International Journal of Food Science and Biotechnology
2017; 2(4): 130-133
http://www.sciencepublishinggroup.com/j/ijfsb
doi: 10.11648/j.ijfsb.20170204.16

Impact of Grinding Machine on Trace Metal Levels in Soup Condiments

Oluwafemi Ogunlalu, Oluwabanke Ademola, Olugbenga O. Oluwasina, Ademola F. Aiyesanmi*

Department of Chemistry, Federal University of Technology Akure, Akure, Nigeria

Email address:

demolaktp@yahoo.com.uk (A. F. Aiyesanmi)

*Corresponding author

To cite this article:

Oluwafemi Ogunlalu, Oluwabanke Ademola, Olugbenga O. Oluwasina, Ademola F. Aiyesanmi. Impact of Grinding Machine on Trace Metal Levels in Soup Condiments. *International Journal of Food Science and Biotechnology*. Vol. 2, No. 4, 2017, pp. 130-133.
doi: 10.11648/j.ijfsb.20170204.16

Received: June 11, 2017; **Accepted**: July 4, 2017; **Published**: November 29, 2017

Abstract: This research seeks to evaluate the extent of metallic release into food condiment due to the use of grinder machine. Grinders aged between approximately 24 months and 42 months were used to grind soup condiments and the latter were analyzed for heavy metals using standard methods. The results revealed that grinder whose age was less than 24 months contained Fe, Mn, Ni, Zn, Pb, Cu, Cd and Cr (in mg/kg) to be 90.15 ± 35.73, 627.64 ± 247.29, 59.89 ± 26.96, 54.21 ± 21.45, 34.85 ± 4.44, 227.05 ± 34.73, BDL ± BDL and 137.68 ± 49.19 respectively. As the grinder's age increased, it was observed that metal contribution also increased, with grinder of aged 42 months showing concentrations for the above-stated metals to be 161.42 ± 56.67, 818.10 ± 229.84, 72.20 ± 40.33, 122.38 ± 103.10, 150.22 ± 9.59, 318.54 ± 51.48, 5.89 ± 5.16 and 88.50 ± 13.79 respectively. Between the period of 24 and 42 months, it was observed that contribution of toxic metals (Pb and Cd) by the grinder increased by at least 300% and there was an equally noticeable increase for other metals under consideration high values obtained for these toxic metals pose great health dangers for humans who might be in regular consumption of foods processed with old grinders.

Keywords: Heavy-Metal, Soup-condiments, Grinders, Toxicity

1. Introduction

Heavy metals can be defined as a group of metals and metalloids having atomic density greater than 4g/cm³ [1]. Some other definitions put the density greater than 5 g/cm³ and consequently, they are toxic elements as they do not degrade [2]. At very low levels, heavy metals can be useful in metabolic activities in the body but as their concentrations exceed permissible levels, they constitute varying degrees of health hazards to man [3].

The food condiment is sometimes made from tomato, onions, scotch bonnet and bell pepper and is mostly processed using mechanical grinders. These grinders are made from metallic alloys which tend to undergo wearing and corrosion over time usage; hence releasing their constituents into the food condiments. Some traditional methods for converting condiments into paste are by the use of grindstones, bricks, mortar and pestle. Although, there is very low risk of heavy metal contaminations using those methods however, they are slow, cumbersome, inefficient and unhygienic in nature [4]. These drawbacks led to the introduction of an alternate grinding method that could be fast, less cumbersome, time-saving and hygienic; thus the development of grinding machines. The grinding machines are always driven at a very high speed and as the condiment passes through the revolving discs, those ingredients are processed into paste; in a slurry form.

At permissible levels, some metals have beneficial effects to the body. Iron assists in metabolizing proteins, formation of haemoglobin and red blood cells [5]. Manganese acts as a coenzyme in a variety of metabolic processes and assist in thyroid functioning and generation of energy for the body. Though Nickel can be harmful at high dosage [6], its beneficial effects include iron absorption and prevention of osteoporosis. Zinc helps in the functioning of the immune system and is very important for body metabolism [7]. Copper is beneficial for body growth. chromium helps in reducing risk of hypertension, while lead and cadmium have no important health benefit to the body. The adverse health

effects of heavy metals are vast. Excessive iron intake results into gastric upset, constipation, vomiting, faintness and abdominal pain. Concentrations of iron more than 20 mg/kg in the body pose serious danger to human health. It is very informative to note that *hemochromatosis* [8], a disease caused by gene mutation is as a result of excessive iron intake. A condition known as *manganism* is caused by high levels of manganese and it leads to a vast array of psychiatric motor disturbances and brain disease. High dose of nickel results into abdominal discomfort, diarrhea, lung fibrosis and dermatitis while zinc toxicity causes vomiting, kidney damage and metallic taste [9]. Copper toxicity results into bloody diarrhea, fever and stomach pain. Kidney disease is always associated with high dosage of chromium. Lead and cadmium are highly carcinogenic causing harmful effects on the kidney, bones and lungs.

This research aims to investigate the possible effect of grinding machine on the level of heavy metals in food condiment, and to find out if

The increase in the ages of the machines will cause any noticeable effect on the heavy metal contribution.

2. Method

2.1. Material

The food condiments (tomatoes, onions, bell peppers and scotch bonnet) were procured from Oja Oba, Akure, Ondo State. Reagents used include HCl and HNO_3 and were of analytical grade.

2.2. Sample Preparation

The purchased samples were brought to the laboratory, all rotten or damage samples were removed and then washed clean with distilled water, before divided into 7 parts. Six portions were ground at Oja Oba with grinding machines ageing between 24 and 42 months, while the last portion was ground in ceramic mortal (the control sample). Distilled water was used for the washing of the engines during the grinding processes. Paste condiments were collected into already washed and cleaned plastic containers and then transported back to the laboratory. The condiments were stored in the refrigerator before further analysis. The 7 samples were labelled A, B, C, D, E, F and Control.

2.3. Digestion of Soup Paste and Instrumental Analysis

The material was digested by slightly modifying the method of [10]. Aqua regia (concentrated acid mixture of 3 HCl: 1 HNO_3) was prepared and 10 mL of this was added to a beaker containing 1 g of the sample. The resulting mixture was then digested under reflux until a clear, transparent solution was obtained. After cooling, the digested sample was filtered using Whatman No. 42 filter paper and the filtrate diluted to 50 mL with distilled water. The prepared sample was analysed for the heavy metals using Atomic Absorption Spectrophotometer (AAS) BUCK SCIENTIFIC 210 VGP model.

3. Result

Table 1. *Metal (mg/kg) detected in tomato-blended soup condiment.*

Metal	Sample						
	A	B	C	D	E	F	Control
Fe	$90.15^{a,b} \pm 35.73$	$83.65^{a,b} \pm 13.15$	$163.65^{b} \pm 11.23$	$163.74^{b} \pm 41.97$	$168.74^{b} \pm 85.65$	$161.42^{b} \pm 56.67$	$16.35^{a} \pm 7.66$
Mn	$627.64^{a} \pm 247.29$	$539.60^{a} \pm 81.88$	$640.94^{a} \pm 45.27$	$744.82^{a} \pm 131.63$	$814.93^{a} \pm 332.03$	$818.10^{a} \pm 229.84$	$314.11^{a} \pm 67.98$
Ni	$59.89^{a} \pm 26.96$	$91.72^{a} \pm 47.82$	$54.64^{a} \pm 19.15$	$52.06^{a} \pm 0.58$	$16.26^{a} \pm 9.65$	$72.20^{a} \pm 40.33$	$8.73^{a} \pm 3.03$
Zn	$54.21^{a} \pm 21.45$	$102.57^{a} \pm 61.08$	$80.14^{a} \pm 38.72$	$84.30^{a} \pm 40.99$	$138.66^{a} \pm 84.75$	$122.38^{a} \pm 103.10$	$14.49^{a} \pm 7.60$
Pb	$34.85^{a,b} \pm 4.44$	$69.20^{b,c} \pm 17.47$	$84.57^{c} \pm 14.03$	$90.29^{c} \pm 21.13$	$85.65^{c} \pm 8.70$	$150.22^{d} \pm 9.59$	BDL
Cu	$227.05^{b} \pm 34.73$	$231.04^{b} \pm 25.60$	$319.72^{b} \pm 19.17$	$310.30^{b} \pm 40.41$	$251.75^{b} \pm 52.00$	$318.54^{b} \pm 51.48$	$57.15^{a} \pm 26.08$
Cd	BDL	$5.14^{a} \pm 2.97$	$5.42^{a} \pm 4.87$	$14.32^{a} \pm 13.30$	$10.46^{a} \pm 3.41$	$5.89^{a} \pm 5.16$	BDL
Cr	$137.68^{a} \pm 49.19$	$61.12^{a,b} \pm 14.77$	$139.00^{c} \pm 21.43$	$134.31^{b,c} \pm 31.87$	$130.68^{b,c} \pm 19.92$	$88.50^{a,c,d} \pm 13.79$	$33.89^{a} \pm 12.52$

Values are means of three replicate ± standard deviation. Column means followed by different letters are significantly different at $P< 0.05$BDL - below instrument detection limit

4. Discussion

Table 1 presents the results of the analysed metals in the soup condiments and revealed that the food condiments were contaminated by the wearing of the metallic material used for the manufacturing of grinding machines. There is a progressive increment in the amount of metal present from 24 months to 42 months having recorded Cd level of below detection limit for grinder of 24 months old and 5.89 mg/kg for 42 months old grinder. A similar marked trend was observed for Fe having 90.15 mg/kg with 24 months grinder and 161.42 mg/kg for 42 months grinder, Mn (627.64 - 818.10 mg/kg), Ni (59.89 - 72.20 mg/kg), Zn (54.21 - 122.38 mg/kg), Pb (34.85 - 150.22 mg/kg) and Cu (227.05 - 318.54 mg/kg). The wearing of metallic materials into the food condiments may be attributed to the acidic nature of most of the food condiments causing metallic corrosion effect; consequently leading to the leaching of the metals into the food condiments. Probably, the increase in metal-related human toxicity in most sub-Sahara African countries may be linked to food condiments contamination [11]; although more researches need to be carried out to further authenticate this claim. As the grinders get older, there is a rapid deterioration of the metallic components and in the course of grinding; these metallic particles leach into the food condiments that is being processed. For grinders less than 24 months, it was observed

that the contribution of heavy metals was relatively minimal. On the other hand, the oldest grinder (aged 42 months) showed higher contribution as there was a marked increase of between 17.05% and 76.80% for Fe, Mn, Ni, Zn, Pb and Cu. It is obvious that there is no standard in terms of the quality of materials being used for the manufacture of the grinding plates as they are mostly fabricated locally. Thus the rate at which individual machine corrodes and leaches metals into the condiment varies independent of the age.

The maintenance culture of the operators may also have an indirect effect on the corrosion rate of a grinder. For Fe, Mn and Cr, it was observed that the contributions decreased between a grinder (with age less than 24 months) and another of age, 30months and then rapidly increased in a grinder of 33 months. This shows that there are other external factors that affect the leaching of metals into food condiments and notably, the quality of materials used for the production of the grinding machines and the maintenance culture of the user operating the machine. The use of mortar and pestle seems to be one of the best alternatives to grinders in terms of food safety and heavy metal contribution as the control sample showed metals levels that were significantly lower compared to that of the grinders.

All analyzed samples showed a very high proportion of manganese. From Table 1, statistical tests showed there was no significant difference ($p>0.05$) among the samples. With the control sample recording Mn concentration of 314.11 mg/kg points to the fact that there was high Mn level in the in some of the ingredients used for the condiment. Most farmlands where these ingredients are cultivated may contain high level of manganese, more so that the metal constitutes one of the micro nutrients required by plant for healthy growth Another reason for high manganese level may be attributed to the quality of water used for irrigation, which can sometimes be polluted with metals before application [12] as there is no adequate regulatory structure to monitor this.

Iron showed relatively high composition in the soup condiments with concentrations ranging from 90.15 – 168.74 mg/kg, while the control sample recorded 16.35 mg/kg. The permissible limits of iron in foods are in the range of 30 – 150 mg/kg [13]. Most samples recorded concentrations above the permissible limits; constituting great danger for human health. The control sample fell below the allowable limits, 48 mg/kg of the WHO/FAO for iron in foods [9]. Other samples gave higher contribution of iron. Sample A shows an iron contribution that is almost twice the recommended value; signifying that grinders nearing the age of 24 months are not even safe for the processing of soup condiments.

The Fe contribution of the grinders to the food condiment increased with the grinders' age. For Samples F, D and C which had a contribution of 161.42mg/kg, 163.74mg/kg and 163.65mg/kg respectively, it was observed that the grinders used to process the foods were the oldest having ages ranging from 33-42 months. The iron content in all the samples were above permissible limits allowed by WHO/FAO standards for foods which was given as 48mg/kg [9]. Nickel contribution by the grinding machines though significant but was relatively small in comparison with other metals under consideration (Fe, Mn, Ni, Zn, Pb, Cu and Cr). The concentrations found in the condiment paste samples varied from 36.43 – 91.72 mg/kg with the control sample containing 8.73 ± 3.03mg/kg. However, a different trend was observed for nickel as some samples ground with old grinders contained lower concentration of nickel than a relatively-younger grinder (sample B showing the highest concentration of 91.72mg/kg). The European Food Safety Authority has set a limit of tolerable daily intake (TDI) of 2.8 micrograms per kilogram for Ni consumption and the obtained values for Ni in this study shows that consumers stand a great risk of absorbing excess Ni into their systems.

The composition of zinc in the samples varied from 54.21 – 138.66mg/kg with Sample E exhibiting the highest concentration. The values obtained were higher than those obtained for nickel and shows arithmetically that grinding machines possess the capability of adding 10-40mg/kg extra of zinc particles than nickel. The zinc levels in the samples exceeded the permissible limits of EC/CODEX, NAFDAC and WHO for zinc in foods [9]. Only the control samples fell within the limits. Possibly due to the relatively younger age of the grinder used for Sample A, the zinc contribution was within permissible limits.

For zinc, the control sample also fell within allowable limits of WHO/FAO (60mg/kg), NAFDAC (50mg/kg) and CODEX (<50mg/kg) standards for zinc in foods [9]. The zinc contribution of Sample A is within the permissible limits of WHO/FAO but above that set by NAFDAC and CODEX. Other samples greatly exceeded the limits. The cadmium contribution is very significant as the samples exceeded the permissible limit of 0.2mg/kg set by CODEX Alimentarius [14] while the control sample showed no cadmium below instrument detection limit; suggesting the risk associated with the use of locally fabricated grinding machine. For Cd, the WHO/FAO Provisional Tolerable Monthly Intake (PTMI) was given as 25 micrograms per gram; obtained results showed this limit can be exceeded in a very transient time if aged grinders are used for processing soup condiments. The results obtained for Cu fell within acceptable limits and that of Cr exceeded allowable limits. Also, the obtained values for the other metals were very high. Pb contribution by all the grinders was very high and for Samples A-F, the Pb content exceeded the CODEX maximum allowable limit of 1.5mg/kg [14].

5. Conclusion

This study has been able to investigate the effects of grinding on the levels of Fe, Mn, Ni, Zn, Cr, Cd, Pb and Cu in soup condiments. The use of grinders in processing condiments to slurry form is efficient and faster. However, this advantage can graduate into a threat as the grinder ages; leading to a rapid release of heavy metals into soup condiments, which might constitute health dangers to the consumer. Results obtained from the study shows that it is

safer to use grinders below 24 months of age or otherwise, mortar and pestle should be employed as this was discovered to contribute a very minimal amount of the heavy metals with concentrations below the allowable limits in food. In general, the processing of soup condiments using mortar and pestle assures a very minimal contribution of heavy metal- making it more safe, hygienic and health-benefitting. Based on the findings of this research work, it is advisable to discourage the use of aged grinding machines in our market and the government should set up enforcement agencies that will ensure the eradication of grinding machines that are no more healthy for use.

References

[1] Duffus, J. H. (2002). "Heavy Metals" – A meaningless term. *Pure and Applied Chemistry*, *74*, 793-807.

[2] Alloway, B. J. (1995): *The Origins of Heavy Metals in Soils*. Heavy Metals in Soils. 2nd Edition. Blackie Academic & Professional.

[3] Dallman P. R. (1986). Biochemical basis for the Manifestations of Iron deficiency, *Annual Review of Nutrition, 6*, 13-40.

[4] Journal of Emerging Trends in Engineering and Applied Sciences (2012). Investigation of Metal Contaminants in Locally Ground Foods, *Scholarlink Research Institute Journals.*

[5] U. S. National Library of Medicine (2015). Medine Plus Trusted Health Information for You; Iron.

[6] Edward Group (2013). Metal Toxicity- Health Dangers of Nickel, *Global Healing Centre.*

[7] Higdon Jane & Drake Victoria (2003). *MicroNutrient Information Centre- Zinc*, Linus Pauling Institute; Oregon State University.

[8] The Office of Dietary Supplements (ODS) of the National Institutes of Health (2016). Health Information; Iron Dietary Supplement Fact Sheet.

[9] Opaluwa O. D, Aremu M. O, Ogbo L. O, Abiola K. A, Odiba I. E, Abubakar M. & Nweze N. O. (2012). Heavy Metal constant in soils, plant leaves and crops grown around dumpsite in Lafia Metropolis, Nassarawa State, Nigeria. *Advances in Applied Science Research, 3* (2), 780-784.

[10] Mohamed H. H & Khairia M. Al-Qahtani (2012). Assessment of some heavy metals in vegetables, cereals and fruits in Saudi Arabian markets, *The Egyptian Journal of Aquatic Research.*.

[11] WHO Media Centre (2015). Food Safety fact sheet. *http://who.int/mediacentre/factsheets/fs399/en.*

[12] Aremu M. O, Arolaiye B. O. & Labaran L. (2010). Environmental Implication of Metal Concentrations in soil, plant foods and pond in area around the derelict Udege mines of Nassarawa State, Nigeria. *Chemical Society of Ethiopia, 24* (3), 351-360.

[13] Patrick O, Bamuwamye M, Apili G. & Musalima J. H. (2014). Health Risk Posed by Lead, Copper and Iron via Consumption of Organ Meats in Kampala City (Uganda). *Journal of Environment Pollution and Human Health*, *2* (3), 6.

[14] Codex Alimentarius International Food Standards (2015). General Standard for contaminants and toxins in food and feed (CODEX STAN 193-1995).

[15] Royal Society of Chemistry (2016). Periodic Table App. *http://rsc.org/periodic-table/element/25/manganese.*