Chemical Composition of Vegetables and Diet-dependent Intensity of Caries in Residents of Chervonograd (Ukraine) and Kraśnik (Poland)

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Research

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Abstract

Background

Nutrition is one of the major determinants of human health. Consuming plant foods provides not only nutrients but also bioactive substances that reduce disease. The health of the oral cavity is determined by the quality of food, including vegetable food.

Objective

To study the effects of macro and microelements in vegetables on the status of mineralised dental tissues in relation to the hygiene and nutritional habits in 15-year-old adolescents living in Lublin Province and Lviv Oblast.

Methods

The chemical composition of plants was assessed (macro and microelements) of carrots and potatoes, vegetables consumed by 15-year-old inhabitants of Poland and Ukraine. The status of mineralised dental tissues was assessed based on caries severity expressed by the mean D3MFT number and the SIC index value. Another part of the study was a socio-medical survey focused on assessment of patients' eating habits.The respondents answered questions about the frequency of consumption of fruit and vegetables and fruit juices.

Results

The chemical composition of plants depended on the species and place of cultivation. The present study showed higher caries frequency in the group of the 15-year-olds living in Kraśnik, i.e. 88% vs. 75% in the group from Chervonograd. The intensity of caries measured by the mean D3MFT value in the 15-year-old teenagers from Chervonograd who declared everyday consumption of fresh vegetables and fruit was 3.77, and from Krasnik 5.17.

Conclusion

The present results show that carrots are a good source of microelements for humans, whereas potatoes provide potassium and calcium. The impact of the frequency of consuming plant products on the health of the oral cavity, which depended on the place of youth research.

Background

Vegetables and fruit are an important element of human diet and a determinant of human health playing a role in prevention of many diseases. Plant products provide the organism with crucial nutrients, e.g. vitamins, carbohydrates, protein, fibre, and bioactive compounds. The most important groups of phytochemicals are phenolics, alkaloids, organosulphur compounds, phytosterols, and carotenoids (1). Although they are regarded as non-nutritive, these substances serve an important special function. Their impact on the human body consists in inhibition of inflammatory processes, stimulation of the enzymatic and cardiovascular systems, and antimicrobial activity (2, 3). Products of plant origin are also a valuable source of micro- and macroelements, in particular potassium, phosphorus, calcium, magnesium, iron, zinc, copper, manganese, and selenium. An insufficient supply of these compounds may be the main cause of periodontal diseases, which affect up to 90% of the world's population (4). Tea, raisins, and cranberries are regarded as functional foods improving oral health (5). As reported by Sierpińska et al.(6), magnesium phosphate and hydroxyapatite are necessary for bone structure, while zinc and copper ensure flexibility and integrity of tissues. An adequate supply of zinc in the organism can reduce enamel demineralisation, and the optimal level of copper limits enamel erosion in an acidic environment. A diet rich in vegetables, not only yellow and green ones, and consumption of high-fibre foods reduce the risk of early tooth loss (7). Taking into account the number of diet-related diseases, the Food and Nutrition Institute published a new Food Pyramid in 2016 with vegetables and fruit at its base and recommendations that the former should be consumed in larger quantities (8). As reported by Murawska (9), fruit should be eaten 2–3 times a day and vegetables even twice as often. According to WHO, adults should consume 400 g of these products daily (10); however, the consumption of fresh fruit and vegetables (excluding potatoes and juices) in Poland does not exceed 250 g (11). With its content of minerals, especially calcium and phosphorus, plant food appears to have an important beneficial effect on oral health. However, a diet rich in vegetables and fruit, which contain acids, may contribute to dental erosion, as confirmed in the case of subjects following a vegetarian diet (12). Athletes are especially exposed to enamel erosion since they consume increased amounts of fruit (especially apples) and vegetables and drink beverages with high erosive potential (juices, sparkling vitamin preparations) (13). As shown by Zimmer et al. (14), apple and orange juices have five-fold higher erosive potential than Coca Cola Light.

The aim of the study was to assess the potential impact of macro- and micronutrients contained in vegetables and fruit on the status of mineralised dental tissues in relation to the hygiene and nutritional habits in 15-year-old adolescents living in randomly selected localities in Lublin Province and Lviv Oblast.

Methods

Analysis of plant material

The analyses of the plant material were carried out in Chervonograd and Kraśnik, which were randomly divided into four areas. In each area, four farms were selected to provide vegetables for the analysis, i.e. *Daucus carota* L. and *Solanum tuberosum* L., and teenagers from these areas were chosen for the examinations. The plant material was dried and ground. The dry samples were burnt at a temperature of 450 °C. After cooling, the ash was treated with diluted hydrochloric acid in a ratio of 1:2. The content of P, K, Ca, Mg, Mn, Zn, Fe, and Cu was determined in the extract. The content of K, Ca, Mg, and trace elements was determined with the ASA atomic absorption spectrophotometry method (Analyst 300 Perkin Elmer). Phosphorus was determined colorimetrically using ammonium vanadomolybdate. The results of the plant material analyses were subjected to the statistically analysis of variance. The least significant difference (LSD) was determined based on Tukey's test at the significance level $\alpha = 0.05$.

Clinical examination

The clinical examination involved teenagers aged 15 (index age group adopted by WHO) attending schools in Chervonograd (Lviv Oblast, Ukraine) and in Kraśnik (Lublin Province, Poland). The investigated group of 110 subjects comprised 60 males and 50 females. Three subjects did not fully meet the conditions of the socio-medical examination.

The clinical examination was conducted in standardised conditions with the use of disposable dental kits in compliance with all principles of sterility and non-invasiveness. The examinations were performed in doctor and nurse offices.

The examinations were conducted with the use of a dental lamp, a mirror, and a periodontal probe and the data were recorded on anonymous examination sheets/cards labelled with code numbers. The clinical assessment of the oral health in the subjects was carried out in accordance with the WHO recommendations and criteria proposed by this organisation (15). The examiners underwent training combined with the calibration process and determination of the magnitude of error. Cohen's kappa coefficient of agreement between the results of the clinical examination was 0.97. The credibility of the assessments was verified by re-examination of every tenth teenager. The status of mineralised dental tissues was assessed based on caries severity expressed by the mean D3MFT number and the SIC index value.

Socio-medical survey

Another part of the study was a socio-medical survey focused on assessment of patients' eating habits. The questions, adjusted to the age of the respondents, were part of questionnaires labelled with the same code numbers as those on the clinical examination cards. The respondents answered questions about the frequency of consumption of fruit and vegetables and fruit juices.

The results were analysed statistically. The database was constructed and statistical analysis was carried out with the use of Statistica 9.1 computer software (StatSoft, Poland).

Results

Plant material

The samples of vegetables collected for the analysis contained varied contents of macronutrients (Table 1). Their concentration depended on the study area and the species. The phosphorus content in dry matter was at the level of 5.00 $g \cdot kg^{-1}$ d.w. in the carrot roots but was two-fold lower in the potato tubers. It was also found that the content of this element in the vegetables from Chervonograd was lower, in the case of potatoes by as much as 39%, than in the plants cultivated in Kraśnik. There were significant differences in the potassium content between the plants grown in Poland and Ukraine. The vegetables from Kraśnik were characterised by a higher concentration of this element. Regardless of the study area, the potatoes had higher content of this component. Both the study area and the species had an impact on the concentration of calcium and magnesium in the plants. Higher levels of calcium were recorded in the potato tubers (4.30 $g \cdot kg^{-1}$ d.w.) than in the carrot roots. An inverse correlation was noted for the content of magnesium. The concentration of both these nutrients was lower in the plants cultivated in Chervonograd.

Table 1

Content of macroelements ($g \cdot kg^{-1}$) in dry matter of plants

Plant species (A)	Place of research (B)	P	K	Ca	Mg
Carrot	Kraśnik	5.20	22.3	2.30	1.50
	Chervonograd	4.90	15.5	1.90	1.20
Potato	Kraśnik	3.10	20.6	4.50	1.11
	Chervonograd	1.90	20.0	4.10	0.90
Mean for A	Carrot	5.00	18.9	2.10	1.30
	Potato	2.50	20.3	4.30	1.00
Mean for B	Kraśnik	4.20	21.4	3.40	1.30
	Chervonograd	3.40	17.7	3.00	1.11
Total average		3.80	19.6	3.20	1.20
LSD 0,05		0.20	n.s	1.40	0.10
A		0.20	2.10	1.40	0.10
B		0.30	4.30	n.s	n.s
A x B		0.52	2.03	2.30	1.50
n.s. - no statistical differences					

The content of microelements presented in Table 2 varied depending on the species and the cultivation area. Plants grown in Ukraine exhibited a lower concentration of manganese, zinc, iron, and copper. The comparison of both species showed higher levels of these elements in the dry matter of the carrot roots, especially in the case of iron.

Table 2

Content of microelements (mg·kg^{-1}) in dry matter of plants

Plant species (A)	Place of research (B)	Mn	Zn	Fe	Cu
Carrot	Kraśnik	7.10	19.26	48.86	3.25
	Chervonograd	6.19	18.83	40.70	3.14
Potato	Kraśnik	4.13	10.86	21.73	2.39
	Chervonograd	4.09	10.46	19.56	2.19
Mean for A	Carrot	6.64	19.05	44.78	3.19
	Potato	4.11	10.66	20.65	2.29
Mean for B	Kraśnik	5.62	15.06	35.30	2.82
	Chervonograd	5.14	14.65	30.13	2.66
Total average		5.38	10.48	32.71	2.74
LSD 0,05		0.19	0.39	1.61	0.05
A		0.19	0.38	1.62	0.06
B		0.38	n.s.	3.18	n.s.
A x B		Mn	Zn	Fe	Cu
n.s. - no statistical differences					

Clinical examinations

In total, 110 inhabitants of Kraśnik (n-47) and Chervonograd (n-60) aged 15 were qualified for the analysis of the study results (three questionnaires were incomplete and the clinical examination was not taken into account in the statistical analysis of the results). The secondary school students from Chervonograd were represented by 45% of girls (n – 27) and 55% of boys (n – 33). The group from Kraśnik comprised 24 boys (48%) and 23 girls (46%). The data are presented in Table 3.

Table 3
Number of the 15-year-olds from Chervonograd and Kraśnik in relation to the sex

Sex		**Chervonograd**	**Kraśnik**
Girls	N	27	23
	%	45.00%	46.00%
Boys	N	33	24
	%	55.00%	48.00%
No data	N	0	3
	%	0.00%	6.00%
Total		60	50

The frequency of dental caries was 75% in the subjects from Chervonograd and 88% in those from Kraśnik. This difference was statistically insignificant ($p = 0.138$). There were also no statistically significant differences in the frequency of caries between the sexes. Its prevalence was 78.79% in the 15-year-old boys from Chervonograd and 95.83% of those living in Kraśnik ($p = 0.149$). These values in the group of girls were 70.37% and 86.96%, respectively ($p = 0.285$). The value of the caries frequency index is presented in Table 4. The mean values of the D3MFT number in the group of the 15-year-olds and its components D3T, MT, FT are presented in Table 5.

Table 4
Caries frequency in the 15-year-olds from Chervonograd and Kraśnik in relation to the sex

	Chervonograd	**Kraśnik**	**Chi^2, p**
Total	75.00%	88.00%	$Chi^2 = 2.202$ $p = 0.138$
Girls	70.37%	86.96%	$Chi^2 = 1.142$ $p = 0.285$
Boys	78.79%	95.83%	$Chi^2 = 2.082$ $p = 0.149$

Table 5
Mean values of the D3MFT number and its components in the 15-year-olds from Chervonograd and Kraśnik

	Place of living	Mean	Standard deviation	Min.	Max.	Lower quartile	Median	Upper quartile	Statistical analysis
D3T	Chervonograd	1.78	1.00	0	15	0.00	3.00	2.60	Z = 1.191
	Kraśnik	1.12	0.50	0	8	0.00	2.00	1.70	p = 0.233
MT	Chervonograd	0.08	0.00	0	2	0.00	0.00	0.33	Z = -0.287
	Kraśnik	0.12	0.00	0	2	0.00	0.00	0.44	p = 0.774
FT	Chervonograd	2.15	1.00	0	12	0.00	3.50	2.61	Z = -1.263
	Kraśnik	2.66	2.00	0	11	0.00	4.00	2.61	p = 0.207
D3MFT	Chervonograd	4.02	3.00	0	16	0.50	6.00	3.86	Z = -0.233
	Kraśnik	3.90	3.50	0	13	1.00	5.00	3.16	p = 0.816

The intensity of caries expressed by the D3MFT number in the analysed group was 4.02 in the 15-year-olds from Ukraine and 3.90 in the group from Poland.

The mean D3T value was 1.78 in the teenagers from Chervonograd and 1.12 in the young people from Kraśnik. The mean MT value was 0.08 and 0.12, respectively, and the value of the FT number was 2.15 and 2.66, respectively. These differences were not statistically significant.

Tables 6 and 7 show the mean values of the D3MFT number and its components in the group of 15-year-olds living in the Lviv and Lublin regions, taking into account the sex of the respondents. The average D3MFT value was 4.04 in the group of Ukrainian girls 3.87 and in the group of the Polish female teenagers. In turn, in the male adolescents, the mean D3MFT value was 4.00 in the Ukrainian group and 4.33 in the Polish group. These differences were not statistically significant (p = 0.852 and p = 0.520, respectively). Similarly, there were no statistically significant differences between the values of the D3T, MT, and FT components.

Table 6
Mean values of the D3MFT number and its components in the examined 15-year-old girls from Lviv Oblast and Lublin Province

	Place of living	Mean	Standard deviation	Min.	Max.	Lower quartile	Median	Upper quartile	Statistical analysis
D3T	Chervonograd	2.04	1.00	0	15	0.00	3.00	3.09	Z = 1.869
	Kraśnik	0.65	0.00	0	3	0.00	1.00	0.98	p = 0.062
MT	Chervonograd	0.11	0.00	0	2	0.00	0.00	0.42	Z = 0.4028
	Kraśnik	0.09	0.00	0	2	0.00	0.00	0.42	p = 0.688
FT	Chervonograd	1.89	1.00	0	11	0.00	3.00	2.65	Z = -1.915
	Kraśnik	3.13	3.00	0	11	0.00	5.00	2.82	p = 0.056
D3MFT	Chervonograd	4.04	3.00	0	15	0.00	6.00	4.07	Z = -0.187
	Kraśnik	3.87	3.00	0	11	1.00	7.00	3.25	p = 0.852

Table 7
Mean values of the D3MFT number and its components in the examined 15-year-old boys from Lviv Oblast and Lublin Province

	Place of living	Mean	Standard deviation	Min.	Max.	Lower quartile	Median	Upper quartile	Statistical analysis
D3T	Chervonograd	1.58	1.00	0	7	0.00	2.00	2.14	*Z* = -0.591
	Kraśnik	1.71	1.00	0	8	0.00	3.00	2.12	*p* = 0.555
MT	Chervonograd	0.06	0.00	0	1	0.00	0.00	0.24	*Z* = -0.857
	Kraśnik	0.17	0.00	0	2	0.00	0.00	0.48	*p* = 0.391
FT	Chervonograd	2.36	2.00	0	12	0.00	4.00	2.60	*Z* = -0.272
	Kraśnik	2.46	1.50	0	9	0.00	4.00	2.45	*p* = 0.785
D3MFT	Chervonograd	4.00	4.00	0	16	1.00	6.00	3.73	*Z* = -0.644
	Kraśnik	4.33	4.00	0	13	2.00	5.50	3.09	*p* = 0.520

The value of the SIC index was 8.24 in the students from Chervonograd (n – 21) and 7.33 in the group from Kraśnik (n – 18). This difference was not statistically significant (p = 0.287). The data are presented in Table 8.

Table 8
SIC value in the examined 15-year-olds from Lviv Oblast and Lublin Province

	Place of living	N	Mean	Standard deviation	Min.	Max.	Lower quartile	Median	Upper quartile	Statistical analysis
SIC	Chervonograd	21	8.24	7.00	6	16	6.00	9.00	3.05	Z = 1.064
	Kraśnik	18	7.33	7.00	5	13	5.00	9.00	2.35	*p* = 0.287

The intensity of caries measured by the mean D3MFT value in the 15-year-old teenagers from Chervonograd who declared everyday consumption of fresh vegetables and fruit was 3.77 (Table 9). In turn, the caries intensity in the group of respondents who ate these products less frequently (every 2–3 days or once a week) was 4.65. This difference was not statistically significant (p = 0.470). No statistically significant differences were found between the mean values of D3T (p = 0.628), MT (p = 0.940), and FT (p = 0.839).

Table 9
Mean values of the D3MFT number and its components in relation to the eating habits declared by the examined 15-year-olds from Chervonograd

	Frequency of consumption of fruit and vegetables	Mean	Standard deviation	Min.	Max.	Lower quartile	Median	Upper quartile	Statistical analysis
D3T	every day	1.53	1.0	0.00	7.00	0.00	3.00	1.93	$Z = -0.484$
	less often	2.41	1.0	0.00	15.00	0.00	3.00	3.81	$p = 0.628$
MT	every day	0.07	0.0	0.00	1.00	0.00	0.00	0.26	$Z = 0.076$
	less often	0.12	0.0	0.00	2.00	0.00	0.00	0.49	$p = 0.940$
FT	every day	2.16	1.0	0.00	12.00	0.00	3.00	2.74	$Z = -0.203$
	less often	2.12	1.0	0.00	7.00	0.00	4.00	2.32	$p = 0.839$
D3MFT	every day	3.77	3.0	0.00	16.00	1.00	6.00	3.68	$Z = -0.722$
	less often	4.65	6.0	0.00	15.00	0.00	7.00	4.31	$p = 0.470$

The caries intensity expressed by the mean D3MFT value in the 15-year-old adolescents living in Kraśnik and consuming fresh vegetables and fruit every day was 5.17 (Table 10), whereas a lower value of this parameter, i.e. 3.19, was calculated in the group declaring less frequent consumption of such foods. This difference was not statistically significant (p = 0.086). In turn, there were statistically significant differences between the mean D3T values, i.e. 1.78 in the group declaring everyday consumption of vegetables and 0.75 in the group of 15-year-olds that eat vegetables occasionally (p = 0.007).

Table 10
Mean values of the D3MFT number and its components in relation to the eating habits declared by the examined 15-year-olds from Kraśnik

	Frequency of consumption of fruit and vegetables	Mean	Standard deviation	Min.	Max.	Lower quartile	Median	Upper quartile	Statistical analysis
D3T	every day	1.78	1.5	0.00	7.00	0.00	3.00	1.77	$Z = 2.705$
	less often	0.75	0.0	0.00	8.00	0.00	1.00	1.57	$p = 0.007$
MT	every day	0.28	0.0	0.00	2.00	0.00	0.00	0.67	$Z = 1.697$
	less often	0.03	0.0	0.00	1.00	0.00	0.00	0.18	$p = 0.090$
FT	every day	3.11	2.0	0.00	9.00	0.00	6.00	3.10	$Z = 0.606$
	less often	2.41	2.0	0.00	11.00	0.50	4.00	2.30	$p = 0.545$
D3MFT	every day	5.17	5.0	0.00	13.00	1.00	9.00	3.87	$Z = 1.719$
	less often	3.19	3.0	0.00	11.00	1.00	4.50	2.48	$p = 0.086$

The analysis of the mean D3MFT number (Speaman's rank correlation) showed lower values of this parameter and its components in respondents who declared less frequent consumption of fruit juices. However, these differences were not statistically significant, as shown in Table 11.

Table 11

Values of the D3MFT number and its components in relation to the frequency of drinking fruit juices declared by the examined 15-year-olds from Chervonograd and Kraśnik

Variable	Chervonograd		Kraśnik	
	R	p	R	p
D3T	0.092	0.487	-0.082	0.572
MT	0.007	0.958	-0.011	0.940
FT	0.029	0.828	-0.084	0.562
D3MFT	0.079	0.549	-0.122	0.398

To make the results as reliable as possible, the survey respondents were asked to indicate the frequency of brushing teeth, the use of fluoride toothpaste, and the use of additional oral hygiene products, such as dental floss. The obtained data are presented in Table 12.

Table 12

Frequency of brushing teeth and the use of fluoride toothpaste and additional oral hygiene products declared by the examined 15-year-olds from Chervonograd and Kraśnik

Variable			Chervonograd	Kraśnik	Statistical analysis
Frequency of brushing teeth	Once a day	N	14	13	$Chi^2 = 0.105$ $df = 1$
		%	23.33%	26.00%	$p = 0.746$
	2–3 times a day	N	46	37	
		%	76.76%	74.00%	
Way of brushing teeth	toothbrush and water	N	1	1	$Chi^2 = 0.344$
		%	1.67%	2.00%	$df = 1$
	toothbrush and toothpaste	N	59	49	$p = 0.558$
		%	98.33%	98.00%	
Additional oral hygiene products		N	38	41	$Chi^2 = 9.128$ $df = 1$
		%	63.33%	89.13%	$p = 0.003$
Use of fluoride toothpaste		N	27	42	$Chi^2 = 17.788$ $df = 1$
		%	46.55%	85.71%	$p < 0.001$

Brushing teeth 2–3 times a day was declared by 76% of the respondents from Lviv Oblast and 74% of the teenagers from Lublin Province. This difference was not statistically significant ($p = 0.746$). A vast majority of the respondents brushed their teeth with a brush and toothpaste (98.33% of the teenagers from Chervonograd and 98% from Kraśnik). Additional oral hygiene products were used by 89.13% of the students from Kraśnik and 63.33% from Chervonograd. The differences were statistically significant ($p = 0.003$). Toothpaste with fluoride was used by 85.71% of the 15-year-olds from Kraśnik (n-42) and 46.55% of those living in Chervonograd (n-27). The difference was statistically significant ($p < 0.001$).

Discussion

Minerals are essential for the function of every living organism, and their deficiency and excess lead to development of diet-related diseases. As evidenced in the latest research and available literature, human health depends on the consumption of foods of both animal and plant origin. The uptake and absorption of macro- and microelements by humans is influenced by interactions between these elements and between all compounds contained in food. For example, ascorbic acid has a positive effect on absorption of iron, which is especially important in a plant-based diet (16). In turn, calcium and phosphorus reduce the absorption of magnesium (17).

Chemical composition of vegetables

The presents study showed that the nutrient content varied depending on the cultivation site. Phosphorus is an important macronutrient in the human diet, as it is involved in mineralisation of bones and teeth and contributes to the maintenance of the acid-base balance in the organism. The intake of increased amounts of basic substances, such as phosphorus or calcium, reduces demineralisation and enhances mineralisation of enamel (18). The phosphorus content in the carrot analysed in the present study ranged from 4.90 to 5.20 $g \cdot kg^{-1}$ and was shown to be higher in the vegetables grown in Poland. Kwiatkowski et al. (19) reported a phosphorus level of 3.50 $g \cdot kg^{-1}$ in carrot roots, while Assunção et al. (20) determined a range of the element from 3.70 to 5.00 $g \cdot kg^{-1}$ depending on the variety. Potatoes are one of the most important sources of potassium for humans. Daily consumption of vegetables covers approx. 20% of the daily requirement for potassium, i.e. an important component reducing the risk of oral cancer (21, 22). A level of 22.50 $g\ K \cdot kg^{-1}$ in dry matter of potato tubers was reported by Wadas et al. (23). In the present study, the content of this element was approx. 20.03 $g\ K \cdot kg^{-1}$. The magnesium deficiency in the diet of people living in Poland is related to e.g. thermal processing of vegetables, addition of food preservatives, or water softening practices (24). The roots of the carrot grown in Kraśnik contained higher amounts of magnesium (1.30 $g \cdot kg^{-1}$) in comparison with the carrots from Ukraine. The analyses have demonstrated that carrots are a better source of magnesium for humans than potatoes. Calcium is the basic macroelement in the structure of bones and teeth. Its low absorption in the human organism results from e.g. the presence of a high level of fibre and phosphorus in the diet. Calcium consumption in Poland covers approx. 60% of the recommended values, with ca. 10% supplied by plant products (25). The level of calcium in the dry matter of potato tubers, i.e. 4.30 $g \cdot kg^{-1}$, was higher than the content of 1.29 $g \cdot kg^{-1}$ reported by Barczak and Nowak (26).

The present study results indicate large variations in the micronutrient content in the dry matter of potato and carrot tubers. As reported by Zarzecka (27), the manganese content in potatoes ranges from 5.98 to 15.00 mg $Mn \cdot kg^{-1}$ d. w. In the present study, the manganese content was significantly lower in the potato tubers (4.11 mg $Mn \cdot kg^{-1}$) than in the carrot roots (6.64 mg $Mn \cdot kg^{-1}$). Gąsiorowska et al. (28) reported the following content of elements in potato tubers: 4.39 mg·kg^{-1} Cu, 48.10 mg·kg^{-1} Fe, and 10.96 mg·kg^{-1} Zn. The levels determined in the potato tubers analysed in the present study, i.e. 2.29 mg·kg^{-1} Cu, 20.65 mg·kg^{-1} Fe, and 10.66 mg·kg^{-1} Zn, were substantially lower. The contents of copper, iron, and zinc in the carrot roots determined in the present study, i.e. 3.19 mg·kg^{-1} Cu, 40.76 mg·kg^{-1} Fe, and 19.05 mg·kg^{-1} Zn, were higher than those in the potato tubers and were comparable with the results reported by Wierzbowska et al. (29), who analysed the chemical composition of organic carrots.

Clinical examinations

The present study showed higher caries frequency in the group of the 15-year-olds living in Kraśnik, i.e. 88% vs. 75% in the group from Chervonograd. Investigations conducted by Bachanek et al. (30) in Ukraine in 2016 showed high caries frequency of 86.67%. Epidemiological research carried out in 2015 as part of the “Monitoring of the health of the oral cavity” programme reported 92.5% frequency of caries in the group of 15-year-old adolescents from Lublin Province (31). In their study, Olczak-Kowalczyk et al. (32) reported 94.0% caries frequency in 15-year-olds from the Polish population. Comparable values of the caries frequency index were recorded in young people living in the cities of Lithuania (92.9%) and in the northeast of Russia (91.8%) (33, 34). Lower values of the index were reported from Georgia – 77.9%, Iran – 75.5%, and Chile - in rural areas: 73.58%, in urban areas: 64.59% (35, 36, 37). Substantially lower caries frequency was observed in the United Arab Emirates – 65% (38).

Even lower values were recorded in Mexico and China, i.e. 48.6% and 24.4%, respectively (39, 40).

The lowest caries frequency of 21.9% was reported in investigations conducted in Malawi by Msyamboza et al. (41). Caries severity is estimated by calculation of the mean D3MFT number. The available literature shows a variety of average D3MFT values ranging from 0.45 in China (40), 0.56 in Macedonia (42), 2.1 in Iran (43), 3.51 in Georgia (44), to 5.03 in Chile (36).

The intensity of caries calculated from data provided by monitoring studies conducted in Poland was 6.12 in 2011 (45) and 5.75 ± 3.74 in 2018 (32). The values of the index shown in a study conducted by Bachanek et al. (46) in a group of 15-year-olds from Lviv Oblast (UA) were 5.58 in Lviv and 3.39 in Sosniłka. The present study revealed lower caries severity (3.90 in Kraśnik and 4.02 in Chervonograd) than the index value of 5.18 calculated by Smolar (47). Similarly high values of the D3MFT number were obtained in Lebanon: 5.44 (48) and Lithuania: 5.6 (33). The statistical analysis of the data obtained in the present study showed a higher value of the SIC index in the group from Chervonograd, i.e. 8.24, than that in the group from Kraśnik – 7.33. A substantially higher value (10.8) was revealed by monitoring studies conducted in a group of 15-year-old (45). Similar values were reported by Giacaman et al. (36) in Chile: 9.16 in rural residents and 8.51 in urban residents. Pondingo-Loyola et al. (39) recorded a substantially lower SIC value of 3.46 in a group of 15-year-olds from Mexico.

The present study showed that the vast majority of the examined teenagers brushed their teeth 2–3 times a day (PL- 74%, UA- 76.76%). A study carried out by Msyamboza et al. (41) conducted in a group of 15-year-old residents of Malawi showed that 35.20% of the examined subjects brushed their teeth twice a day. Similar observations were reported by Gupta et al. (49), who examined young people in South India. As shown by their study, 61.90% of the respondents brush teeth twice a day or more often, and over 90% of the surveyed population use toothbrushes and toothpaste, although 63.30% of them do not know whether their toothpaste contains fluorine.

Conclusion

Consumption of fruit and vegetables provides the organism with macro- and microelements that exert an effect on oral health. The present results show that carrots are a good source of microelements for humans, whereas potatoes provide potassium and calcium. However, the present study has shown that, despite their unquestionable health value, the content of acids in vegetables should be considered as a factor promoting enamel demineralisation.

Taking into account the effect of macro- and microelements supplied with food on oral health, the frequency of consumption of fruit and vegetables on the D3MFT index was analysed. The comparison of the survey data with the medical examinations of the population of Chervonograd and Kraśnik demonstrated that respondents that consumed vegetables and fruit every day had a higher value of the index, but only in the group from Kraśnik. These differences in the D3T values were confirmed statistically.

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Availability of data and materials

The data set supporting the conclusions of this article is included within the article

Consent for publication

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Competing interests

The authors declare that they have no competing interests.

Authors'contributions

Zbigniew Jarosz - first author, development of research, its coordination, supervised the analysis, responsible for the entire manuscript

Karolina Pitura – corresponding author, coordination and conducting of research, writing the manuscript, performing statistical analysis

Ewa Wolańska – Klimkiewicz - coordinating and conducting medical research, writing the manuscript

Barbara Hendzel - research participant, participation in writing the manuscript

Dariusz Samborski - participant of research, graphic design

Volodymyr Shybinsky - research coordinator in Ukraine

Teresa Bachanek - research participant, responsible for the research carried out

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Barbara Tymczyna – Borowicz - participation in writing the manuscript, participant of research

Each of the authors read and approved the manuscript

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