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Assessment of heavy metals in Mukunuwenna (*Alternanthera sessilis*) collected from production and market sites in and around Colombo District, Sri Lanka

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Abstract

The present study was conducted to evaluate the levels of trace metals (Ni, Cd, Cr, Pb and Cu) in *Mukunuwenna* (*Alternanthera sessilis*) samples randomly collected from the production and market sites located in and around Colombo District, Sri Lanka, using the Atomic Absorption Spectrophotometry. Significant differences in heavy metal concentrations were observed between both the production sites and market sites (P<0.05). Heavy metal accumulations in *Mukunuwenna* tested were higher at the market sites than at the crop production sites. The average concentrations (mg kg^{-1}) of heavy metals in *Mukunuwenna* samples collected from the production sites were estimated as Ni (6.48±6.74), Cd (0.20±0.11), Cr (3.36±2.76), Pb (2.96±2.16) and Cu (11.85±7.51). The mean concentrations (mg kg^{-1}) of Ni, Cd, Cr, Pb and Cu in *Mukunuwenna* samples collected from different marketing sites were reported as 7.90±5.98, 0.25±0.18, 4.09±3.36, 3.63±3.65, 13.05±5.15 respectively. The highest contaminated field and market samples were reported from the Kolonnawa area. The samples collected from the market sites were subjected to three processing treatments (raw, cooked and stir-fried) and analyzed for heavy metals, in order to find out the effect of food processing techniques on reducing the heavy metal contaminations of *Mukunuwenna* samples. The average levels (mg kg^{-1}) of metals detected in raw, cooked and stir-fried *Mukunuwenna* samples were as follows: Ni (2.20±1.04, 1.77±0.84, 1.46±1.03), Cd (0.19±0.11, 0.12±0.07, 0.10±0.06), Cr (2.37±1.58, 2.27±1.57, 2.20±1.54), Pb (0.26±0.39, 0.22±0.34, 0.21±0.34) and Cu (9.59±4.48, 8.29±3.35, 7.45±3.72). The results showed no significant differences in heavy metal contents among three processing methods (P<0.05). Therefore, the type of processing method has a minimal effect on reducing the heavy metal contents of *Mukunuwenna* samples.

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1. Introduction

Green leafy vegetables are a major component of the Sri Lankan meal. Among them, sessile joyweed (*Alternanthera sessilis*), which is locally popular as *Mukunuwenna*, is the most widely produced and consumed green leafy vegetable in Sri Lanka. The crop is native to Brazil and inhabit in many tropic and subtropical regions all over the world. There is an increased trend in consumption of this vegetable among the urban community of Sri Lanka because it is cheap, convenient and providing wide range of nutrients (fiber, vitamins, minerals and anti-oxidants). However, as reported by many previous studies, it is well known that leafy vegetables are heavy metal accumulators[1]. In Sri Lanka, extensive cultivation of *Mukunuwenna* is practiced primarily in and around Colombo District which is the commercial capital of Sri Lanka. In addition, the crop is mostly sold in the urban roadside open markets, where the environment is heavily polluted with heavy metal-laden exhaust. Consequently, these toxic metals can be deposited on the vegetable surfaces during their production, transport and marketing[2].

Food safety and security is a foremost public concern in global context. Recently, the increasing demand for food safety has inspired more research concerning the risks associated with the consumption of foods polluted with heavy metals. The implication associated with heavy metal contamination is of great concern, since they can cause numerous health hazards in mankind. Even though *Mukunuwenna* is a Sri Lankan staple food, scanty literature is available on the trace metal contaminations of the crop from production and market areas of Sri Lanka. Therefore, the experiment was conducted to determine the Ni, Cd, Cr, Pb and Cu concentrations of *Mukunuwenna* samples collected from selected production and market areas in and around Colombo District, Sri Lanka. Further, the study focused on determining the effect of different food processing methods on minimizing the heavy metal contamination of the food crop.

2. Methodology

2.1 Study area

Based on the preliminary investigation carried out, six production areas (Piliyandala, Bandaragama, Kahathuduwa, Wellampitiya, Kolonnawa and Kottawa) and vendors from eight marketing areas (Piliyandala, Wellampitiya, Kolonnawa, Kottawa, Bandaragama, Kahathuduwa, Pettah and Delgoda) were selected for the experiment.

2.2 Mukunuwenna sampling and analysis

Mukunuwenna samples were randomly collected from field and market sites, in appropriately labeled polyethylene bags and brought to the laboratory. Samples were washed thoroughly with running tap water to remove soil, dirt and other air-borne pollutants. The edible parts were chopped in to small pieces. Test samples were dried in a drying oven, at 105°C, until a constant weight was obtained and then cooled to ambient temperature, crushed by means of a clean pestle and mortar to obtain homogenized samples. The ground samples were analyzed by Atomic Absorption Spectroscopy (AAS) after dry ashing technique as described in AOAC 975.03[3].

2.3 Effect of different processing techniques on heavy metal content of Mukunuwenna samples

Fresh *Mukunuwenna* samples (n=10) were collected from different marketing points located in and around Colombo District. The cleaned edible portions of each single sample were divided into three portions (200 g each). One portion was analyzed as fresh (raw) sample and the other two portions were prepared by cooking and stir-frying as described below;

Preparation of *Mukunuwenna* by cooking: 200 g of washed and sorted *Mukunuwenna* sample was finely cut and mixed with 100 mL of coconut milk and cooked by moderate heating in an open stainless steel pan for 10-15 minutes.

Preparation of *Mukunuwenna* by stir-frying: 200 g of washed and sorted *Mukunuwenna* sample was finely cut and fried with 25 mL of boiling coconut oil in an open stainless steel frying pan for 10-15 minutes, with occasional stirring.

Each sample was analyzed for heavy metals, according to the AOAC method 975.03 (2006), as described previously. The estimated levels of trace metals in field, market and processed samples were compared with WHO/FAO guidelines to ensure the safety of consumption.

2.4 Statistical Analysis

Descriptive statistics and statistical significance of collected data were analyzed by ANOVA using Minitab 14.0 and Excel computer packages.

3. Results and Discussion

Heavy metal concentrations in the field, market and in processed *Mukunuwenna* samples are presented in the Table 1.

Significant differences were observed in the trace metal levels between the production sites and market sites ($P<0.05$). The mean concentrations of metals in *Mukunuwenna* samples from both field and market sites were found in the order of their abundance as Cu>Ni>Cr>Pb>Cd. However, the levels of Cu in all samples remained well below the WHO/FAO safe limit. In contrast, mean concentrations of Ni, Cd, Cr and Pb in *Mukunuwenna* samples procured from field and market sites exceeded the WHO/FAO safe limit. The highest contaminated field *Mukunuwenna* samples were reported in the Kolonnawa area followed by Wellampitiya and Kottawa areas. Comparatively the samples collected from the agricultural fields of Piliyandala, Bandaragama and Kahathuduwa areas showed significantly low Ni, Cd, Cr and Pb levels. The results are comparable with the values reported by Premarathna *et al*[1] in *Mukunuwenna* samples collected from the agricultural fields of low country, Sri Lanka. As reported by Chandran *et al*[4], the extent of Cd contamination (2.65 mg kg^{-1}) detected in *A. sessillis* under waste water irrigation in Madurai, India was higher than the present study in contrast to Pb (0.2 mg kg^{-1}) and Cr (1.15 mg kg^{-1}).

In market samples, higher degree of metal contaminations were reported in the *Mukunuwenna* samples collected from the Kolonnawa, Wellampitiya, Pettah and Kottawa areas in contrast to the Piliyandala, Bandaragama, Kahathuduwa and Delgoda areas (Table 1). The levels of heavy metals in all the samples collected from the market sites were higher than those of heavy metals in the respective vegetable collected from the production sites. This might be due to heavy metal depositions on the vegetable during transport and marketing in more polluted urban environment of Colombo District.

The variations in the concentrations of the heavy metals in *Mukunuwenna* samples observed during the present study may be ascribed to the chemical and physical characteristics of the soil of the production sites, atmospheric deposition of heavy metals, which may be affected by numerous environmental aspects such as temperature, moisture content and wind velocity, deviations in the anthropogenic behaviors, long term application of phosphate fertilizers and metal-based pesticides in production sites, and urban industrial activities around the market sites. In the present study, *Mukunuwenna* samples collected from Wellampitiya and Kolonnawa areas showed higher degree of metal contamination. This may be attributed to the close proximity of the selected sites to the Kolonnawa and Orugodawatta oil refinery and storage tanks and the Meethotamulla garbage dumpsite. In addition, the two areas contain several medium scale industries and warehouses, numerous automobile workshops and garages, as well as high population and traffic density. In Kottawa area, the selected sites were located closer to the Southern Expressway (E01 Road) and along the heavily traffic congested High-level Road (A4 Road). However the production and market sites selected in Piliyandala, Bandaragama, Delgoda and Kahathuduwa areas are suburban settings with less congested traffic and other urban activities.

Table 1. Mean (±SD) heavy metal concentrations of field, market and processed Mukunuwenna samples (mg kg^{-1}, Dry Weight Basis)

Sample	No of samples (n)	Ni	Cd	Cr	Pb	Cu
Production Sites:						
Piliyandala	9	2.16±1.13^{a}	0.11±0.03^{a}	0.85±0.50^{a}	0.20±0.12^{a}	6.80±2.02^{ab}
Wellampitiya	11	7.67±4.16^{ab}	0.27±0.11^{ab}	5.58±2.59^{b}	5.87±3.46^{b}	17.34±6.16^{c}
Kolonnawa	5	18.92±7.97^{c}	0.30±0.14^{b}	6.51±2.82^{b}	6.22±3.44^{b}	19.53±7.46^{c}
Kottawa	5	7.47±3.76^{ab}	0.22±0.08^{ab}	4.52±2.86^{b}	3.69±3.17^{b}	13.41±7.27^{bc}
Kahathuduwa	5	2.51±0.70^{a}	0.14±0.02^{a}	1.26±0.62^{a}	0.23±0.08^{a}	7.63±2.73^{ab}
Bandaragama	5	2.20±1.64^{a}	0.15±0.04^{a}	0.76±0.49^{a}	0.26±0.05^{a}	3.87±1.69^{a}
All	40	6.48±6.74	0.20±0.11	3.36±2.76	2.96±3.16	11.85±7.51
Market Sites:						
Piliyandala	7	3.12±2.19^{ad}	0.24±0.31^{a}	0.92±0.40^{a}	0.28±0.10^{a}	8.85±2.10^{ad}
Wellampitiya	10	9.42±2.28^{b}	0.30±0.16^{a}	5.59±2.66^{b}	6.14±4.09^{b}	16.40±2.22^{bc}
Kolonnawa	4	19.35±3.74^{c}	0.42±0.18^{a}	8.74±2.07^{b}	7.05±1.67^{b}	20.30±4.01^{c}
Kottawa	6	7.50±1.77^{ab}	0.23±0.08^{a}	5.55±1.51^{b}	3.89±1.81^{ab}	12.90±4.23^{abd}
Bandaragama	4	2.79±0.93^{ad}	0.15±0.04^{a}	1.55±1.13^{a}	0.26±0.04^{a}	9.11±5.44^{ad}
Kahathuduwa	2	2.42±0.99^{ad}	0.16±0.03^{a}	0.78±0.64^{a}	0.31±0.01^{a}	5.96±0.97^{ad}
Pettah	4	10.88±6.81^{b}	0.25±0.11^{a}	5.93±4.32^{b}	6.53±0.76^{b}	14.01±4.99^{cd}
Delgoda	3	0.63±0.28^{d}	0.09±0.06^{a}	0.53±019^{a}	0.12±0.03^{a}	10.95±4.12^{ad}
All	40	7.90±5.98	0.25±0.18	4.09±3.36	3.63±3.65	13.05±5.15
Processed samples:						
Raw	10	2.20±1.04^{a}	0.19±0.11^{a}	2.37±1.58^{a}	0.26±0.39^{a}	9.59±4.48^{a}
Cooked	10	1.77±0.84^{a}	0.12±0.07^{a}	2.27±1.57^{a}	0.22±0.34^{a}	8.29±3.35^{a}
Stir Fried	10	1.46±1.03^{a}	0.10±0.06^{a}	2.20±1.54^{a}	0.21±0.34^{a}	7.45±3.72^{a}
WHO/FAO	MPL	4.0*	0.2	2.3	0.3	40

*According to Food and Nutrition Board: Institute of Medicine, 2010. MPL – Maximum Permissible Limit established by WHO/FAO, 2006. Values in the same column with a same superscript letter are not significantly different from each other ($P < 0.05$).

The results showed no significant differences in heavy metal contents among raw, cooked and stir-fried *Mukunuwenna* samples ($P<0.05$). Therefore, the different processing techniques have minimal effects on reducing the heavy metal levels in *Mukunuwenna* and this may be due to the difficulty of eliminating trace elements by either washing or heat processing.

4. Conclusions

Mukunuwenna grown and consumed in and around Colombo District, Sri Lanka, is contaminated with heavy metals. The average concentrations of Ni, Cd, Cr and Pb detected in the field and market *Mukunuwenna* samples, have exceeded the recommended values. Long term consumption of contaminated *Mukunuwenna* may cause detrimental effect on human and animals. Therefore, regular monitoring of heavy metals in *Mukunuwenna* as well as in other leafy vegetables should be performed to ensure the consumer safety.

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References

1. Premarathna HMPL, Indraratne SP, Hettiarachchi G. Heavy metal concentration in crops and soils collected from intensively cultivated areas of Sri Lanka. *19th World Congress of Soil Science*. 2010.
2. Sharma RK, Agrawal M, Marshall FM. Heavy metals in vegetables collected from production and market sites of a tropical urban area of India. *Food and Chemical Toxicology,* 2009; **47,** 583-591..
3. AOAC. *Official Methods of Analysis*. 15th Ed., Arlington, VA: AOAC; 2006.
4. Chandran S, Niranjana V, Bennyjoseph, Accumulation of heavy metals in wastewater irrigated crops in Madurai, India. *Journal of Environmental Research and Development*, 2012; **6 (3),** 432-438.