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Chromium content in selected convenience and fast foods in Poland

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Abstract

The chromium content in selected convenience and fast foods was determined. Samples were wet digested with HNO_3 (69%) in a microwave digestion system. Chromium was determined by graphite furnace atomic absorption spectroscopy (GF-AAS). The chromium content in convenience food ranged on average from 2.22 to 18.2 μg/100 g, in fast food from 3.76 to 28.6 μg/100 g, and in instant food from 0.34 to 4.75 μg/100 g.

Keywords: Chromium; Convenience food; Fast food; Instant food; Atomic absorption spectroscopy; Graphite furnace

1. Introduction

Chromium plays an essential role in maintaining normal carbohydrate, lipid and protein metabolism. Physiologically active Cr form – chromodulin intensifies insulin action by increasing the number of receptors on insulin-sensitive cells and by enhancing insulin receptor phosphorylation (Anderson, 1998). Chromium also improves glucose tolerance and lipid profile by increasing the level of high density lipoprotein cholesterol and decreasing total serum cholesterol (Anderson, 1997). The beneficial effects of this element on glucose and lipid metabolism have prompted investigations into the importance of Cr supplementation in the human diet (Lukaski, 1999). Chromium is usually presented in food as Cr (III) and its bioavailability depends on the chemical and physical properties of Cr compounds and complexes; its absorption from the gut is low ranging from 0.5% to 2% (Anderson & Kozlovsky, 1985).

The safe and adequate daily Cr intake in Poland is not known. The National Research Council (USA) tentatively established the Recommended Dietary Allowances (RDA) at 50–200 μg/day for adults (RDA, 1989). In 2001, the Food Nutrition Board of the National Academy of Science proposed the Adequate Daily Intake (ADI) at 20–35 μg for adults (Trumbo, Yates, Schlicker, & Poos, 2001). Because of the uncertainty regarding Cr intake in individual population groups, it is necessary to base the requirements of Cr in the RDA range.

Studies performed in Poland indicate that the daily dietary chromium intake in the elderly ranged from 36.2 to 58.7 μg (Czerwińska & Zadrużna, 2003) and in adults from 32 to 102 μg (Marzec, 1999). The estimated chromium intakes for adults living in different countries ranged from 22 to 240 μg/day (reviewed by Garcia, Cabrera, Lorenzo, Sanchez, & Lopez, 2001). Intakes of fewer than 50 μg/day of Cr with a well-balanced diet appears to be adequate and does not lead to the Cr deficiency symptoms, such as glucose intolerance. However, excessive and long-term intakes of processed food with a high sucrose concentration may enhance urine Cr losses (Anderson & Kozlovsky, 1985).

The assessment of the chromium daily intake requires the determination of the Cr levels in different kinds of foods. In Poland, Cr concentration was determined in some groups of food products including vegetables and fruits (Kocjan, Kot, & Ptasiński, 2002; Ręczajska, Jędrzejczak, & Szteke, 2005). However, there is no information on the Cr contents in convenience and fast foods. In many

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developed countries, convenience food has become popular in recent years because of its accessibility, economy and easy preparation. Convenience food includes processed food and prepared dishes designed for long shelf-life and short preparation time. This food must be produced from materials according to good technological practices (Boer, McCarthy, Cowan, & Ryan, 2004; Świderski, 2003).

The aim of this study was to determine the chromium contents in selected convenience food, instant products and fast food in Poland.

2. Materials and methods

Selected convenience food, instant products and fast food were purchased in 2005–2006 in domestic retail stores. Each kind of product, if possible, originated from different manufacturers. The collected samples were homogenized in a blender equipped with a plastic bowl and titanium blades to avoid sample contamination and then packed in polyethylene bags and stored below −20 °C prior to analysis. All plastic ware and glassware were cleaned by soaking overnight in 10% HNO_3 and then rinsed several times with deionized water to avoid contamination and analyte absorption.

One gram instant servings or 0.500 g of the rest of the investigated food were digested with 4–6 ml 69% HNO_3-(Baker Instra-Analyzed® Reagent, J.T. Baker) in the microwave digestion system Plazmatronika, based on the manufacturer's recommendation (Table 1). The blank digests were carried out in the same way. Three samples of each food product were analyzed in three replications. Sample preparation blanks were analyzed with each batch of 8 samples and all results were blank corrected. Cr concentration in the blank solutions was <3.5 μg/kg. After cooling, the digested solutions were diluted with deionized water to 10 ml.

A Perkin Elmer Model 1130 atomic absorption spectrometer equipped with a HGA-600 graphite furnace and an AS-40 autosampler was used for Cr quantification.

Table 1
The digestion conditions of the food samples in the microwaves digestion system

Food sample	HNO_3 (69%) volume (ml)	Time of dissolution (min)	Microwave power per sample (W)	Total processing time (min)
Pancakes, dumplings, croquets, hamburger, pizza, breaded chicken, instant products	6	8 2 10	20 50 100	20
Sauerkraut stew, white beans and meat in tomato sauce, beef tripe, stuffed cabbage, meat balls	4	5 5 9	70 130 200	19

Table 2
The operating conditions and instrumental parameters for chromium determination in foods by GF-AAS

Operating conditions	Temperature (°C)	Ramp time (s)	Hold time (s)
Dry	120	10	50
Dry	130	1	30
Ash	1600	1	30
Atomize	2500	0	5
Clean	2650	1	5

Instrumental parameters	
Gas	Argon (300 ml/min)
Wavelength	357.9 nm
Slit width	Low 0.7 nm
Lamp current	56 mA
Sample volume	20 μl
Matrix modifier volume	5 μl 1.2% $Mg(NO_3)_2$
Measurement mode	Peak height
Characteristic mass	3.3 pg

The experimentally established operating conditions and instrumental parameters were as summarized in Table 2.

All reagents were prepared using deionized water, with specific resistivity of 18.2 MΩ cm. The calibration working standard solutions were prepared from the chromium standard solution of 1000 ± 3 μg/ml (CPI International, USA) and 0.2% HNO_3 in the range of the Cr concentration from 1 to 15 μg/l. A 1.2% solution of $Mg(NO_3)_2$ was used as a matrix modifier.

The recovery of Cr obtained for selected spiked samples of food was: 96.7% in stuffed cabbage and 92.7% in tomato noodle soup. The accuracy and precision was also assessed by the determination of Cr in the certified reference material (CRM SLV Diet B), which was digested analogous to the food samples. The recovery of the certified Cr level in the CRM was 102%.

3. Results and discussion

The mean chromium concentrations in the selected convenience food, fast food and instant products analyzed in this study were as reported in Tables 3 and 4. Chromium contents in the prepared convenience food ranged from 2.22 to 18.2 μg/100 g (Table 3). The highest concentration of chromium was found in beef tripe (14.7, 18.2, 15.3 μg/100 g), and the lowest in pancakes filled with cottage cheese (8.04, 6.03, 8.82 μg/100 g). Chromium levels in fast food ranged from 3.76 μg/100 g for breaded chicken wings to 28.6 μg/100 g for pizza (Table 3).

Chromium contents in ready-to-eat instant food – calculated per serving – ranged from 0.34 to 4.04 μg/100 g in soups and from 1.22 to 4.75 μg/100 g in pasta with sauces (Table 4). The lowest concentration of Cr was characteristic for soup without noodles or croutons, i.e. red borsch.

The serving sizes were used to calculate how much Cr might be expected in a typical serving of the analyzed foods and to help identify those of the studied foods which might

Table 3
Cr contents in selected convenience food and in fast food (mean ± standard deviation)

Food sample	*n*	Cr (μg/100 g)	Weight of serving (g)	Cr (μg/serving)
Convenience food				
Pancakes filled with cottage cheese				
1[a]	5	8.04 ± 0.09	250	21.0
2	7	6.03 ± 0.38		15.1
3	7	8.82 ± 0.27		32.1
Dumplings filled with meat				
1	4	8.38 ± 0.22	300	25.1
2	6	14.3 ± 0.79		42.8
3	3	5.55 ± 0.43		16.7
Dumplings filled with potato and cottage cheese				
1	3	15.8 ± 0.73	300	47.4
2	7	6.84 ± 0.38		20.5
3	5	8.63 ± 0.39		25.9
Croquets with meat				
1	5	7.18 ± 0.62	230	16.5
2	6	12.7 ± 0.73		29.2
3	5	5.79 ± 0.60		13.3
Sauerkraut stewed with sausage and meat				
1	5	15.4 ± 1.57	300	46.1
2	6	8.42 ± 0.17		25.3
3	5	13.8 ± 0.54		41.5
White beans and meat in tomato sauce				
1	5	5.28 ± 0.86	350	18.5
2	9	2.22 ± 0.81		7.77
3	6	12.5 ± 0.51		43.6
Beef tripe				
1	6	14.7 ± 1.14	400	58.8
2	6	18.2 ± 0.37		73.0
3	3	15.3 ± 0.61		61.1
Cabbage stuffed with meat and rice				
1	5	8.77 ± 0.32	400	35.1
2	4	10.1 ± 1.15		40.4
3	5	2.73 ± 0.47		10.9
Meat balls				
1	6	4.28 ± 0.09	120	5.14
2	9	17.8 ± 0.32		21.4
3	6	13.1 ± 0.98		15.8
Fast food				
Hamburger with vegetables				
1	3	16.8 ± 0.20	300	50.5
2	3	17.2 ± 0.33		51.5
3	3	18.7 ± 0.86		56.0
Pizza				
1	6	24.0 ± 0.41	100	24.0
2	7	23.3 ± 0.41		23.3
3	4	28.6 ± 0.73		28.6
Breaded chicken breast				
1	4	3.87 ± 0.40	100	3.87
2	9	7.18 ± 0.65		7.18
3	5	7.74 ± 0.97		7.74
Breaded chicken wings				
1	6	5.09 ± 0.36	100	5.09
2	3	3.76 ± 0.17		3.76

n – number of sample.
[a] The next number of products represents other manufacturers.

Table 4
Cr contents in selected instant products (mean ± standard deviation)

Food sample	*n*	Cr (μg/100 g dry product)	Cr (μg/100 g ready-to-eat product)	Cr (μg/serving)[a]
Soups				
Red borsch				
1[b]	3	8.61 ± 0.40	0.45	1.12
2	3	7.02 ± 0.67	0.34	0.84
3	3	11.9 ± 0.34	0.62	1.54
Tomato noodle soup				
1	5	24.7 ± 0.52	2.08	5.19
2	5	15.2 ± 0.59	1.22	3.04
3	3	12.0 ± 0.37	1.92	4.81
4	3	12.3 ± 0.11	0.98	2.46
Chicken broth with noodles				
1	3	12.1 ± 0.14	0.57	1.44
2	3	15.4 ± 2.17	0.74	1.85
3	3	12.6 ± 2.84	1.01	2.52
4	5	21.2 ± 0.39	4.04	10.1
Mushroom soup with croutons				
1	6	7.79 ± 0.99	0.53	1.32
2	4	12.0 ± 0.28	0.82	2.05
3	3	17.7 ± 1.42	1.35	3.37
Cucumber soup with croutons				
1	4	10.1 ± 1.33	0.61	1.52
2	3	21.8 ± 1.06	1.30	3.26
Goulash noodle soup				
1	4	15.0 ± 0.17	1.02	2.54
2	5	19.2 ± 0.40	3.17	7.93
Pasta with hunter's sauce				
1	4	7.53 ± 0.85	1.50	3.76
2	4	15.5 ± 0.61	3.41	8.52
Pasta with mushroom sauce				
1	6	6.09 ± 0.61	1.22	3.04
2	3	21.5 ± 0.98	4.75	11.9
Pasta with Bolognese sauce				
1	3	13.0 ± 0.25	2.59	6.47
2	3	20.7 ± 0.97	4.56	11.4
Pasta with goulash sauce				
1	4	15.9 ± 0.93	3.17	7.94

n – number of samples.
[a] Serving of soup or ready-to-eat pasta was prepared by adding hot water to the dry product according to the manufacturer's recommendation (usually 200 or 400 ml of hot water).
[b] The next number of products represents other manufacturers.

be a significant source of this element based on a single portion. The highest Cr concentration in a serving of convenience food was in beef tripe (58.6–73.0 μg/serving), sauerkraut stewed with sausage and meat (25.3–46.1 μg/serving) and dumplings with potato and cottage cheese (20.5–47.4 μg/serving) (Table 3). The highest level of Cr in fast food was in a serving of hamburger (50.5–56.0 μg/serving) or pizza (23.3–28.6 μg/serving) (Table 3). Instant products contained lower amounts of chromium than convenience food and fast food. A serving of an instant food is likely to be a poor source of Cr (Table 4). Among instant

soups, the highest Cr contents were in tomato soup with noodles (2.46–5.19 μg/serving) or chicken broth soup with noodles (1.44–10.1 μg/serving). Among pastas, the highest Cr contents were in pasta with Bolognese (6.47–11.4 μg/serving) or mushroom sauce (3.04–11.9 μg/serving).

The food composition and regional differences of the food material sources have an impact on the Cr concentration in diets. Cr is mainly found in whole-grain products (50–360 μg/kg) (Bratakos, Lazos, & Bratakos, 2002), green vegetables (13–107 μg/kg) (Lendinez, Lorenzo, Cabrera, & Lopez, 2001), spices (390–1100 μg/kg) (Buliński & Błoniarz, 1996) or cocoa powder (1394 μg/kg) (Miller-Ihli, 1996). The concentration of chromium in vegetables, fruits and grain depends on the pH of soil, excessive usage of fertilizers, environmental contamination or seasonal changes (Lendinez et al., 2001). Chromium contents of diary products is relatively low: 28–32 μg/kg Cr in cottage cheese (Buliński et al., 1993); 20–65 μg/kg in skimmed milk (Lendinez et al., 2001) but their consumption is high, which makes their contribution to chromium intake significant.

The contents of Cr in the food analyzed in this study varied depending on the manufacturer (Tables 3 and 4). This might be the result of chromium contamination during processing, packaging and transporting. Stainless steel, which contains about 13–30% of the Cr used in food processing equipment, may contribute to the increase of Cr contents in diets (Miller-Ihli, 1996). Smart and Sherlock (1985) reported that canned fruit contained significantly higher levels of Cr than fresh fruits. They proposed that the elevated levels were the result of the extraction of chromium from the stainless steel cooling vats due to the presence of malic and citric acids in fruits. They also reported that the plastic materials used for food packaging may contribute to the Cr content of food through migration.

A well-balanced diet guarantees an optimal Cr absorption and utilization. Animal studies have shown that a high fat diet (Striffler, Polansky, & Anderson, 1998) and a low protein diet (Mertz & Roginski, 1969) had induced Cr deficiency. Studies have also reported that ascorbic and nicotinic acids promote Cr absorption in humans (Urberg & Zemmel, 1987). Nutritional analysis showed fast food to be high in fat, saturated fatty acids, and fructose and poor in fiber, vitamins and calcium (Isganatis & Lustig, 2005). Large portions of fast food, its excessive consumption paired with the sugar-sweetened soft drinks, may contribute to the decrease of Cr absorption. Foods high in sucrose or fructose negatively affect Cr status by enhancing this microelement with urine loss (Anderson, 1997).

In recent years, the changes of lifestyles in Poland, especially in the cities, have influenced food customs and induced the rise in the popularity of convenience food. According to the Kowalczuk survey (2004), Polish consumers choose convenience food mainly because of the lack of time for preparing meals traditionally. The consecutive conditions for choosing convenience food were: the comfort of use, long shelf-life, wide offer of products on the market, taste, economy and – lastly – their nutritional value. The research of public opinion in Poland conducted by PENTOR Institute (Raport Instytutu Pentor, 2005) showed that ready-to-eat products are consumed by 31.6% of respondents, and instant soups by 35.9%. These kinds of food are bought frequently by men living in cities at the ages of 15–44. A survey conducted by Zwierzyk (2005) showed that fast food is very popular in Poland among young people up to 25 years of age: 21% of young respondents ate fast food several times a week.

This study demonstrates that the selected products of convenience food and fast food in Poland may be an alternative source of Cr in comparison with the traditional meals especially for young, professional active people. For example, the consumption of one serving of beef tripe or hamburger with vegetables may be sufficient to meet the lowest estimated safe and adequate daily intake for Cr, i.e. 50 μg. The rest of the studied foods may constitute additional sources of this element in a daily food ration.

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