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ORIGINAL ARTICLE

Assessing Heavy Metal Contamination in Traditional Herbal Medicine (Jamu) by Atomic Absorption Spectrophotometry

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Abstract

Heavy metal contamination of traditional herbal medicine (jamu) is a threat to humans, especially at levels above known threshold concentrations. Traditional herbal medicine found in Banda Aceh City – Indonesia, polluted by heavy metals cadmium (Cd), lead (Pb), and mercury (Hg) was performed. Heavy metal analysis used Flame - Atomic Absorption Spectrometry (FAAS) and Chemical Vapor Generation - Atomic Absorption Spectrometry (CVG - AAS) methods. The validation of the method was performed to obtain more accurate heavy metal analysis results for the samples. Heavy metal contamination, especially Pb metal, with concentrations of 4.32 ± 0.14 mg/Kg to 29.25 ± 0.24 mg/Kg. The Cd metal contamination was only found in herbal medicine sample E with a concentration of 0.80 ± 0.02 mg/Kg, above the threshold. The Hg metal contamination was also found with concentrations of 0.20 ± 0.01 to 2.14 ± 0.06 mg/Kg, and some were not detected. The government should be very concerned about stopping the distribution of herbal medicine that can be harmful to health and should inspect drug stores that still sell herbs that do not have established standards.

Introduction

Traditional herbal medicine (jamu) is a product made from natural ingredients for health purposes [1]. Factors that motivate people to consume traditional herbal medicine include low price, easy to obtain, healing and no side effects [2–5]. However, the quality of herbal medicine is influenced by the processing process, such as the use of clean water, the drying process, environmental factors, storage, and packaging [6]. One that is easily contaminated by a product is heavy metal contamination [7].

Based on BPOM RI (The Indonesian Food and Drug Authority) Regulation Number 32 of 2019, requirements have been established for the quality control of traditional medicines. The aim is to protect the public from health risks associated with the use of medicinal products that do not meet safety, efficacy, and quality criteria. The maximum allowable levels for metal contamination in herbal medicine are ≤ 10 mg/Kg or mg/L for lead, ≤ 0.3 mg/Kg or mg/L for cadmium, and ≤ 0.03 mg/Kg or mg/L for mercury [8].

The consumption of herbal medicine aims to reduce resistance to synthetic drugs [9–12]. However, the presence of contaminants such as heavy metals will contribute to poisoning and increased accumulation of heavy metals in the bodies [13]. Diseases arising from the accumulation of heavy metals in the body include growth disorders, reproduction, hypertension, and possibly even cancer [14]. Cases of cadmium, lead and mercury metal contamination in herbal medicine have been found in Pekalongan City-Central Java Province, Pekanbaru-Riau Province and Tasikmalaya, with an average content exceeding the threshold [15–17].

Many herbal medicines in distribution have been found to contain high levels of heavy metal contamination. Until now, there has been no research reported on heavy metal contamination in herbal medicines sold commercially in Banda Aceh City, Indonesia. Therefore, this study analyzed heavy metal contamination, such as lead, cadmium and mercury, in herbal medicines sold commercially in Banda Aceh City. This study aimed to analyze the heavy metal contamination of commercially sold herbal medicines in Banda Aceh City, Indonesia. Specifically, the study sought to determine the levels of lead, cadmium, and mercury contamination in these herbal medicine products. By measuring the contamination levels, the study aimed to provide important safety information to consumers in Banda Aceh City who regularly take herbal medicines, as many herbal medicines distributed commercially have been found to contain high levels of toxic heavy metal contaminants. The data presented in this study provides important information for consumers who often take herbal medicines.

Materials and Methods

Tools, Equipment and Materials

The tools and equipment used were Flame – Atomic Absorption Spectrometry (FAAS) (Thermo Scientific iCE 3500), Chemical Vapor Generation – Atomic Absorption Spectrometry (CVG – AAS) (Agilent Technologies 200 series AA), Lead Hollow Cathode Lamp (Fisher Scientific), Cadmium Hollow Cathode Lamp (Fisher Scientific), Mercury Hollow Cathode Lamp (Agilent), Analytical Balance (OHAUS), Hot Plate (IKA), Fume Hood (Kewaunee), Volumetric Flask (Pyrex), Beaker Glass (Pyrex), Micropipette (Eppendorf), Funnel (Pyrex), Filter Paper (Whatman).

The materials used were Standard Lead Solution $Pb(NO_3)_2$ (Merck), Standard Cadmium Solution $Cd(NO_3)_2$ (Merck), Standard Mercury Solution $Hg(NO_3)_2$ (Merck), HNO_3 p.a (Merck), H_2O_2 p.a (Merck), HCl p.a (Supelco), deionized water, and a six different traditional herbal medicine (jamu) samples.

Sampling Technique

Six different brands of traditional herbal medicine (jamu) samples were collected using a random sampling technique in Banda Aceh-Indonesia, these herbs are easily available in drug stores and sold commercially without being registered with the Indonesian Food and Drug Authority (BPOM). Samples of herbs that have properties such as weight loss, gout arthritis and stamina booster.

Preparation of Standard Solution

Standards solutions of Pb, Cd and Hg were prepared refers to Souza 2020 research. The calibration solutions used in range of 0.1 to 3.2 mg/kg, 0.6 to 3.6 mg/kg and 0.1 to 0.6 mg/kg for Pb, Cd and Hg, respectively. The calibration standards solutions of Pb and Cd were determined by FAAS, and Hg was determined by CVG-AAS.

Sample Destruction

The herbal (jamu) sample in powder was weighed at 2 grams and placed into a 250-milliliter Erlenmeyer flask. Demineralized water (30 mL) and HNO_3 p.a. (20 mL) were added and stirred. Heat was applied for 5 minutes, and H_2O_2 p.a. (5 mL) was added. After cooling, the solution was filtered and diluted with deionized water in a 100-milliliter volumetric flask [18].

Determination of Pb, Cd, and Hg Concentrations

The analysis of lead (Pb) and cadmium (Cd) was measured by Flame – Atomic Absorption Spectrometry (FAAS) and the analysis of mercury (Hg) was measured by Chemical Vapor Generation – Atomic Absorption Spectrometry (CVG – AAS). The Pb, Cd, and Hg measurements were carried out at wavelengths of 283.3 nm, 228.8 nm, and 253.7 nm, respectively [19].

Data Analysis

The Pb, Cd, and Hg concentrations data were obtained based on the calibration curves that had been made. Determination of validation parameters was also carried out in the form of linearity (R^2), relative standard deviation (RSD) was used to determine the precision, and the recovery (%) was calculated based on intensity signal generated by the sample spike, limit of detection (LoD), limit of quantification (LoQ) and the uncertainty of sample concentration measurements expressed as standard deviation of concentration (Sc). All parameters was performed based on LINEST function on Microsoft Excel (Redmond, Washington, USA) [18].

Results and Discussion

This study analyzed the heavy metal content of lead (Pb), cadmium (Cd), and mercury (Hg) in traditional herbal medicines (jamu) distributed commercially in Banda Aceh City. The herbal medicine samples were purchased as powders from local drug stores and had registration numbers but were not approved by the Indonesian Food and Drug Authority (BPOM). The samples included weight loss herbs (A and B), gout and arthritis herbs (C, D, and E), and a stamina booster (F).

Heavy metal measurements were measured based on the method validation data presented in Table 1. Validation tests were performed to obtain good results [20]. These metals were measured with wavelengths in accordance with the sensitivity and intensity of the respective wave absorbance [21].

Table 1. Validation method parameters used to determine the heavy metal contents

Standard	Linearity	R^2	RSD (%)	Recovery (%)	LoD (mg/L)	LoQ (mg/L)
Pb	y=0.016x + 0.0007	0.9996	0.97	100.17	0.021	0.050
Cd	y=0.243x + 0.004	0.9995	0.99	100.22	0.029	0.075
Hg	y=0.0507 + 0.0067	0.9995	1.04	102.04	0.022	0.059

Table 1 shows that the content of heavy metals in herbal medicine samples varies based on the herbal medicine products collected. The results showed that the highest concentration of Pb metal was found in herbal medicine sample C, which was 29.25 ± 0.24 mg/Kg, and herbal medicine sample B had the lowest Pb metal concentration, which was 4.32 ± 0.14 mg/Kg. All of the samples, three herbal medicine samples have Pb concentration over the threshold (Pb ≤ 10), i.e., herbal medicine samples C, D, and F with concentrations of 29.25 ± 0.24 mg/Kg, 10.47 ± 0.15 mg/Kg, and 16.88 ± 0.21 mg/Kg, respectively. Some herbal medicines were also found in the Pekanbaru Riau Province-Indonesia, where the concentration of Pb metal reached 9.20 to 34.94 mg/Kg, over the threshold [15].

Table 2. Heavy metal concentrations contained in traditional herbal medicine (jamu)

Sample Code	Sample Weight (g)	Heavy Metal Concentration ± *Sc* (mg/Kg)		
		Pb	Cd	Hg
A	2.01	7.50 ± 0.18	n.d.	2.14 ± 0.06
B	2.02	4.32 ± 0.14	n.d.	0.68 ± 0.01
C	2.01	29.25 ± 0.24	n.d.	n.d.
D	2.03	10.47 ± 0.15	n.d.	0.20 ± 0.01
E	2.05	5.79 ± 0.18	0.80 ± 0.02	n.d.
F	2.01	16.88 ± 0.21	n.d.	n.d.
Max. threshold		≤10	≤0.3	≤0.03

n.d. = not detected

The Cd metal content in herbal medicine was only detected in sample E at 0.80 ± 0.02 mg/Kg, and it was over the threshold (Cd ≤ 0.3). Analysis of Hg metal content showed that three herbal medicine samples were contaminated, including samples A, B, and D, with concentrations of 2.14 ± 0.06 mg/Kg, 0.68 ± 0.01 mg/Kg, and 0.20 ± 0.01 mg/Kg, respectively, with a Hg metal threshold of ≤ 0.03. The Cd and Hg metal contents were also found in some herbal medicine samples, with Cd metal concentrations reaching 7.38 to 18.86 mg/Kg and Hg metal concentrations reaching 0.21 to 1.82 mg/Kg, metals over the threshold [15,22].

Conclusions

This study found concerning levels of toxic heavy metal contamination, particularly lead, in traditional herbal medicines sold commercially in Banda Aceh City, Indonesia. Using validated analytical methods of FAAS and CVG-AAS, samples of locally purchased herbal medicines contained measurable amounts of lead, cadmium, and mercury. The lead concentrations ranged from 4.32 ± 0.14 mg/Kg to 29.25 ± 0.24 mg/Kg, with several samples exceeding acceptable safety limits. One sample contained cadmium at 0.80 ± 0.02 mg/Kg, also surpassing the permitted threshold. Mercury was detected in all samples at concentrations from 0.20 ± 0.01 to 2.14 ± 0.06 mg/Kg. These results demonstrate that traditional herbal medicines sold in Banda Aceh City currently pose health risks to consumers due to heavy metal contamination making them unsafe for human consumption. Regulatory action is needed to halt the sale of contaminated herbal medicines. The government and the Indonesian Food and Drug Authority should increase inspections and enforce standards to restrict the circulation of toxic herbal medicines. Further research on heavy metal levels is also recommended to inform evidence-based policies to better protect public health. Tighter controls and regulatory oversight of all distributed herbal medicines should be implemented to prevent heavy metal exposure and ensure consumer safety.

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Conflicts of Interest: All the authors declare that there are no conflicts of interest.

References

[1] Sumarni W, Sudarmin S, Sumarti SS. The scientification of jamu: a study of Indonesian's traditional medicine. J. Phys. Conf. Ser., vol. 1321, IOP Publishing; 2019, p. 32057.

[2] Alkhamaiseh SI, Aljofan M. Prevalence of use and reported side effects of herbal medicine among adults in Saudi Arabia. Complementary Therapies in Medicine 2020;48:102255.

[3] Maulydia NB, Khairan K, Noviandy TR. Prediction of Pharmacokinetic Parameters from Ethanolic Extract Mane Leaves (Vitex pinnata L.) in Geothermal Manifestation of Seulawah Agam Ie-Seu'um, Aceh. Malacca Pharmaceutics 2023;1:16–21. https://doi.org/10.60084/mp.v1i1.33.

[4] Dolongtelide JI, Fatimawali F, Tallei TE, Suoth EJ, Simbala HEI, Antasionasti I, et al. In Vitro Antioxidant Activity of Chrysanthemum indicum Flowers Extract and Its Fraction. Malacca Pharmaceutics 2023;1:43–7. https://doi.org/10.60084/mp.v1i2.26.

[5] Khairan K, Arini M, Idroes R, Awang K, Jacob C. Antibacterial Activity of n-Hexane Dragon's Blood Resin Extract (Daemonorops draco wild Blume) from Bener Meriah, Aceh Province, Indonesia. Malacca Pharmaceutics 2023;1:22–9. https://doi.org/https://doi.org/10.60084/mp.v1i1.29.

[6] Ahad B, Shahri W, Rasool H, Reshi ZA, Rasool S, Hussain T. Medicinal plants and herbal drugs: An overview. Medicinal and Aromatic Plants: Healthcare and Industrial Applications 2021:1–40.

[7] Mishra S, Bharagava RN, More N, Yadav A, Zainith S, Mani S, et al. Heavy metal contamination: an alarming threat to environment and human health. Environmental Biotechnology: For Sustainable Future 2019:103–25.

[8] Obat BP, Indonesia MR. Peraturan Badan Pengawas Obat dan Makanan Nomor 32 Tahun 2019 tentang Persyaratan Keamanan dan Mutu Obat Tradisional. Jakarta, Indonesia: Badan Pengawas Obat Dan Makanan Republik Indonesia 2019.

[9] Singh A, Mishra A, Chaudhary R, Kumar V. Role of herbal plants in prevention and treatment of parasitic diseases. J Sci Res 2020;64:50–8.

[10] Noviandy TR, Maulana A, Emran TB, Idroes GM, Idroes R. QSAR Classification of Beta-Secretase 1 Inhibitor Activity in Alzheimer's Disease Using Ensemble Machine Learning Algorithms. Heca Journal of Applied Sciences 2023;1:1–7. https://doi.org/10.60084/hjas.v1i1.12.

[11] Fakri F, Harahap SP, Muhni A, Khairan K, Hewindati YT, Idroes GM. Antimicrobial Properties of Medicinal Plants in the Lower Area of Ie Seu-um Geothermal Outflow, Indonesia. Malacca Pharmaceutics 2023;1:55–61. https://doi.org/10.60084/mp.v1i2.44.

[12] Noviandy TR, Maulana A, Idroes GM, Maulydia NB, Patwekar M, Suhendra R, et al. Integrating Genetic Algorithm and LightGBM for QSAR Modeling of Acetylcholinesterase Inhibitors in Alzheimer's Disease Drug Discovery. Malacca Pharmaceutics 2023;1:48–54. https://doi.org/10.60084/mp.v1i2.60.

[13] Wieczorek J, Baran A, Urbański K, Mazurek R, Klimowicz-Pawlas A. Assessment of the pollution and ecological risk of lead and cadmium in soils. Environmental Geochemistry and Health 2018;40:2325–42.

[14] Fatima G, Raza AM, Hadi N, Nigam N, Mahdi AA. Cadmium in human diseases: It's more than just a mere metal. Indian Journal of Clinical Biochemistry 2019;34:371–8.

[15] Husna OL, Hanifah TA, Kartika GF. Analisis Kandungan Logam Timbal, Kadmium dan Merkuri dalam Produk Jamu Pegal Linu yang Beredar di Kota Pekanbaru 2015.

[16] Endah SRN. Validasi Metode Analisis Cemaran Logam Berat: Timbal (Pb) Dan Kadmium (Cd) Dengan Variasi Oksidator Secara Spektrofotometri Serapan Atom Dalam Sediaan Obat Herbal. Journal of Pharmacopolium 2020;2.

[17] Rusmalina S, Khasanah K, Madusari BD. Uji Cemaran Logam Berat Timbal Dan Cadmium Pada Formula Jamu Serbuk Kunyit Asem Dengan Metode Spektrofotometri Visibel. Benzena Pharmaceutical Scientific Journal 2023;2.

[18] Irnawati I, Idroes R, Zulfiani U, Akmal M, Suhartono E, Idroes GM, et al. Assessment of arsenic levels in water, sediment, and human hair around ie seu'um geothermal manifestation area, aceh, indonesia. Water (Switzerland) 2021;13:1–13. https://doi.org/10.3390/w13172343.

[19] Abubakar A, Yusuf H, Syukri M, Nasution R, Yusuf M, Idroes R. Heavy metals contamination in geothermal medicinal plant extract; Chromolaena odorata Linn. Global Journal of Environmental Science and Management 2023;9:995–1004.

[20] Winarsih A, Idroes R, Zulfiani U, Yusuf M, Mahmudi M, Saiful S, et al. Method Validation for Pesticide Residues on Rice Grain in Aceh Besar District, Indonesia Using Gas Chromatography-Electron Capture Detector (GC-ECD). Leuser Journal of Environmental Studies 2023;1:18–24. https://doi.org/10.60084/ljes.v1i1.37.

[21] Maurya A, Kesharwani L, Mishra MK. Analysis of heavy metal in soil through atomic absorption spectroscopy for forensic consideration. Int J Res Appl Sci Eng Technol 2018;6:1188–92.

[22] Devi GLG, Susanti MM. Analisis Cemaran Logam Berat Kadmium (Cd) Dalam Jamu Pegal Linu Dengan Metode Spektrofotometri Serapan Atom (SSA). Journal Clinical Pharmacy and Pharmaceutical Science 2022;1:9–16.