

# Heavy Metal Content of Potato Chips and Biscuits from Nagpur City, India

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**Abstract** Heavy metals composition of foods is of immense interest because of its essential or toxic nature. In view of this, we determined concentrations of select heavy metals from food items such as, potato chips and biscuits that were obtained from Nagpur City, India. The present study revealed preferred digestion method for different heavy metal recovery. The accumulation trend for Potato chips was in following order Fe > Al > Zn > Ni > Cu > Mn > Co > Cr > Pb and Cd, while for Biscuits it was Al > Fe > Zn > Ni > Mn > Co > Cr > Pb > Cu and Cd.

**Keywords** Heavy metals · Potato chips · Biscuits · Accumulation

Heavy metals composition of foods is of interest because of the essential or toxic nature. For example, iron, zinc, copper, chromium, cobalt, and manganese are essential while lead, cadmium, nickel and mercury are toxic at certain levels (Schroeder 1973; Somer 1974; Underwood 1971; WHO 1973; Onianwan et al. 1999). Chronic low-level intakes of heavy metals are known to have damaging effects on human beings, since there is no good mechanism for their elimination (Bahemuka et al. 1999). Metals such as lead, mercury, cadmium, and copper are cumulative poisons, which cause environmental hazards and are reported to be exceptionally toxic (Ellen et al. 1990). On the positive side, many metals have therapeutic applications and some of them are essential nutrients (Hammond

and Beliles 1980; Goyer 1995; NRC 1989; Moffat and Whittle 1999). Metals that are essential nutrients can also exert toxic action if the homeostatic mechanism maintaining their physiological limit is disrupted (NRC 1989; Moffat and Whittle 1999). Vegetables take up metals by absorbing them from contaminated soils, as well as from deposits on parts of the vegetables exposed to the air from polluted environments (Zurera et al. 1989; Bahemuka and Mubofu 1999).

On consumption of food in the diet, the trace metal contents of food are directly taken into the body (Tuzen et al. 2003; Soylak et al. 2004; Ferreira et al. 2004; Mendil et al. 2005). Potato chips and biscuits are common in our daily diet. Children also consume potato chips and biscuits in large amounts. Therefore the trace heavy metal ions content in potato chips and biscuits is important. For the determination of the trace heavy metal ions, ICP-AES is the current technique capable for simultaneous determination of over 70 elements in virtually any sample in less than 2 min (Settle 1997). For the ICP-AES determinations, the physical state of the sample analyzed has to be liquid. Because of this constraint, a digestion procedure is necessary prior to ICP-AES determinations of metals in food samples. Wet digestion is an important methodology for the digestion of the trace heavy metals in solid samples.

In the present work, the levels of zinc, lead, nickel, cadmium, cobalt, manganese, iron, chromium, aluminium and copper were determined in selected potato chips and biscuits by ICP-AES after wet digestion.

## Materials and Methods

All reagents used in present work were of analytical reagent grade unless otherwise stated. Double deionized

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water (Milli-Q, Milli-Pore 18.2 M $\Omega$ /cm resistivity) was used for all dilutions. H<sub>2</sub>SO<sub>4</sub>, HNO<sub>3</sub> and H<sub>2</sub>O<sub>2</sub> were of supra-pure quality (E. Merck). All the plastic and glassware were cleaned by soaking in dilute nitric acid (1 + 9) and were rinsed with distilled water prior to use. The standard solution of investigated metal ions for calibration procedure was prepared by diluting a stock solution of 1,000 mg/L of all the investigated elements supplied by E. Merck.

An atomic emission spectrometer with inductively coupled plasma excitation (ICP-AES), Jobin Yvon, France make, model JY-24 with a sequential mode of operation was used in the present study. The separating parameters for the investigated elements were set as recommended by the manufacturer.

Potato chips and biscuits of selected brands that were available locally were purchased for further processing. Wet digestion of potato chips and biscuits was performed using a mixture of HNO<sub>3</sub>:H<sub>2</sub>O<sub>2</sub> (8:4), HNO<sub>3</sub>:H<sub>2</sub>SO<sub>4</sub> (8:4) and HNO<sub>3</sub>:HCl (8:4) (12 mL for a 1.0 g sample) (Narin et al. 2005). This mixture was heated up to 130°C for 3 h after cooling 5 ml of distilled water was added to the sample and mixed. The residue was filtered through Whatmann filter paper No. 41. The sample was then diluted to 50 mL with distilled water. Blank digestions were also performed in the same way. The levels of analytes in the final solutions were determined by ICP-AES. All sample solutions were run in triplicates and were clear.

A recovery test of the total analytical procedure was carried out for some of the metals in selected samples by spiking analyzed samples with aliquots of metal standards and then reanalyzing the samples, after subjecting it to three different types of digestion methods mentioned above. Table 1 shows the digestion performance of the various wet digestions for the recovery of trace heavy

metal contents of the samples fortified with known amount of heavy metal.

## Results and Discussion

The mixture of HNO<sub>3</sub>:H<sub>2</sub>O<sub>2</sub> (8:4), HNO<sub>3</sub>:H<sub>2</sub>SO<sub>4</sub> (8:4) and HNO<sub>3</sub>:HCl (8:4) were applied to all the samples of potato chips and biscuits as well as to the spiked samples, which were then digested with wet digestion. Table 1 shows that the analytical results for analyte ions in spiked samples were within or near the certified values for different acid mixtures for wet digestion with some exceptions. Approximately, total time for the wet digestion was 4 h for a sample.

In general, the values of heavy metals recovered following the wet digestion method that involved three different acid mixtures (mentioned above) were >95%. The relative standard deviations were less than 1% for all the

**Table 2** Detection limits of ICP-AES

Element	Wavelength (nm)	Detection limit ( $\mu$ g/L)
Al	396.152	0.9
Cd	214.439	0.2
Co	238.892	0.4
Cr	267.716	0.5
Cu	327.395	0.9
Fe	238.204	0.3
Mg	279.55	0.05
Mg	279.8	1.5
Mn	257.61	0.1
Ni	231.6	0.7
Zn	213.86	0.2

**Table 1** Variations in recovery of each heavy metal from the selected sample (fortified with known amount of Heavy Metal Standard) and processed by different digestion techniques (n = 9)

Heavy metal	Digestion A (HNO <sub>3</sub> :H <sub>2</sub> O <sub>2</sub> ) Mean $\pm$ SD	Digestion B (HNO <sub>3</sub> :H <sub>2</sub> SO <sub>4</sub> ) Mean $\pm$ SD	Digestion C (HNO <sub>3</sub> :HCl) Mean $\pm$ SD	p
Zn	9.800 $\pm$ 0.020 (98.0)	9.9 $\pm$ 0.173 (99.0)	9.28 $\pm$ 0.020 (92.8)	<0.01
Pb	9.75 $\pm$ 0.010 (97.5)	9.72 $\pm$ 0.010 (96.3)	9.557 $\pm$ 0.055 (95.6)	<0.01
Ni	9.813 $\pm$ 0.012 (98.2)	9.860 $\pm$ 0.020 (98.6)	9.480 $\pm$ 0.020 (94.8)	<0.01
Cd	9.700 $\pm$ 0.030 (97.3)	9.920 $\pm$ 0.010 (99.2)	9.390 $\pm$ 0.010 (93.9)	<0.01
Co	9.690 $\pm$ 0.010 (96.9)	9.850 $\pm$ 0.020 (98.5)	9.520 $\pm$ 0.020 (95.2)	<0.01
Mn	9.807 $\pm$ 0.025 (98.0)	9.730 $\pm$ 0.010 (95.3)	9.673 $\pm$ 0.012 (96.8)	<0.01
Fe	9.580 $\pm$ 0.017 (95.9)	9.793 $\pm$ 0.006 (97.9)	9.430 $\pm$ 0.030 (97.3)	<0.01
Cr	9.620 $\pm$ 0.020 (97.2)	9.850 $\pm$ 0.050 (96.5)	9.240 $\pm$ 0.040 (92.4)	<0.01
Al	9.673 $\pm$ 0.012 (96.8)	9.860 $\pm$ 0.020 (93.6)	9.560 $\pm$ 0.060 (96.6)	<0.01
Cu	9.400 $\pm$ 0.010 (94.0)	9.760 $\pm$ 0.040 (94.6)	9.580 $\pm$ 0.020 (95.8)	<0.01

**Table 3** Variations in heavy metal concentrations ( $\mu\text{g/g}$ ) in different brands of potato chips (PC-1 to 5) and biscuits (BC-1 to 5) available in Nagpur City, India

Sr. No.	Sample	Properties	Zn	Pb	Ni	Cd	Co	Mn	Fe	Cr	Al	Cu
1	PC-1	Classic salted	0.800 $\pm$ 0.010	ND	3.296 $\pm$ 0.017	ND	ND	1.052 $\pm$ 0.111	16.7 $\pm$ 0.051	ND	4.1 $\pm$ 0.142	3.961 $\pm$ 0.108
2	PC-2	Salted	6.949 $\pm$ 0.031	ND	5.05 $\pm$ 0.002	ND	0.451 $\pm$ 0.002	0.599 $\pm$ 0.012	8.7 $\pm$ 0.048	ND	10.006 $\pm$ 0.093	2.199 $\pm$ 0.100
3	PC-3	Tomato tango	8.550 $\pm$ 0.011	ND	8.7 $\pm$ 0.015	ND	0.75 $\pm$ 0.002	2.199 $\pm$ 0.100	23.501 $\pm$ 0.053	ND	17.35 $\pm$ 0.024	1.05 $\pm$ 0.002
4	PC-4	Salted	3.297 $\pm$ 0.010	ND	3.05 $\pm$ 0.001	ND	1.05 $\pm$ 0.002	0.65 $\pm$ 0.023	9.401 $\pm$ 0.015	ND	17.25 $\pm$ 0.046	ND
5	PC-5	Salted	15.503 $\pm$ 0.016	ND	10.5 $\pm$ 0.023	ND	0.85 $\pm$ 0.004	0.499 $\pm$ 0.011	0.699 $\pm$ 0.015	0.75 $\pm$ 0.045	13.55 $\pm$ 0.054	4.699 $\pm$ 0.016
6	BC-1	Salted	ND	ND	8.5 $\pm$ 0.015	ND	1.25 $\pm$ 0.001	8.249 $\pm$ 0.046	31.6 $\pm$ 0.034	ND	37.068 $\pm$ 0.097	ND
7	BC-2	Sweet and salted	9.45 $\pm$ 0.017	ND	8.55 $\pm$ 0.061	ND	1.3 $\pm$ 0.024	2.053 $\pm$ 0.028	ND	0.499 $\pm$ 0.011	14.35 $\pm$ 0.047	ND
8	BC-3	Milk and honey	13.4 $\pm$ 0.015	0.08 $\pm$ 0.001	5.7 $\pm$ 0.015	ND	1.85 $\pm$ 0.002	3.45 $\pm$ 0.053	36.25 $\pm$ 0.050	ND	25.15 $\pm$ 0.051	ND
9	BC-4	Sweet	3.25 $\pm$ 0.018	ND	9.85 $\pm$ 0.038	ND	1.05 $\pm$ 0.002	7.95 $\pm$ 0.036	14.15 $\pm$ 0.050	0.55 $\pm$ 0.015	126.518 $\pm$ 0.032	ND
10	BC-5	Sweet	5.75 $\pm$ 0.003	0.13 $\pm$ 0.033	7.397 $\pm$ 0.012	ND	0.85 $\pm$ 0.004	2.396 $\pm$ 0.012	ND	1.6 $\pm$ 0.023	14.749 $\pm$ 0.052	ND

ND Not detectable

investigated elements. The comparison of wet digestion methods showed statistically significant differences ( $p < 0.01$ ) in recovery results (Table 1). The detection limit for each investigated analyte ion by ICP-AES is given in Table 2.

A randomly selected sample was fortified with known quantity of each heavy metal (10 ppm) and further processed with different digestion techniques (A, B and C). The value in parentheses represents the percentage of total quantity recovered for each heavy metal; the expected value was 10 ppm. Comparison of means following ANOVA revealed significant differences ( $p < 0.01$ ) between digestion methods and showed the best method for maximum recovery.

In all a total of ten samples (five of potato chips and five of biscuits) were processed to determine heavy metal concentrations following wet digestion method with the aid of three different types of acid mixtures, which were  $\text{HNO}_3\text{:H}_2\text{O}_2$  (8:4),  $\text{HNO}_3\text{:H}_2\text{SO}_4$  (8:4) and  $\text{HNO}_3\text{:HCl}$  (8:4) (12 mL for 1.0 g of sample), respectively. The heavy metals included zinc, lead, nickel, cadmium, cobalt, manganese, iron, chromium, aluminium and copper. The metal determinations were performed by ICP-AES. The results are presented in Table 3. The investigated element concentrations in the analyzed samples ranged from ND to 15.5  $\mu\text{g/g}$  for zinc, ND to 0.13  $\mu\text{g/g}$  for lead, 3.05 to 10.5  $\mu\text{g/g}$  for nickel, ND to 1.85  $\mu\text{g/g}$  for cobalt, 0.5 to 8.25  $\mu\text{g/g}$  for manganese, ND to 36.25  $\mu\text{g/g}$  for iron, ND to 1.6  $\mu\text{g/g}$  for chromium, 4.1 to 126.5  $\mu\text{g/g}$  for aluminium and ND to 4.7  $\mu\text{g/g}$  for copper respectively, while cadmium was not present in any of the samples.

The data generated during the study was processed using various statistical tests with the aid of Statistica 5.1 software (TX, USA). The data characteristics such as mean, SD, range, etc. were determined and the One-Way Analysis of Variance procedure was followed to test the hypothesis that several means are equal. In addition to determining the existence of differences among the means, the data was further processed to specifically check, which means differ, following the post hoc tests. The significance level was chosen to be 0.05 (or equivalently, 5%) by keeping in view the consequences of such an error. That is, we want to make the significance level as small as possible in order to protect the null hypothesis and to prevent, as far as possible, from inadvertently arriving at false conclusions.

Data pertaining to the heavy metals determined from the select potato chips (PC 1-5) and biscuit (BC 1-5) brands that are available locally is presented in Table 3. The lowest iron content was found in locally available PC-5 chips and the highest iron content was found in PC-3 chips. In biscuits the lowest iron content was found in BC-2 and BC-5 whereas the highest iron content was found in BC-3.

The highest manganese content was found in PC-3 and BC-1 while lowest was found in PC-5 and BC-2. The lowest and highest zinc contents were found in PC-1 chips, BC-1 biscuits and PC-5 chips, BC-3 biscuits, respectively. The highest copper content was determined from PC-5 chips and lowest in PC-4 Chips. In general copper concentrations were found to be below detectable limits in the selected biscuit samples. Highest chromium concentration was determined from PC-5 chips and BC-5 biscuits. Lowest Aluminium content was found in PC-1 chips and BC-2 biscuits, while it was highest in PC-3 chips and BC-4 biscuits. Lead concentration was found to be highest in BC-5 biscuits. Nickel content was found to be highest in PC-5 chips and BC-4 biscuits whereas lowest in PC-4 chips and BC-3 biscuits. Lowest cobalt concentrations were found in PC-1 chips and BC-5 biscuits while highest in PC-4 chips and BC-3 biscuits. In general, cadmium concentrations were found to be below detectable limits in all chips and biscuit samples.

The potatoes contain approximately 80% water (Holland et al. 1991; Joint food safety and standards group 1998) and hence when potato slices are cooked during the manufacture of crisps, the dehydration occurs, which will increase the proportion of dry matter and thus the concentration of elements in the finished product.

Metals like iron, copper, zinc and manganese are essential metals for humans, since they play an important role in biological systems, but the essential heavy metals can produce toxic effects when their intake is excessively elevated (Schroeder 1973; Mendil et al. 2005; Narin et al. 2005).

The order of accumulation of trace metals in potato chips and biscuits was determined as

Aluminum > Iron > Zinc > Nickel > Manganese > Copper > Cobalt > Chromium > Lead > Cadmium

And for potato chips and biscuits individually was found as:

Potato chips → Fe > Al > Zn > Ni > Cu > Mn > Co > Cr > Pb and Cd

Biscuits → Al > Fe > Zn > Ni > Mn > Co > Cr > Pb > Cu and Cd

The heavy metal concentrations presented are mean ± SD values obtained from a total of nine replicates for the selected samples (potato chips and biscuits)

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