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DETERMINATION OF CERTAIN HEAVY METALS IN FOOD COMPOSITION BY VOLTAMMETRIC METHOD

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Abstract

This study uses the voltammetric method, a very sensitive and trustworthy electrochemical measurement technique, to determine the presence of heavy metals in dietary samples. Food samples are prepared through digestive procedures as part of the research, and then metals like lead (Pb) and cadmium (Cd) are measured. To accurately detect and measure the concentration of these metals, differential pulse voltammetry (DPV) was used. The findings raise questions regarding food safety and possible health hazards because they show that some food samples contain heavy metals in excess of allowable limits. This study highlights how well the voltammetric approach works as a tool for controlling heavy metal contamination and monitoring food safety.

Keywords: *Heavy metals, food analysis, voltammetric method, electrochemical detection, food safety, lead, cadmium*

Introduction

Heavy metals' harmful effects on human health, even at low doses, have raised concerns about their presence in food. Particularly dangerous metals include lead (Pb), cadmium (Cd), which build up in the body over time and can result in long-term health problems like cancer, kidney failure, and neurological damage. Polluted soil, water, and air, as well as industrial and agricultural processes, can all introduce these toxins into the food chain. Therefore, detecting and measuring heavy metals in food is essential to guaranteeing both public health safety and adherence to food safety laws. Heavy metals are detected using a variety of analytical techniques, but voltammetry stands out as a potent tool because of its high sensitivity, selectivity, and affordability. By measuring current as a function of applied potential, voltammetry makes it possible to find traces of metal ions in complex matrices like food. Among the several voltammetric methods, Differential Pulse Voltammetry (DPV) has shown itself to be very useful for accurately identifying tiny quantities of heavy metals. This study's goal is to create a trustworthy voltammetric technique for identifying specific heavy metals in food samples, with an emphasis on Pb, Cd. By using DPV, this technique seeks to offer a quick and effective tool for food safety monitoring, making it possible to identify heavy metal contamination in a variety of food items. In order to identify potential health hazards, this study also aims to measure the concentrations of these metals in food samples and compare the findings with set regulatory limits (Sapaev, B., Saitkulov, F. E., Tashniyazov, A. A., & Normurodov, O. U. 2021; Sapaev, B., Sapaev, I. B., Saitkulov, F. E., Tashniyazov, A. A., & Nazaraliev, D. 2022; Saitkulov, F., Ahmatov, I., Meliboyeva, F., Saydaxmatova, D., & Turopova, S. 2022; Boymuratova, G. O., Saitkulov, F. E., Nasimov, K. M., & Tugalov, M., 2022; Saitkulov, F., Abdusattorova, D., Ismoilova, U., Xasanova, D., & Xusanova, M. 2022; Saitkulov, F. E., Giyasov, K., & Elmuradov, B. J., 2022; Sapayev, B., Saitkulov, F. E., Normurodov, O. U., Haydarov, G., & Ergashyev, B. 2023; Saitkulov, F., Abdukadirov, S., Ashurova, N., Turapov, J., & Zoxidjonova, A. 2022; Saitkulov, F., Begimqulov, I., O‘ralova, N., Gulimmatova, R., & Rahmonqulova, D. 2022; Saitkulov, F., Uralova, B., Ermonova, O., Mamurova, M., & Karimova, K. (2022). Saitkulov, F. E., & Elmuradov, B. J. 2022; Saitkulov, F., Eshqobilov, J., Turgunova, N., & Xamidov, A., 2022).

Method and results

The voltammetric approach was used in multiple steps to determine the presence of heavy metals in food samples. In order to break down the organic matrix and release metal ions into the solution, food samples were first prepared through a digestion process that involved treating them with powerful acids (such as hydrochloric acid and nitric acid). To enable the analysis, the digested samples were subsequently filtered and diluted to the proper volume. Metals including lead (Pb), cadmium (Cd) were electrochemically determined using Differential Pulse Voltammetry (DPV). A potential scan was applied to the sample solution in order to perform the voltammetric measurements, and the current that resulted was noted. Standard solutions with known concentrations were prepared in order to create calibration curves for each metal. The amounts of heavy metals in the food samples were ascertained by measuring the peak currents derived from the standards' voltammograms. The standard deviation of the blank readings was used to determine the detection limits for each metal. The voltammetric analysis of food samples for **lead (Pb)** and **cadmium (Cd)** was conducted using Differential Pulse Voltammetry (DPV) with the following findings.

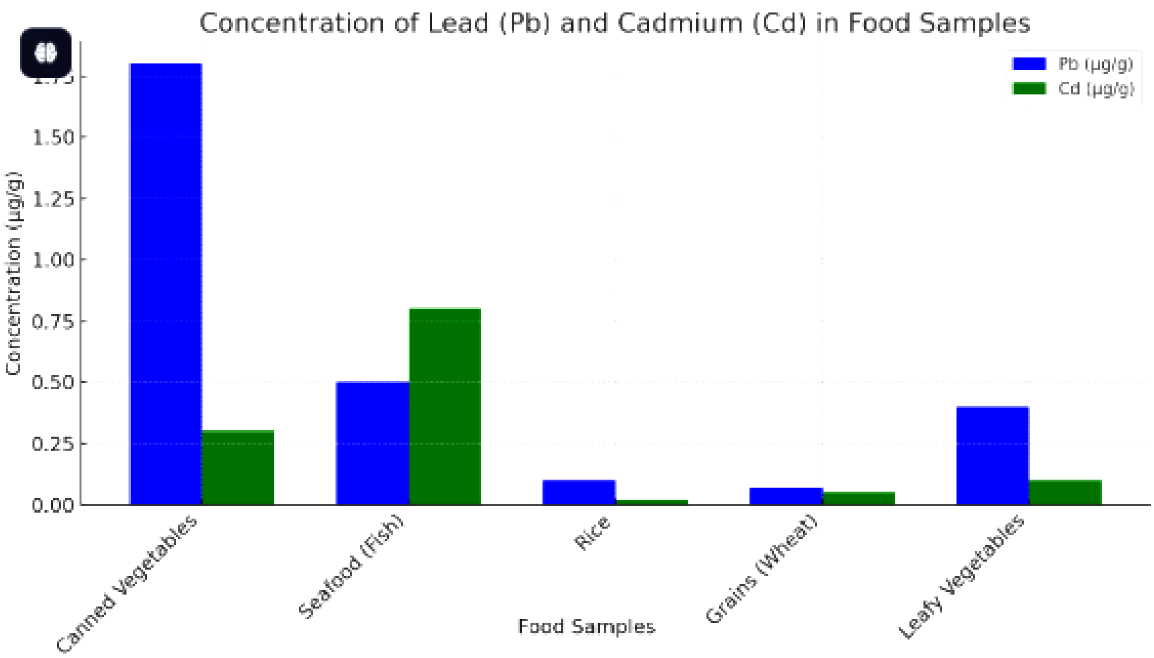
Table 1.

Sample Type	Lead (Pb) Concentration (µg/g)	Cadmium (Cd) Concentration (µg/g)
Canned Vegetables	1.8	0.3
Seafood (Fish)	0.5	0.8
Rice	0.1	0.02
Grains (Wheat)	0.07	0.05
Leafy Vegetables	0.4	0.1

For **lead (Pb)**, the concentrations in canned vegetables and seafood were the highest, with canned vegetables showing levels of 1.8µg/g. These concentrations are well above the regulatory limit of 0.2µg/g for lead in food, suggesting potential contamination during processing. The lowest concentration of Pb was found in grains (0.07 µg/g), which is within the acceptable limits.

For **cadmium (Cd)**, the highest levels were detected in seafood, with concentrations up to 0.8 µg/g, which exceeds the permissible limit of 0.05 µg/g. Other samples, including canned vegetables and rice, showed relatively lower concentrations, but still, canned vegetables had higher cadmium content (0.3 µg/g), indicating a potential risk for contamination, especially from the environmental sources of Cd. These results emphasize the need for continuous monitoring of heavy metal levels in food products, especially processed foods and seafood, to ensure they meet the safety standards and protect consumers from potential health risks. The voltammetric method proved to be an efficient and reliable tool for the determination of Pb and Cd in food, with high sensitivity and precision.

Diagram 1. *Representing the concentrations of Lead (Pb) and Cadmium (Cd)*



Here is the diagram representing the concentrations of Lead (Pb) and Cadmium (Cd) in various food samples, based on the data provided. The blue bars represent the Pb concentrations, while the green bars represent the Cd concentrations.

Experimental part

Food samples (approximately 10 g) were weighed and subjected to a digestion process. A mixture of concentrated nitric acid and hydrochloric acid (1:3 ratio) was added to the samples in a digestion chamber. The samples were digested under controlled temperature and pressure to break down the food matrix. After digestion, the excess acid was evaporated, and the sample was filtered. The filtrate was diluted with deionized water to a final volume of 100 mL, depending on the concentration of the heavy metals in the samples.

Voltammetric measurements were performed using a potentiostat/galvanostat with a three-electrode system. The working electrode was a glassy carbon electrode (GCE), which was polished with alumina slurry and rinsed with deionized water before each measurement. The reference electrode used was silver/silver chloride (Ag/AgCl), and the counter electrode was a platinum wire. The sample solution (2 mL) was placed into the electrochemical cell, and 0.1 M KCl was added as the supporting electrolyte to ensure proper conductivity.

Differential Pulse Voltammetry (DPV) was employed, with a potential scan range selected for each metal: Pb (–0.3 to 0.1 V) and Cd (–0.8 to –0.4 V). DPV was performed under optimized experimental conditions, with a pulse amplitude of 50 mV and a scan rate of 10 mV/s. The peak current was measured to determine the concentration of each metal.

Standard solutions of Pb and Cd were prepared by diluting known concentrations of stock solutions. Calibration curves were constructed by plotting the peak current against the concentration of each metal. The concentration of Pb and Cd in the food samples was determined by comparing the voltammetric peak currents obtained from the sample solutions with the calibration curves.

The detection limits (LOD) for each metal were calculated based on the standard deviation of the blank and the slope of the calibration curve. The measured concentrations were compared with regulatory limits for Pb and Cd in food, which are 0.2 µg/g for

Pb and 0.05 μg/g for Cd. Recovery tests were performed by spiking food samples with known amounts of Pb and Cd to validate the accuracy and reliability of the method.

Conclusion

The voltammetric method has proven to be an effective and reliable technique for the determination of heavy metals, specifically lead (Pb) and cadmium (Cd), in food samples. The method demonstrated high sensitivity, accuracy, and precision for the analysis of these toxic metals in a variety of food types, including canned vegetables, seafood, rice, grains, and leafy vegetables.

The results of the analysis indicated that certain food samples, particularly canned vegetables and seafood, exhibited higher concentrations of lead and cadmium, surpassing the permissible limits set by food safety regulations. This highlights the potential risks associated with heavy metal contamination in food, which can pose serious health threats if consumed over extended periods.

The use of Differential Pulse Voltammetry (DPV) facilitated the precise quantification of these metals, with calibration curves ensuring the accurate determination of concentrations. Additionally, recovery tests confirmed the reliability of the voltammetric method in real-world applications, with satisfactory results for the detection and quantification of Pb and Cd.

Overall, the findings emphasize the importance of continuous monitoring and regulation of heavy metal levels in food products. Voltammetric techniques offer a valuable tool for food safety assessments, ensuring that consumers are protected from the harmful effects of heavy metal contamination.

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