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Preliminary Study on Heavy Metals in Coconut and Coconut Products

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Abstract

Coconut is one of the major plantation crops which plays a pivotal role in the economy of Sri Lanka. The objective of this study is to investigate the presence of heavy metals in fresh coconut kernel and in some coconut products in Sri Lanka.

Levels of lead (Pb), Chromium (Cr), Aluminum (Al), Ferrous (Fe), Copper (Cu), Manganese (Mn), Cadmium (Cd), Zinc (Zn), and Arsenic (As) were determined in samples of fresh coconut kernel, coconut milk, coconut milk powder, and coconut cream using the Atomic Absorption Spectrometer (AAS) method. Fresh coconut kernel and coconut products were found to contain Fe, Zn, Cu and Mn. Fresh coconut kernels showed the highest content of these metals. Coconut cream and coconut milk samples demonstrated the lowest levels of these metals. Potentially toxic heavy metals such as Pb, Cd, As, and Al were not detected in the tested samples. The occurrence of the heavy metals in all the coconut products tested was below the permissible levels suggested by the USDA, World Health Organization, and the Quality Standards of CODEX Vol. 1 Section 6, 1991.

Keywords: heavy metals, coconut products, atomic absorption spectrometer (AAS).

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Introduction

Coconut, a major plantation crop, plays a pivotal role as a source of nutrition and as a contributor to the economy of Sri Lanka. Essentially, the heavy metals have only become a focus of public interest since analytical techniques have made it possible to detect them even in very small traces. Heavy metals have a specific gravity (density) of more than about 5 g/cm3. Some of them, such as copper, nickel, chromium and iron are essential in very low concentrations for the survival of all forms of life. Like other crops, coconut also absorbs and accumulates heavy metals in its plant parts depending on the soil type, geography, levels of pollution and agronomic practices (ZHANG Xin1a et.al., 2009).

ZHANG Xin1a et.al., 2009 reported that the concentration of Pb, both in coconut barks and leaves, was significantly higher in the coconut plants grown on roadways in China. Moreover, reports of a study on biological absorption coefficients (BAC) and elemental correlations between coconut trees and soils, have indicated that the distributions of heavy metals in plants is influenced to a limited extent by soils and by their individual biogeochemical characteristics.

Heavy metals such as lead, cadmium and mercury have been recognized to be potentially toxic within specific limits. Hence, deficiency or excess of these elements could lead to a number of disorders in human beings (Underwood 1971). Toxicity of cobalt (Co), cadmium (Cd), zinc (Zn), lead (Pb), copper (Cu), and nickel (Ni) has been very well documented by Casarett & Doull (1975) and Goyer & Mehlman (1977). Allen and Steinnes (1978) have discussed bioaccumulation of heavy metals in food plants. Dara, 1993 reported that plants are carriers of heavy metals from the soil to humans. The total concentrations of heavy metals in soils, plants, their chemicals forms, mobility, and availability to the food chain provide the level of contaminations (Fazeli M.S. et. al., 1991).

Coconut cultivation in Sri Lanka, covers an area of over 3.94 million ha with an annual production of 2.87 billion nuts. Coconuts contribute Rs 1.8 million to the country's Gross Domestic Product (GDP). Approximately 70 % of annual production is consumed domestically while the remainder is processed. In the year 2008, desiccated coconut 38,414 MT, Coconut milk 4,762 MT, coconut oil 59,018 MT, and coconut cream 1,750MT and coconut milk powder 3,955MT were been produced in Sri Lanka for export purposes (Sri Lanka Coconut Statistics, 2008).

The objectives of this study were to investigate the occurrence of heavy metals in the fresh coconut kernel, coconut milk, coconut milk powder, and coconut cream produced and sold in Sri Lanka and on export markets. The method of the AAS is now used by the CDA to determine the levels of heavy metals in coconut products prior to the export. This paper describes the results of investigations into the heavy metal content of fresh coconut and some coconut products.

Materials and methods

Samples of fresh coconut, coconut milk, coconut cream and coconut milk powder were collected in October 2008. Total of fourteen (14) samples of fresh coconut were collected from coconut plantations in Kurunegala, North Western Province and Gampaha, Western Province, Sri Lanka. Ten samples of each coconut milk, coconut cream and coconut milk powder were collected from leading supermarkets in Colombo, Sri Lanka for further analysis. Collected samples were transported to the laboratory with care under hygienic conditions.

Samples were homogenized using sterile equipment and then dried the samples until constant weight in an Oven at 105^0C to measure the heavy metal content. A one-half (0.5g) sample of coconut milk powder and one gram of samples of coconut milk, cream and fresh coconut were weighted into digestion vessels (XP 1500 Plus) and digested in a microwave digester (CEM Corp., Mars model).

The each samples were pre-digested by treatment with 6 mL analytical grade concentrated Nitric Acid (HNO_3) 6 mL and 1 mL of 30% Hydrogen Peroxide (H_2O_2) for about 20 minutes. The vessels were closed and placed into a holder which was transferred to a Microwave Digester (CEM Corp., Mars model). The temperature of the digester was set to 180^{0}C, with a ramp time of 25 minutes, under a pressure of 800psi. The samples were digested over 15 minutes following which the digestion vessels were allowed to cool. Digested samples were subsequently filtered through whatman No. 542 filter papers and the filtrate was collected into 50ml volumetric flasks, and diluted using de-ionized water, Model Smart2Pure. A blank sample also treated in a similar manner and analyzed along with each test samples. The samples were aspirate into atomic absorption spectrometry. Two replicate of each sample were analyzed using Flame Atomic Absorption Spectrometry (FAAS), model Varian AA240 and Graphite Furnace Atomic Absorption Spectrometry (GFAAS) model, GTA 120 Varian as per the official Standard lmethods (AOAC 999.10, 2000) to determine the levels of Cu, Pb, Zn, Al, Fe, Mn, Cr, As, and Cd in the samples by using appropriate wavelength for each metals. The procedure described by Horwitz (2000) and the standard methods (AOAC) were used in the analysis.

Results and discussions

Coconut milk and coconut cream refers to the oil-protein water emulsion obtained by squeezing grated fresh coconut kernel. Usually, the Asian and Pacific householders, the undiluted forms are referred as coconut milk and concentrated form as coconut cream. Coconut milk powder is a spray dried product similar to dairy milk powder (Ohler G.J., 1999).

The results showed that the levels of Iron, Zinc, Copper and Manganese varied in the samples of fresh coconut kernel, coconut milk, coconut cream and coconut milk powder (Table 1).

Coconut milk powder and coconut cream has lowest levels of Zn, Cu and Mn when compared with the levels detected in fresh coconut kernel. This is likely due to the fact that these water soluble minerals are lost during processing. Iron content was higher in the samples of fresh coconut as well as coconut milk. Likewise, the fresh coconut kernel had highest levels of Fe, Cu and Mn (Table 1). The coconut cream samples showed the lowest amounts of heavy metals.

A series of washing and squeezing operations are involved during the process of coconut milk and cream production. Hence, the heavy metals that are available in soluble form could possibly be washed off during the process (Barman, S.C. et.al., 1994). This is very likely one of the reasons for the low concentrations of heavy metals in the coconut cream and the milk samples. Huggins *et al.*, 2000 has been discussed the water removable proportions of Cu, Pb and Zn in vegetables. Likewise, Heal *et al.*, 2005 and Karthikeyan *et al.*, 2006 reported that Cu and Zn are present in airborne particulate as water-soluble sulphate salts. Further study on heavy metal content in the dispose water is needed to support the washed off of the heavy metals. Generally, the leaching of each metal is related to the kinds of liaisons between metals and the solid matrix (De Nicola *et al.*, 2008). The variations in the concentrations of the heavy metals in coconut products may be ascribed to the heavy metals concentrations of soil, air and water used for processing of products. The Sri Lankan coconut is grown mostly in the outside of urban areas and in non-polluted lands. Therefore, the occurrence of excess levels of heavy metals in coconut product is very unlikely.

The Lead, Cadmium, Arsenic, Chromium and Aluminum weren't detected in all tested samples. Either this may be due to presence of low content in the environment or the AAS method could not detect the existence amounts of these heavy metals. The minimum detection levels of the atomic Absorption Spectrophotometer for the treated heavy metals are considered as Lead (Pb) 0.5 mg/kg, Cadmium (Cd) 0.5 mg/kg, Chromium (Cr) 1.5 mg/kg, Arsenic (As) 0.5 mg/kg, Aluminium (Al) 0.5 mg/kg, Copper (Cu) 1.0 mg/kg, Zinc (Zn) 0.3 mg/kg, Iron (Fe) 1.5 mg/kg, Mn 0.5 mg/kg and below this level is undetectable.

Table 1. Average metal contents of coconut based products (in 100g of the samples)

	Iron (mg/100g)	Zinc (mg/100g)	Copper (mg/100g)	Manganese (mg/100g)
Fresh coconut	1.581 ± 0.021	0.43 ± 0.015	0.45 ± 0.02	1.06 ± 0.02
Coconut milk powder	0.17 ± 0.019	0.37 ± 0.018	0.20 ± 0.024	0.39 ± 0.022
Coconut cream	0.35 ± 0.02	0.18 ± 0.014	0.16 ± 0.021	0.19 ± 0.017
Coconut milk	1.35 ± 0.020	0.92 ± 0.019	0.33 ± 0.029	0.78 ± 0.022

Figure 1. Iron and Zinc Levels Vs USDA permissible levels in Coconut products

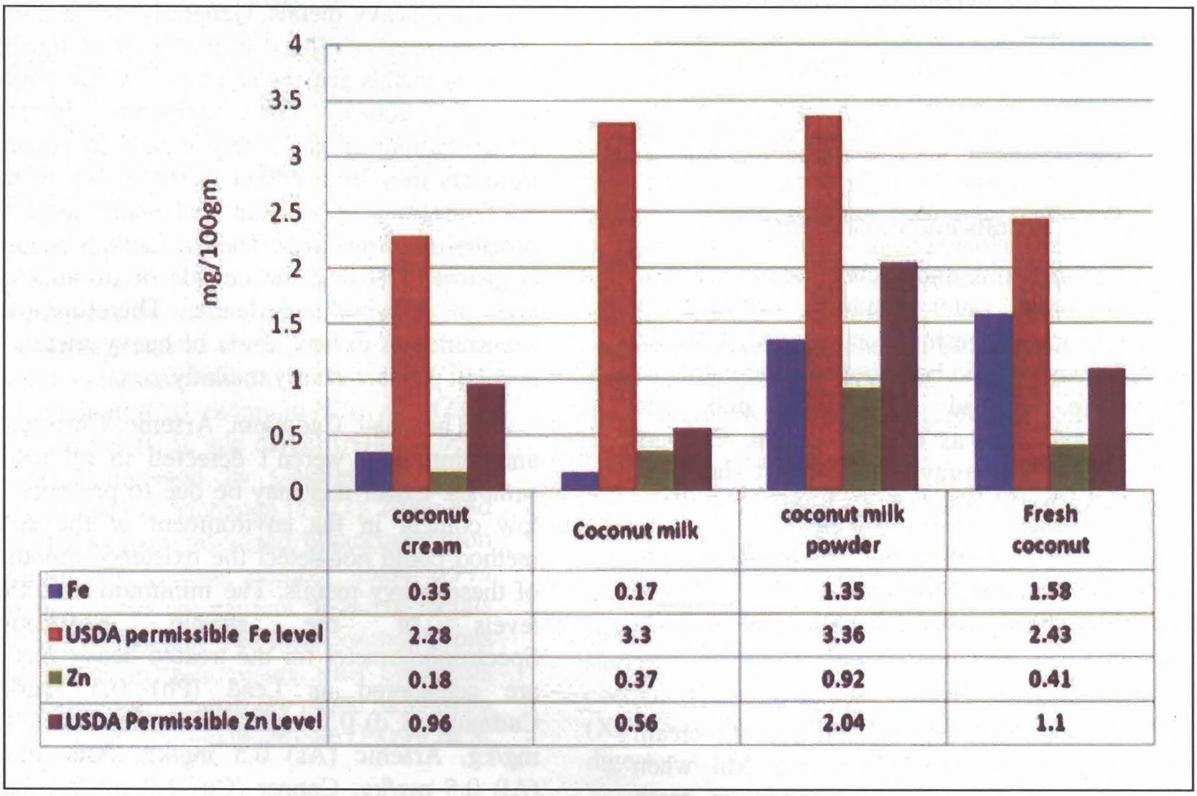
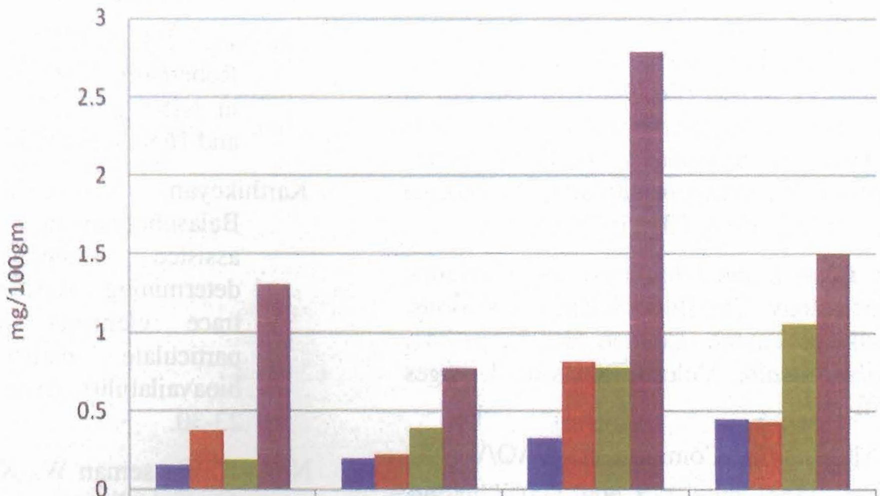


Figure 2. Cupper and Manganes levels Vs USDA permissible levels in coconut products



	coconut cream	Coconut milk	coconut milk powder	Fresh coconut
Cu	0.16	0.2	0.33	0.45
USDA permissible Cu Level	0.378	0.223	0.807	0.435
Mn	0.19	0.39	0.78	1.06
USDA Permissible Mn Level	1.304	0.768	2.783	1.5

Statistical analysis by using Kruskal Wallis test described by Neter J. et. al., 1990 revealed that the Cu, Fe, Zn and Mn levels detected in the fresh coconut, coconut milk, cream and milk powder samples are not significantly different from each other at the probability level of $p<0.05$.

It was also noted that the existing levels of Fe, Zn, Cu and Mn are below the permitted levels given in the Aqueous Coconut Products Quality Standards of CODEX Vol. 1 Section 6, 1991 and also USDA National Nutrient Database for Standard Reference, Release 22 (2009). The permitted levels are shown in the Fig 01 & Fig 02. Xin Zhang et. al., 2009, reported that the biological absorption coefficients (BAC) and elemental correlations between coconut plants is limited, the absorption degree is inconsistent with the concentrations of each element in soils, which not only influenced by soil types, but also controlled by biological absorption ability.

Conclusion

All the samples of fresh coconut kernel, coconut milk, cream and milk powder showed very low levels of metal concentrations and those figures are below the limits described in the USDA National Nutrient Database for Standard Reference and Aqueous Coconut Products Quality Standards of CODEX Vol. 1 Section 6, 1991. Therefore, it can be concluded that the Sri Lankan coconut products are not contaminated with heavy metals. Anyhow, based on the results of this study, the CDA introduced a coconut product quality assurance system in Sri Lanka.

References

Association of Official Chemists, (2000). Official Methods of Analysis of the Association of Official Analytical Chemists, 17th Edition, AOAC International, Suite 500, 481 North Frederick avenue, Gaithersburg, Maryland

20877-2417 USA, Official Method 999.10 & 999.11, Chap. 9 pp. 16 – 20.

http://www.aomega.com/minerals/minerals.htm#zi

Barman, S.C. & Lal, M.M., 1994. Accumulation of heavy metals (Zn, Cu, Cd, and Pd) in soil and cultivated vegetables and weeds grown in industrially polluted fields. Journal of Environmental Biology, Volume 15, Issue 2, 1994, Page 107-115

Casarett, Louis J. and John Doull, 1975. Editors, Toxicology- The Basic Science of Poisons, Bailliere Tindall, London (1975), p. 741. *Public Health*, Volume 90, Issue 4, Pages 196-197

Codex Alimentarius Commission, (FAO/WHO), 1991. Food additives and contaminants. Joint FAO/WHO Food Standards Programme, ALINORM 01/12A:

Codex Alimentarius Commission, (FAO/WHO), 2001. Food additives and contaminants. Joint FAO/WHO Food Standards Programme, ALINORM 01/12A: 1-289.

Dara SS (1993). A Text book of Environmental Chemistry and pollution control, Printed at Rjendra Rarindra Printers (PVT) Ltd Ram Niger, New Delhi 10055, 167 – 206.

De Nicola, F., G. Maisto, M.V. Prati and A. Alfani, 2008. Leaf accumulation of trace elements and polycyclic aromatic hydrocarbons (PAHS) in *Quercus ilex* L. Environ. Pollut., 153: 376-376.

Fazeli, M.S., Sathyanarayan, S., Satish, P.N. & Muthana, L. (1991). Effect of paper mill effluents on accumulation of heavy metals in coconut trees near Nanjangud, Mysore District, Karanataka, India. Environmental Geology, Volume 17, Issue 01, January 1991.

Goyer, R. A. and Mehlman, M. A. 1977. Advances in modern toxicology. Vol. 2 Toxicology of trace elements, New York, Wiley, pp. 41-77

Heal, M.R., L.R. Hibbsa, R.M. Agiush and J.I. Beverland, 2005. Total and water-soluble trace metal content of urban background PM10, PM2.5 and black smoke in Edinburgh, UK Atmos, Environ., 39: 1417-1430.

Huggins, F.E., G.P. Huffman and J.D. Robertson, 2000. Speciation of elements in NIST particulate matter SRMS 1648 and 1650 J. Hazardous Mater., 74: 1-23.

Karthikeyan, S., U.M. Joshi and R. Balasubramanian, 2006. Microwave assisted sample preparation for determining water-soluble fraction of trace elements in urban airborne particulate matter: Evaluation of bioavailability Anal. Chimica Acta, 576: 23-30.

Neter J., Wassernan W., Kutner H. M., (1990). Applied linear statistical models, 3ed edition Printed in the United State of Sri Lanka, pp 633-647

Ofomaja, A.E. & Ho Y. Effect of pH on cadmium biosorptio by coconut copra meal 2007. Journal of Hazardous Materials, Volume 139, Issue 2, 10 January 2007, pp 356-362.

Ohler G.J. (1999). Modern Coconut Management Palm cultivation & products, Printed in Great Britain by SRP Exeter pp 365-366.

Reilly Conor, (1980). Metal contamination of foods, Printed in Great Britain by Galliard, (Printers) Ltd, Great Yarmouth, pp 9-45

Sri Lanka Coconut Statistics (2008). Coconut Development Authority, Nawala Road, Colombo 5, Sri Lanka.

http://www.nal.usda.gov/fnic/foodcomp/cgi-bin/list_nut_edit.pl USDA National Nutrient Database for Standard Reference, Release 22 (2009)

Van Loon, J. C. 1980. Analytical Atomic Absorption Spectroscopy cover (New York: Academic Press)

ZHANG Xin, WU Guo-ai1b, FU Yang-rong, YANG Yi2, BAO Zheng-yu1b (2009)-

Key Laboratory of Biogeology and Environmental Geology of Ministry of Education, China University of Geosciences, Wuhan 430074, China Heavy Metals in Barks and Leaves of Coconut Trees and Its Environmental Significance in Haikou and Sanya Cities, Hainan Province, Geological Science and Technology Information; 009-04