human diet. However, specialist literature contains little information regarding the mineral composition of bread. The problem is not limited to our country only, foreign literature offers scarce information on this issue, either.

The aim of the study was to assess the content of selected mineral elements (Ca, Mg, Na, K, P, Fe, Zn, Cu, Mn) in different types of breadstuff produced from wheat and rye flour, of different degree of grinding. The calculation of minerals daily intake was based on mean daily consumption of bread and mean values of minerals in analysed breads. Moreover, the frequencies of bread consumption were determined in a selected group of students at one of universities in Lublin.

MATERIAL AND METHODS

Food samples

The material for the study was provided by breadstuff available on the consumer market, produced from wheat and rye flour, of different degree of grinding. Breadstuff was purchased in local markets in Lublin. The types of bread used in the study were: 2 sorts of wheat bread (lecytal and graham), 3 sorts of mixed wheat-rye bread (with soybean, wheat-rye bread, "sitkowy" with amaranthus), 3 sorts of whole meal rye bread (with honey and plum, rye bread and rye bread with sunflower grains), 1 sort of pump-

kin and 1 sort of crisp bread with sesame grains. Also, 3 samples were taken (weighing ca. 10 g) from the each of the bread.

Chemical analysis

The contents of dry matter and crude ash in the samples were determined with the use of standard AOAC methods [1990]. Ca. 10 g of the analysed material was weighed, the samples were dried at the temperature of 105°C for 48 hours and next mineralized in a zinc furnace, at the temperature of 550°C for 16 hours. 10 ml of 6 N HCl was added to the burnt samples and the solution was filtered to measuring flasks and completed with distilled water to the volume of 50 ml. The stock solution was used in the analyses. The content of Mg, Zn, Cu, Ca, Mn, Na, Fe and K was determined by means of the AAS flame technique in the Unicam 939 (AA Spectrometer Unicam) apparatus. Phosphorus content was analysed by the colorimetric method according to PN-76/R-64781 with a Helios α -Unicam apparatus, using molybdate-vanadate reagent. The reagent was prepared by mixing the same volumes of NH_4VO_3 , $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}\cdot 4\text{H}_2\text{O}$ and HNO_3 . Phosphorus was measured at 430 nm. All chemical analyses were performed in two replications.

Calculation of minerals intake and statistical analysis

The calculation of minerals daily intake was based on mean daily consumption of bread [Concise Statistical Yearbook of Poland 2009] and mean values of minerals. Contribution of bread to the daily intake of minerals was calculated based on RDA (recommended daily allowance) or AI (adequate intake) for adults and minerals daily intake from analysed bread.

The obtained results were statistically analysed. Arithmetic mean values and standard deviation (SD) were calculated with the use of STATISTICA 6.0 software.

Questionnaire investigation

The questionnaire investigation was performed in a group of 100 university students in Lublin (69 women and 31 men). The questionnaire included 35 questions which were aimed at determining the frequencies of the selected population, as well as the volume of consumed breadstuff. 74% of respondents lived outside the home, among them 55 persons lived in the student's dormitory.

The obtained results were used for calculations of average frequency degree for each type of bread. They were formed for both the total of the examined, as well as separately for women and men.

RESULTS AND DISCUSSION

Chemical composition of bread

In the majority of the studied bread types the content of dry matter ranged from 56% to 64% of fresh mass. The only type where a significantly higher value, above 93%, was noted, was crisp bread with sesame seeds (Table 1).

Table 1. Dry matter (%), crude ash (%) and some minerals levels in the bread, n = 2 (mean \pm SD)

Bread	Dry matter %	Crude ash %	Macroelements, mg 100 g ⁻¹ fresh mass					Microelements, mg 100 g ⁻¹ fresh mass			
			Ca	Mg	Na	K	P	Fe	Zn	Cu	Mn
1.	62.20 ± 4.11	1.71 ± 0.10	10.3 ± 0.82	15.0 ± 1.12	426.2 ± 21.0	48.3 ± 3.21	219.6 ± 13.0	2.07 ± 0.11	0.53 ± 0.01	0.38 ± 0.01	0.44 ± 0.02
2.	56.94 ± 3.34	1.71 ± 0.09	8.4 ± 0.32	26.1 ± 1.31	373.8 ± 30.0	57.4 ± 2.02	197.5 ± 9.9	1.68 ± 0.12	1.24 ± 0.09	0.27 ± 0.01	1.13 ± 0.06
3.	58.72 ± 2.32	1.56 ± 0.09	8.9 ± 0.52	25.2 ± 1.97	350.9 ± 19.1	74.2 ± 4.60	183.1 ± 15.2	2.00 ± 0.09	0.92 ± 0.02	0.21 ± 0.006	0.81 ± 0.02
4.	61.44 ± 4.20	0.99 ± 0.07	6.9 ± 0.32	17.9 ± 1.10	260.3 ± 21.3	44.8 ± 3.98	204.9 ± 14.0	1.93 ± 0.09	0.65 ± 0.01	0.32 ± 0.001	0.73 ± 0.04
5.	59.20 ± 3.80	1.04 ± 0.0	8.2 ± 0.71	40.1 ± 2.09	217.5 ± 13.2	70.7 ± 5.02	230.7 ± 19.0	2.05 ± 0.10	1.47 ± 0.07	0.29 ± 0.001	2.10 ± 0.10
6.	56.98 ± 5.01	1.62 ± 0.11	6.0 ± 0.11	26.7 ± 1.90	225.6 ± 16.3	85.9 ± 6.10	230.4 ± 15.0	1.91 ± 0.09	1.13 ± 0.06	0.29 ± 0.001	2.05 ± 0.08
7.	57.10 ± 2.90	1.55 ± 0.11	7.5 ± 0.23	36.9 ± 2.98	321.0 ± 19.9	79.4 ± 6.01	252.6 ± 11.3	2.11 ± 0.03	1.58 ± 0.04	0.33 ± 0.009	2.11 ± 0.11
8.	57.76 ± 3.01	1.26 ± 0.09	7.3 ± 0.13	66.1 ± 3.08	392.5 ± 21.0	85.3 ± 7.11	276.9 ± 20.1	2.50 ± 0.10	1.85 ± 0.07	0.41 ± 0.002	1.94 ± 0.13
9.	64.30 ± 1.25	2.33 ± 0.17	20.4 ± 1.40	48.0 ± 2.08	460.9 ± 31.1	115.7 ± 5.28	297.5 ± 19.7	2.20 ± 0.04	1.78 ± 0.10	0.34 ± 0.01	2.15 ± 0.08
10.	93.40 ± 4.44	3.11 ± 0.13	16.3 ± 1.12	142.2 ± 7.98	362.6 ± 21.0	236.9 ± 9.10	576.5 ± 30.4	5.45 ± 0.23	4.24 ± 0.20	0.84 ± 0.01	4.14 ± 0.1

Breads: 1 – wheat “lecytal”, 2 – graham, 3 – with soybean, 4 – wheat-rye, 5 – mixed wheat-rye „sitkowy” with amaranthus, 6 – rye with honey and plum, 7 – wholemeal rye, 8 – rye with sunflower grains, 9 – pumpkin, 10 – crisp with sesame grains.

The highest share of crude ash (above 3%) was found in crisp bread, whereas the lowest figures were noted for wheat-and-rye bread and mixed brown bread with amaranthus (slightly above 1%).

Calcium content in the majority of the studied bread types varied from 6 to 10 mg/100 g of fresh mass. The only exceptions were pumpkin and crisp bread in which 20.4 mg and 16.3 mg per 100 g of fresh mass, respectively, were recorded. It should be noted that both types of bread were made of rye. Much higher values are quoted by Gaşiorowski [2004], who recorded almost 40 mg of Ca in wheat bread and nearly 31 mg of Ca in mixed bread.

The content of magnesium in breadstuff ranged from 15 to 142 mg/100 g of product's fresh mass. The highest amounts of this element were recorded in crisp bread with sesame seeds. The higher share of magnesium in crisp bread resulted from the addition of sesame seeds and wheat bran. A lower amount of Mg was noted in wheat bread, in comparison to rye or mixed varieties. A higher share of Mg in rye bread in comparison to wheat bread was also noted by Grembecka et al. [2007]. The lowest content of this element was observed in wheat bread with lecithin. Different results were obtained by Gaşiorowski [2004], who recorded a double amount of magnesium in wheat bread.

In most types of the studied breadstuff the content of sodium ranged between 300 and 400 mg/100 g of fresh mass. Lower amounts were observed in mixed brown bread with amaranthus (ca. 217 mg) and rye honey-and-plum bread (ca. 266 mg). The author's own studies revealed that the highest share of sodium was present in wheat bread "lecytal" (ca. 426 mg) and in pumpkin (nearly 461 mg). The basic source of sodium in bread is table salt.

The content of potassium in the studied bread varieties ranged from 45 to 237 mg/100 g of product's fresh mass. It was noted that wheat and wheat-rye bread types contained lower amounts of this element than rye bread. The highest share of potassium was found in crisp bread. Gašiorowski [2004] recorded a significantly higher value of this element in wheat and wheat-and-rye bread, namely ca. 150 mg.

The studied breadstuff contained about 200-300 mg of phosphorus per 100 g of product's fresh mass. An exception was crisp bread with sesame seeds in which as much as 576 mg of this element was recorded. Wheat bread revealed slightly higher values than rye or mixed bread. At the same time it was noted that whole wheat bread had a much higher share of this element than white bread. Similar results were quoted by Grembecka et al. [2007].

The highest content of iron was found in crisp bread (nearly 5.5 mg/100 g of fresh mass), whereas its lowest share was noted in graham bread (1.68 mg/100 g). On the basis of the results obtained in the author's own analyses, no significant differences were recorded, concerning the content of Fe resulting from the type of flour. Similar results were obtained by Grembecka et al. [2007]. However, according to Gašiorowski [2004], whose observations were different, the content of iron in brown bread is the highest. Iron and zinc present in grain products is characterized by low assimilability, which is related to the presence of e.g. phytinians and dietary fiber [Hurrell et al. 2002]. Because iron and zinc deficiency is a significant global problem [Hotz et al. 2003], several countries are implementing flour fortification programs for corn and wheat flour with iron and other minerals [Akhtar and Anjum 2007].

Zinc in the studied breadstuff accounted for ca. 1-2 mg per 100 g of product's fresh mass. Exceptions were wheat bread "lecytal" and wheat-rye bread which contained ca. 0.5 mg of Zn and crisp bread in which Zn made 4 mg per 100 g of fresh mass. Moreover, it was observed that rye bread contained almost a double amount of this element in comparison with wheat bread. According to Grembecka et al. [2007], bread may contain from nearly 0.7 mg to nearly 2.5 mg of zinc.

The studied material revealed a content of 0.21-0.84 mg of copper per 100 g. The type of flour did not have any effect on the share of Cu in bread. The highest amount of copper was noted in crisp bread (0.84 mg/100 g of fresh mass). According to the norms PN-92/A-74101, PN-92/A-74103 and PN-92/A-74105, the content of copper in breadstuff must not exceed 0.5 mg/100 g of fresh mass. The author's own analyses showed that this level was exceeded only in crisp bread.

The share of manganese in the studied breadstuff ranged from 0.44 mg to 4.14 mg per 100 g of product's fresh mass. The highest amount of this element was recorded in crisp bread. It was also noted that rye bread contained much more Mn than wheat products.

Assuming that a statistical Pole consumes daily 166 g of bread, it may be calculated that the men consumes daily with bread 20.3 mg of Ca (1.6-2.0% of AI), 93.3 mg of Mg (ca. 22-30% of RDA), ca. 602 mg of Na (40-50% of AI), 183 mg of K (3.9% of AI), 512 mg of P (73% of RDA), 4.5 mg of Fe (25-45% of RDA), 3.2 mg of Zn (29-40% of RDA) and 0.7 mg of Cu (ca. 78% of RDA) (Table 2).

Table 2. Mean content of minerals in the bread and daily intake minerals from bread for adults

Bread	Macroelements, mg 100 g ⁻¹ fresh mass					Microelements, mg 100 g ⁻¹ fresh mass			
	Ca	Mg	Na	K	P	Fe	Zn	Cu	Mn
Wheat	9.4	20.6	400.0	52.9	208.6	1.9	0.9	0.3	0.8
Mixed wheat-rye	8.0	27.7	276.2	63.2	206.2	2.0	1.0	0.3	1.2
Whole meal rye	6.9	43.2	313.0	83.5	253.3	2.2	1.5	0.3	2.0
Pumpkin	20.4	48.0	460.9	115.7	297.5	2.2	1.8	0.3	2.2
Crisp bread	16.3	142.2	362.6	236.9	576.5	5.4	4.2	0.8	4.2
Mean value	12.2	56.2	362.5	110.4	308.4	2.7	1.9	0.4	2.1
Daily intake*	20.3	93.3	601.8	183.3	511.9	4.5	3.2	0.7	3.5
RDA	1000-1300**	310-420	1200-1500**	4700**	700	10-18	8-11	0.9	-***
% of RDA	2.0-1.6	30.1-22.2	50-40.1	3.9	73.1	45-25	40-29.1	77.8	-

*Assuming that a statistical Pole consumes 166 g of bread per day. RDA – Recommended Dietary Allowances for adults [Jarosz and Bułhak-Jachymczyk 2008].

**AI (Adequate Intake), since RDA for Ca, Na, K consumption in Poland has not been determined.

***There is no recommended level set in Poland for Mn.

Questionnaire investigation

The questionnaire investigation revealed that nearly all respondents consumed bread (99%), with 69% consuming bread several times a day, 22% once daily and 8% less frequently than once a day (Fig. 1). Men had bread more often than women, the product was consumed several times daily by 77.4% of men, whereas the percentage for women amounted to 65.2%. The most frequently consumed type was white bread which was preferred and regularly eaten by nearly 80% of the questioned men. 96% of the questioned students chose whole meal products, and only 37% of them consumed it regularly while 59% did so on rare occasions (Fig. 2). 4% of the respondents did not eat this type of products at all. Women chose whole meal products more often than men (40.6% vs. 29%). As much as 6.45% of men and less than 3% of women did not consume this variety at all.

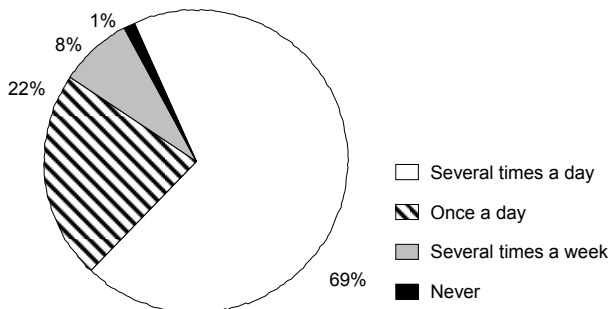


Fig. 1. Frequency of breadstuff consumption by students, %

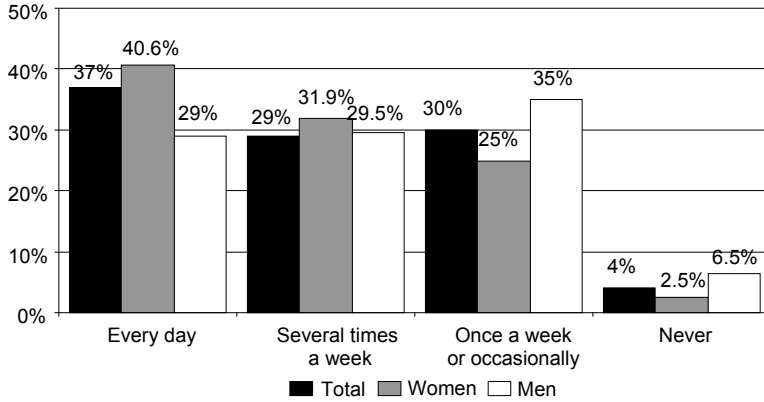


Fig. 2. Frequency of whole meal breadstuff consumption by students, %

It is estimated that a statistical Pole consumes slightly more than 166 g of bread daily [Concise Statistical Yearbook of Poland 2009]. This is less than e.g. in Bulgaria or Serbia, where daily bread consumption amounts to ca. 300 g [Isserliyska et al. 2001, Škrbić and Filipčev 2007]. In Yemen, daily consumption of bread ranged from 250-320 g [Al-Mussali and Al-Gahri 2009].

Research has shown that the Poles choose most commonly white bread [Szczęsna et al. 2005]. A low consumption of whole wheat bread may result from a rather poor quality of this variety of bread since many types are made of white flour and the dough is dyed. It also occurs that bread labelled “whole wheat” is baked not only from whole wheat flour but with a high share of white flour, which may lead to errors in determining the chemical composition of products called “whole wheat bread”.

The frequency of bread consumption among students may be regarded as adequate, yet an excessive consumption of white bread should be noted, in comparison with rather low intake of whole wheat or whole meal bread. Whole wheat and whole meal bread are more favorable in the diet, as they contain a higher amount of vitamins, minerals and dietary fiber than those found in white bread produced from flour of high degree of grinding [Arvola et al. 2007].

CONCLUSION

The content of mineral elements in breadstuff depended on its recipe’s composition and their higher share was noted in rye and mixed-flour bread. Whole wheat bread was richer in minerals in comparison with white bread. Bread is an important source of minerals, especially phosphorus and copper, assuming that a statistical Pole consumes daily 166 g of bread, it may be calculated that the men consumes daily with bread 512 mg of P (73% of RDA) and 0.7 mg of Cu (ca. 78% of RDA). Moreover, a daily portion of bread contains ca. 20 mg of Ca (1.6-2.0% of AI), 93 mg of Mg (ca. 22-30% of RDA), 602 mg of Na (40-50% of AI), 183 mg of K (3.9% of AI), 4.5 mg of Fe (25-45% of RDA) and 3 mg of Zn (29-40% of RDA). Among students an excessive consumption of white bread should be noted contrasting with a low intake of whole wheat or whole meal bread.

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ZAWARTOŚĆ SKŁADNIKÓW MINERALNYCH W PIECZYWIE ORAZ CZĘSTOTLIWOŚCI JEGO SPOŻYCIA

Wstęp. Celem badań była ocena zawartości wybranych składników mineralnych (Ca, Mg, Na, K, P, Fe, Zn, Cu, Mn) w różnych gatunkach pieczywa. Ponadto określono preferencje spożycia pieczywa w wybranej grupie studentów lubelskich uczelni.

Materiał i metody. Materiałem do badań było dostępne na rynku konsumenckim pieczywo, otrzymane z mąk pszennych i żytnich, różniących się stopniem przemiału. W próbach oznaczono zawartość suchej masy, popiołu surowego oraz elementów mineralnych (Ca, Mg, Na, K, P, Mn, Cu, Fe i Zn). Badanie ankietowe zostało przeprowadzone w grupie 100 studentów lubelskich uczelni. W ankiecie zawarto pytania pozwalające określić preferencje w spożywaniu pieczywa.

Wyniki. Zawartość składników mineralnych w pieczywie była uzależniona od składu recepturowego, więcej notowano ich w chlebie żytnim i mieszanym. Pieczywo razowe było bogatsze w składniki mineralne niż pieczywo jasne. Przyjmując, że statystyczny Polak spożywa dziennie około 166 g chleba można oszacować, że wraz z tym produktem spożywa 512 mg P (73% RDA) i 0,7 mg Cu (ok. 78% RDA), około 20 mg Ca (1,6-2,0% AI), 93 mg Mg (ok. 22-30% RDA), 602 mg Na (40-50% AI), 183 mg K (3,9% AI), 4,5 mg Fe (25-45% RDA) oraz 3 mg Zn (29-40% RDA).

Wnioski. Pieczywo jest dobrym źródłem składników mineralnych, szczególnie fosforu i miedzi. Wśród studentów należy zauważyć nadmierne spożycie białego pieczywa, a małe spożycie pieczywa razowego i pełnoziarnistego.

Słowa kluczowe: pieczywo, mikroelementy, makroelementy

Received – Przyjęto: 28.01.2011

Accepted for print – Zaakceptowano do druku: 2.06.2011

For citation – Do cytowania: Winiarska-Mieczan A., Kwiecień M., 2011. Evaluation of the mineral composition of breadstuff and frequency its consumption. *Acta Sci. Pol., Technol. Aliment.* 10(4), 487-495.