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Total intake of zinc, manganese, copper, vitamin C and phenols in students` daily food rations

Całkowite pobranie cynku, manganu, miedzi, witaminy C i fenoli z całodziennymi dietami studentów

INTRODUCTION

The levels of antioxidant dietary nutrients are extremely important due to their capacity to scavenge free radicals, thus preventing cell structure damage induced by oxidative stress. Manganese, copper and zinc, the components of mitochondrial and intracellular superoxide dismutase (SOD), protect the relevant compounds from oxidation by the superoxide ion [12]. Vitamin C and polyphenols also show antioxidative properties [16]. Since the source of all the components mentioned above is food, the aim of the present study was to assess their intake in diets of students, who constitute a socially important group of young people.

MATERIAL AND METHODS

The study was conducted in 2009 and 2010 and involved 536 randomly chosen students, both sexes (402 women and 134 men), from the Medical University of Lublin (176 women and 64 men), University of Life Sciences in Lublin (146 women and 38 men) and Catholic University of Lublin (80 and 32, respectively).

All students were volunteers; their lifestyles were characterized by moderate physical activity. The investigations were conducted using the dietary recall and dietary record techniques. The analogous duplicates of diets were prepared based on the information obtained from the students involved in the study. Questionaires contained qualitative and quantitative parameters of diets**.** The products for reconstruction of diet duplicates were purchased in retail and small gastronomy outlets (ready-made meals) in Lublin. The daily rations included the plate portions of the main meals identical with the ones consumed by a particular individual and all foodstuffs and beverages consumed daily. Diet duplicates were prepared according

to the generally accepted culinary techniques. Daily food rations (DFRs), after the removal of inedible parts (bones, fishbones), were weighed and homogenized. From the averaged sample prepared, three weighed amounts, 50 g each, were prepared and placed in quartz crucibles for chemical assays of mineral components. Samples were ashed at 450^{o} in a muffle furnace. The ash was dissolved in hydrochloric acid, Suprapur-Merck, diluted with deionised water (1+1 v/v). Copper, manganese and zinc were determined with flame atomic absorption spectrometry in the Thermoelemental Solaar M5 spectrometer at λ= 324.75 nm; 279.48 nm and 213.86 nm, respectively. All routine sample runs included a reagent blank, the standard treated in the same manner as the samples and reference samples. To determine polyphenols, the averaged diet sample (75 g) was extracted with methanol three times (Analytical grade- POCH); after evaporation under decreased pressure, the remaining amount was dissolved in the mixture of methanol and water (1+1 v/v); 0.5 ml was collected from the solution obtained (100 ml) and total polyphenols were determined using the modified Folin-Ciocalteu method [13]. Absorbance was read at λ=760 nm in the Cecil 6600 CE spectrometer compared to gallic acid reference solutions. The DIETETYK 2006 software was used to compare analytical results and calculations of intakes of the elements studied and levels of vitamin C. The energy value and intake of protein, fats, carbohydrates, copper, manganese and zinc were calculated based on the questionnaire data. To compare the results of nutritional component intakes, statistical analysis was conducted using the test of difference significance available in Statistica 8.0 (StatSoft). $P < 0.05$ was considered statistically significant [14].

RESULTS AND DISCUSSION

Energy levels, as well as protein, fat, carbohydrate intakes and percentage distribution of energy from each component in students' daily food rations are presented in Table 1.

The energy levels in male diets are significantly higher than in female diets, except for the Catholic University students, whose levels are not significantly statistically different – $P > 0.05$. It should be noted that the energy value of diets of female students is too low covering on average about 68.8% to 72.9% of energy demands recommended for this age group with moderate physical activity level (PAL). In 2009, diets of students of the Medical University and University of Natural Sciences covered about 96–99% of energy requirements (according to recommended dietary allowance – RDA). The highest energy deficits were found in diets of Catholic University students – 60.0–61.0% of energy requirements; in 2010, the energy value of daily food rations decreased amongst students of Medical and Life Science Universities, about 76% and 69% of the recommended amount, respectively. The protein-derived energy in all the diets examined in both sexes exceeds the optimal values, yet is not too high; similar tendencies are observed in other academic centres [2, 6, 11]. The percentage of fat-derived energy is alarming, which concerns both sexes and all universities – on average from 31.3% to 37.7%, which is higher than the acceptable 30% [5]. This fact may adversely affect the health of young individuals and lead to the development of cardiovascular diseases, obesity, diabetes mellitus type II or other diet-related diseases. The dietary components influencing the oxidative status of the human body were determined using chemical analysis of reconstructed daily food rations and calculated based on the national database contained in DIETETYK 6.0 [7]. The intake of zinc, manganese and copper was evaluated by calculations and analytically (Table 2); the level of vitamin C only using the software base whereas polyphenols only analytically, as the database does not provide information about this group of compounds (Table 3).

Table 1. Energy levels and percentage distribution of energy from protein, fat, carbohydrates in students' diets in 2009 and 2010

Diet parameters	Females		Males	
	2009	2010	2009	2010
Medical University				
Energy (kcal)	1785 ± 623	1785 ± 649	3023 ± 1318	2320 ± 646
Proteins (g)	70.5 ± 26.3	66.4 ± 20.1	114.8 ± 48.8	96.6 ± 33.4
Fats (g)	68.5 ± 33.2	68.8 ± 31.1	127.4 ± 70.3	91.5 ± 34.6
Carbohydrates (g)	239 ± 88.1	241 ± 94.6	372 ± 148	290 ± 88.4
Energy from proteins (%)	16.0 ± 3.33	15.7 ± 4.13	15.4 ± 2.74	16.8 ± 3.57
Energy from fats (%)	34.1 ± 8.80	34.2 ± 7.56	37.2 ± 6.68	34.8 ± 8.72
Energy from carbohydrates (%)	50.0 ± 9.68	50.1 ± 8.14	47.5 ± 6.20	48.3 ± 9.12
University of Natural Sciences				
Energy (kcal)	1901 ± 535	1650 ± 542	2933 ± 778	2100 ± 710
Proteins (g)	80.3 ± 31.1	71.5 ± 24.3	132.9 ± 44.4	95.9 ± 37.6
Fats (g)	70.2 ± 29.2	60.3 ± 30.3	118.1 ± 43.3	79.8 ± 24.9
Carbohydrates (g)	254 ± 88.4	226 ± 10.4	348 ± 88.6	226 ± 118
Energy from proteins (%)	16.8 ± 3.38	17.7 ± 3.63	18.1 ± 3.58	18.7 ± 4.45
Energy from fats (%)	32.8 ± 8.77	32.5 ± 8.01	35.9 ± 6.29	35.2 ± 7.17
Energy from carbohydrates (%)	50.4 ± 10.0	49.8 ± 9.90	46.0 ± 6.52	46.2 ± 9.34
Catholic University				
Energy (kcal)	1701 ± 358	1727 ± 560	1831 ± 339	1864 ± 587
Proteins (g)	65.8 ± 23.8	65.0 ± 20.9	100.4 ± 35.4	87.9 ± 24.6
Fats (g)	70.1 ± 23.8	54.2 ± 20.6	91.5 ± 41.3	82.5 ± 40.2
Carbohydrates (g)	240 ± 66.7	216 ± 83.8	277 ± 78.2	220 ± 101
Energy from proteins (%)	14.6 ± 3.37	17.1 ± 3.88	17.7 ± 2.26	18.8 ± 3.33
Energy from fats (%)	35.4 ± 8.56	31.3 ± 8.06	35.6 ± 8.89	37.7 ± 10.9
Energy from carbohydrates (%)	50.0 ± 8.64	51.6 ± 9.46	46.7 ± 9.62	43.5 ± 10.4

The mean level of zinc in female diets ranged from 5.64 mg/person/ day to 9.88 mg/person/ day, whereas in male diets – 7.52 mg/person/day – 18.23 mg/person/day. It should be stressed, however, that the intake values calculated are generally statistically significantly higher compared to real levels of the element in daily food rations determined using the chemical analysis method. Similar regularities were demonstrated by Lebiedzińska et. al [8]. The zinc intake in relation to the recommended dietary allowance (RDA) is found satisfactory only amongst female students of the Medical University and University of Life Science in 2009; all the remaining diets provide on average 71–81% of RDA. The intake of zinc is more favourable among male students as the RDA of 11 mg/ person/day is substantially exceeded or met in 80–90%. The exception are the dietary rations of male students of the Catholic University in 2010 – less than 70% of RDA, which is likely to be associated with an extremely low energy value of those diets and a relative low number of them (14). Our findings are similar to the results from other centres, e.g. Warsaw, Gdańsk, Białystok, or Poznań [1, 2, 6, 8, ,11]. The intake of manganese ranges on average from 3.03 mg to 5.71 mg in female diets and 3.64 mg – 7.01 mg in male diets. However, in the case of this element, compared to zinc, there is no explicit dependence as analytical results are similar to calculated ones or even higher; nevertheless,

the intake of manganese is generally lower in females compared to males due to the higher intake of food products and a significantly higher energy of food rations. It should be emphasized that this last parameter is positively correlated with the intake of a substantial number of mineral components. From the dietary point of view, the level of manganese in students` diets does not carry the risk of deficits or excesses since it is significantly higher than the adequate intake (AI**)** and markedly lower that 11 mg, i.e. the tolerable upper intake level (UL**)** [3]. The levels of copper in diets were 0.71 mg – 1.01 mg and 0.88 mg – 1.60 mg in females and males, respectively. The chemical analysis and calculation results for copper, similar to those for zinc, are lower, yet the differences are not statistically significant at α=0.05. Assuming that the chemical analysis results correspond better to real intake of this element by the respondents, it is found that the mean level of copper in all diets exceeds the estimated average requirement (EAR) for this age group. The assessment of copper levels in food rations of male students reveals that the mean values are higher than RDA (0.9 mg); only Catholic University male students consumed slightly lower amounts of copper than RDA in 2010. For female students, the analysis results ranged from 78.9% to 94.4% RDA; according to the calculations, RDA was on average met in all diets, except for Catholic University students in 2010. Comparable values of copper intake were found amongst students from Poznań, young sportsmen as well as 19-year-old individuals from Białystok; additionally, the studies mentioned confirm a higher intake of copper by males with the proportions similar to our findings [1, 2, 6]. Moreover, earlier studies concerning diets of Lublin students revealed proportions and intake of copper comparable to the present findings [9, 10]. The amounts of vitamin C in female students' diets was about 80 mg – 119 mg, whereas in diets of male students – about 67 mg – 85 mg. Interestingly, despite generally higher mass of their diets, male students consumed lower or similar amounts of vitamin C compared to female students, which undoubtedly proves a relatively low intake of vegetables and fruit. Nevertheless, the intake of vitamin C should be considered satisfactory, especially amongst female students as all of them consume on average more than 100% of RDA; for male students these values are usually higher than EAR, except for Medical University students in 2010 and Catholic University students in 2009. Unfortunately, all mean values of vitamin C intake amongst male students are lower that RDA – 90 mg. The results of the WOBASZ study (a multicentre nationwide study of the Polish population's health) involving over 3 thousand individuals of both sexes show similar intakes of vitamin C (about 80 mg); the youths from Białystok, young sportsmen and students from Poznań consumed lower or much lower amounts of this antioxidant [1, 2, 6, 15]. The important antioxidants are phenol compounds found in food products in various forms, which in our study were determined as total phenols and expressed as the gallic acid equivalents. In general, the diets of female students were found to contain higher amounts of phenol compounds ranging from 452 to 822 mg, compared to 472–659 mg in male diets; only in 2009, the diets of male students from the University of Life Science contained on average 1090 mg of polyphenols. This tendency is in agreement with the intake of vitamin C and confirms a low intake of vegetables, fruit, and tea being the main sources of phenol compounds of antioxidative properties. A similar regularity was demonstrated by Regulska et al., i.e. higher intake of antioxidants by females; and although the study focused on flavonoids, their intake was significantly higher in the group of women and their main source of flavonols and flavan-3-ols was tea [4].

Table 2. Zinc, manganese and copper intake with students' diets in 2009 and 2010

Diet parameters	Females		Males	
	Calculation	Analysis	Calculation	Analysis
2009				
Medical University				
Zinc (mg)	9.17 ± 3.54 3.06 – 21.63	8.25 ± 3.18 2.75 – 19.46	14.51 ± 6.01 4.39 – 28.93	12.77 ± 5.29 3.86 – 25.46
Manganese (mg)	5.00 ± 1.87 1.48 – 9.47	5.27 ± 1.97 1.56 – 10.08	6.00 ± 2.76 0.95 – 14.05	3.64 ± 2.02 0.88 – 8.35
Copper (mg)	0.98 ± 0.38 0.35 – 2.48	0.85 ± 0.33 0.31 – 2.15	1.44 ± 0.63 0.45 – 3.04	1.12 ± 0.49 0.35 – 2.36
University of Natural Sciences				
Zinc (mg)	9.88 ± 3.81 2.65 – 21.09	8.83 ± 3.40 2.37 – 18.85	18.23 ± 7.17 7.37 – 32.69	13.85 ± 5.44 5.60 – 24.83
Manganese (mg)	4.50 ± 1.59 1.13 – 8.23	5.71 ± 2.02 1.44 – 10.44	7.01 ± 2.62 2.98 – 11.94	5.96 ± 2.23 2.54 – 10.15
Copper (mg)	0.99 ± 0.37 0.33 – 2.13	0.82 ± 0.30 0.27 – 1.76	1.60 ± 0.84 0.65 – 4.23	1.52 ± 0.79 0.62 – 4.02
Catholic University				
Zinc (mg)	8.46 ± 2.56 4.59 – 13.85	6.39 ± 1.93 3.47 – 10.46	12.42 ± 4.70 6.39 – 20.02	9.85 ± 3.80 5.12 – 17.78
Manganese (mg)	3.33 ± 1.27 1.49 – 6.64	3.12 ± 1.19 1.40 – 6.23	4.26 ± 1.33 2.45 – 6.54	4.85 ± 1.52 2.79 – 7.45
Copper (mg)	1.01 ± 0.25 0.56 – 1.48	0.78 ± 0.20 0.43 – 1.14	1.13 ± 0.33 0.78 – 1.80	0.93 ± 0.27 0.64 – 1.48
2010				
Medical University				
Zinc (mg)	8.65 ± 2.34 3.99 – 16.10	6.46 ± 1.89 2.98 – 14.59	13.43 ± 5.79 6.18 – 35.80	8.77 ± 4.30 4.04 – 27.42
Manganese (mg)	4.58 ± 1.54 1.82 – 9.22	3.25 ± 1.09 1.35 – 6.72	6.77 ± 2.76 0.95 – 16.96	3.64 ± 2.02 0.88 – 8.35
Copper (mg)	0.92 ± 0.32 0.35 – 2.03	0.75 ± 0.26 0.27 – 1.57	1.27 ± 0.47 0.67 – 2.29	1.03 ± 0.42 0.54 – 2.11
University of Natural Sciences				
Zinc (mg)	8.33 ± 3.24 2.37 – 19.60	5.64 ± 2.39 1.98 – 17.38	11.89 ± 5.24 3.74 – 24.35	9.85 ± 3.91 4.45 – 18.55
Manganese (mg)	3.99 ± 1.57 0.64 – 7.95	3.28 ± 1.35 0.53 – 6.95	5.40 ± 2.63 0.66 – 10.45	3.95 ± 2.01 0.48 – 8.23
Copper (mg)	0.91 ± 0.42 0.27 – 2.40	0.71 ± 0.37 0.21 – 2.27	1.12 ± 0.50 0.20 – 1.67	1.02 ± 0.45 0.17 – 1.64
Catholic University				
Zinc (mg)	7.76 ± 2.84 2.15 – 14.83	6.07 ± 2.30 1.68 – 12.89	10.42 ± 3.18 4.27 – 16.59	7.52 ± 2.26 3.08 – 12.25
Manganese (mg)	4.26 ± 1.68 0.81 – 8.55	3.03 ± 1.24 0.68 – 7.28	4.29 ± 1.80 2.17– 8.30	4.04 ± 1.74 2.04 – 8.14
Copper (mg)	0.86 ± 0.43 0.15 – 2.29	0.75 ± 0.38 0.13 – 2.11	1.03 ± 0.55 0.38 – 2.60	0.88 ± 0.47 0.32 – 2.11

Table 3. Vitamin C and polyphenols level in students' diets in 2009 and 2010

Diet parameters	Females		Males	
	2009	2010	2009	2010
Medical University				
Vitamin C (mg)	93.4 ± 73.4 0 - 357	119 ± 102 8.46 - 637	85.0 ± 62.8 1.73 - 279	73.4 ± 74.1 0.00 - 338
Polyphenols* in whole diet	822± 153	590 ± 100	659± 45.6	588 ± 74.3
in 1g diet	0.38 ± 0.07	0.31 ± 0.05	0.28±0.02	0.26 ± 0.03
University of Natural Sciences				
Vitamin C (mg)	88.6 ± 75.9 0.32 - 394	79.9 ± 74.2 0.51 - 382	81.4 ± 88.1 2.46 - 328	81.0 ± 75.3 16.1 - 281
Polyphenols* in whole diet	793± 161	452 ± 113	1090± 100	472 ± 31.0
in 1g diet	0.40 ± 0.08	0.28 ± 0.07	0.45±0.04	0.22 ± 0.01
Catholic University				
Vitamin C (mg)	92.1 ± 66.9 5.00 - 247	81.5 ± 64.1 3.30 - 253	66.6 ± 45.8 13.0 - 154	82.0 ± 119 9.60 - 514
Polyphenols* in whole diet	746± 37.5	497 ± 51.2	633± 157	473 ± 49.9
in 1g diet	0.44 ± 0.02	0.28 ± 0.03	0.35±0.09	0.25± 0.03

* As an equivalent of gallic acid

CONCLUSIONS

In the majority of cases, the results concerning the intake of mineral components are not statistically significantly different from the calculations based on national database and DIETETYK software and may be used for quantitative evaluation of their intake. Students make dietary mistakes; their diets require correction of energy intake and reduction in dietary fats. The intake of mineral components poses no significant health-related risks. The analysis of intake of vitamin C and polyphenol antioxidants demonstrates that the intake of vegetables, fruit and tea should be increased in the group of male students. Due to the relevant role of dietary antioxidants, further studies monitoring their intake should be carried out. Their results may be useful for modifications of dietary habits and prevention of civilization diseases.

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SUMMARY

In 2009 and 2010, based on dietary recall, duplicates of daily food rations of 536 randomly chosen students from the Medical University of Lublin, University of Natural Sciences and Catholic University in Lublin were investigated. The levels of zinc, manganese and copper were determined by flame atomic spectrometry and estimated using the DIETETYK 2006 software. Moreover, the intake of vitamin C, total energy of diets, energy derived from proteins, fats and carbohydrates were calculated and the sum of phenol compounds determined using the Folin-Ciocalteu reagent. The findings demonstrate that dietary habits should be modified in relation to energy values of diets and the proportion of fats. The intake of mineral components does not carry the health risks in the light of present dietary reference intakes (DRI**)** values while the intake of vegetables, fruit and tea should be increased amongst male students as their diets contain too low amounts of antioxidants.

Keywords: diets, zinc, manganese, copper, vitamin C, polyphenols

STRESZCZENIE

W oparciu o metodę wywiadu żywieniowego analizie poddano w latach 2009 i 2010 duplikaty 536 losowo wybranych całodobowych racji pokarmowych studentów lubelskich uczelni: Uniwersytetu Medycznego, Uniwersytetu Przyrodniczego i Katolickiego Uniwersytetu Lubelskiego. Zawartość cynku, manganu i miedzi oznaczono techniką płomieniową atomowej spektometrii absorpcyjnej oraz oszacowano za pomocą programu DIETETYK 2006. Obliczono również pobranie witaminy C, całkowitą energię diet, udział energii z białka, tłuszczu i węglowodanów oraz oznaczono sumę związków fenolowych stosując odczynnik Folin-Ciocalteu. Stwierdzono, że konieczna jest modyfikacja sposobu odżywiania dotycząca wartości energetycznej diet oraz udziału w nich tłuszczu. Poziom pobrania składników mineralnych nie stwarza zagrożeń zdrowotnych w świetle aktualnych wartości DRI, natomiast wskazane byłoby wyższe spożycie warzyw, owoców i herbaty w grupie studentów ze względu na zbyt niską zawartość antyoksydantów w ich dietach.

Słowa kluczowe: diety, cynk, mangan, miedź, witamina C, polifenole