Influence of some boron-based foliar fertilizers on the Cd and Pb content of Pleurotus ostreatus mushrooms

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Abstract

In this paper we present our results obtained from a study aimed at determining the Cd and Pb concentrations of Pleurotus ostreatus mushrooms grown on three identical substrates, of sawdust and straw, with a surface area of one square meter, which were fertilized with a different Boron-based foliar fertilizer (Folibor, Polyaciv B, and Agribor). The amounts of Boron administred were 30 mg/m^2 for Folibor, 26 mg/m^2 for Polyactiv B, and 27 mg/m^2 for Agribor. Determination of Cd and Pb concentrations in mature mushroom were performed using a Shimadzu AA-7000 Grafite Furnace Atomic Absorption Spectrophotometer (AAS-GF). Cd concentrations in mushrooms had the values 0.79 µg/g, 0.77 µg/g, and 0.60 µg/g in the case of the fertilizers Folibor, Plyactiv B, and Agribor, respectively. These values exceed approximately four times the maximum permissible concentration for Cd in mushrooms, 0.15 µg/g. The values of Pb concentrations in mushrooms were 0.16 µg/g, 0.15 µg/g, and 0.14 µg/g for Folibor, Polyactiv B, and Agribor, respectively. Even though the Pb concentrations in mushrooms fertilized in this way are about two times lower than the maximum permissible limit for Pb, 0.30 µg/g, due to the high Cd concentrations, these fertilizers cannot be applied to the substrate on which mushrooms are grown because they do not satisfy the nutritional requirements.

Keywords: Pleurotus ostreatus, (AAS-GF) Shimadzu AA-7000, Folibor, Polyactiv B, Agribor, heavy metals Cd and Pb

1. Introduction

Pleurotus ostreatus mushrooms are widely cultivated due to their nutritional value, rich in protein, fiber, vitamins, and bioactive compounds with antioxidant properties [1].

These mushrooms have the ability to grow on various agricultural waste (straw, sawdust, wood chips, stems), thus being promoters of the circular economy through the reuse of degradable biomass [1, 2].

The functions of boron-based foliar fertilizers in plants are known: cell growth and development, stimulates cell division and cell wall formation, helps with cell elongation and the development of young tissues, pollination and fertility.

Mushrooms are notable for their ability to absorb heavy metals from the substrate. A recent study reveals the ability of Pleurotus ostreatus to accumulate elements such as Cd and Zn from the substrate, highlighting a high bioaccumulation factor for these metals [2]. The methods used in studying the composition of mushrooms are similar to those generally used in chemical analysis [3–10]. Quantitative analysis of mushrooms can be also performed using laser-induced fluorescence [11]. By using a Shimadzu AA-7000 Graphite Furnace Atomic Absorption Spectrophotometer (AAS-GF) we determined the concentrations of Pb and Cd in Pleurotus ostreatus mushrooms cultivated on substrates fertilized with boron-based fertilizers (Folibor, Polyactiv B, and Agribor) and we discussed the results obtained by comparing these values with the maximum permissible concentrations of these heavy metals.

2. Experimental part. Sample preparation

In our study, we used three boron-based foliar fertilizers: Folibor, Polyactiv B, and Agribor. Their boron concentrations were: 150 g/L, 130 g/L, and 135 g /L, respectively. Taking into account the fact that for fertilizing one hectare by fertigation with these fertilizers, a solution composed of 2 liters of fertilizer and 798 liters of water is prepared, it results that, for an area of one square meter, a solution composed of 0.2 ml of fertilizer and 79.8 ml of water is used. Consequently, the amounts of boron used per square meter are: 30 mg, 26 mg, and 27 mg, respectively.

In our study, we prepared three identical substrates of straw and sawdust, each one square meter in area. The first substrate was fertilized uniformly with the solution from Folibor (30 mg boron per square meter). For the second substrate we used the solution prepared from Polyactiv B (26 mg boron per square meter), and the third substrate was fertilized with the solution prepared from Agribor (27 mg boron per square meter). For the cultivation of Pleurotus ostreatus mushrooms on the these three substrates, the same mycelia were used and all growth conditions were identical (temperature, humidity, brightness, etc.). When the mushrooms reached maturity, a quantity of 14 – 16 g mushrooms from the three substrates were harvested separately. In order to analyze the concentration of Cd and Pb in the harvested mushrooms, drying, grinding and acid digestion in the 200 mL HNO3 solution 10%, during 24 Hours, followed.

3. Results and discussion

The analyses were performed using a Shimadzu AA-7000 Graphite Furnace Atomic Absorption Spectrophotometer (AAS-GF). In order to determine the Cd concentrations in samples, the Cd lamp was used and the wavelength λ=228.8 nm was selected. The calibration curve for Cd is presented in Fig. 1, which shows the dependence of the Absorbance (Abs) on the Cd concentration [Cd].

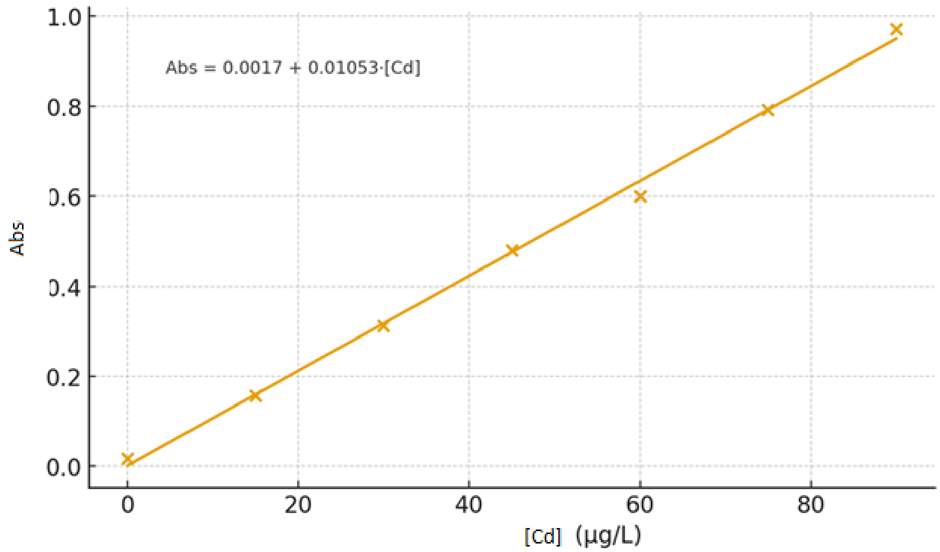

Figure 1. Calibration curve for Cd

Regulation (EU) 2023/915 established the maximum permissible concentration (MPC) for Cd in mushrooms as 0.15 µg/g and for Pb as 0.30 µg/g [12]. The experimental results in the case of Cd determination are contained in the Table 1.

Table 1. The concentration of Cd in Pleurotus ostreatus mushrooms determined by Atomic Absorption Spectrometry

Fertilizer	Pleurotus weight (g)	[Cd] from liquid sample (µg/L)	Weight of Cd from 200 ml of liquid sample (µg)	[Cd] from mushrooms (µg/g)	MPC for Cd (µg/g)
Folibor	14.33	56.87	11.37	0.79	0.15
Polyactiv B	14.99	58.23	11.64	0.77	
Agribor	15.42	46.48	9.29	0.60	

We remark that the concentrations of Cd in all three cases are greater than approximately four times the MPC for Cd in mushrooms. Therefore, these fertilizers cannot be used on mushrooms in the usual doses for plants.

To determine the Pb concentrations in the samples, a Pb lamp was used and the wavelength λ=288.3 nm was chosen. The calibration curve for Pb is shown in Fig. 2, which shows the dependence of the Absorbance (Abs) on the Pb concentration [Pb].

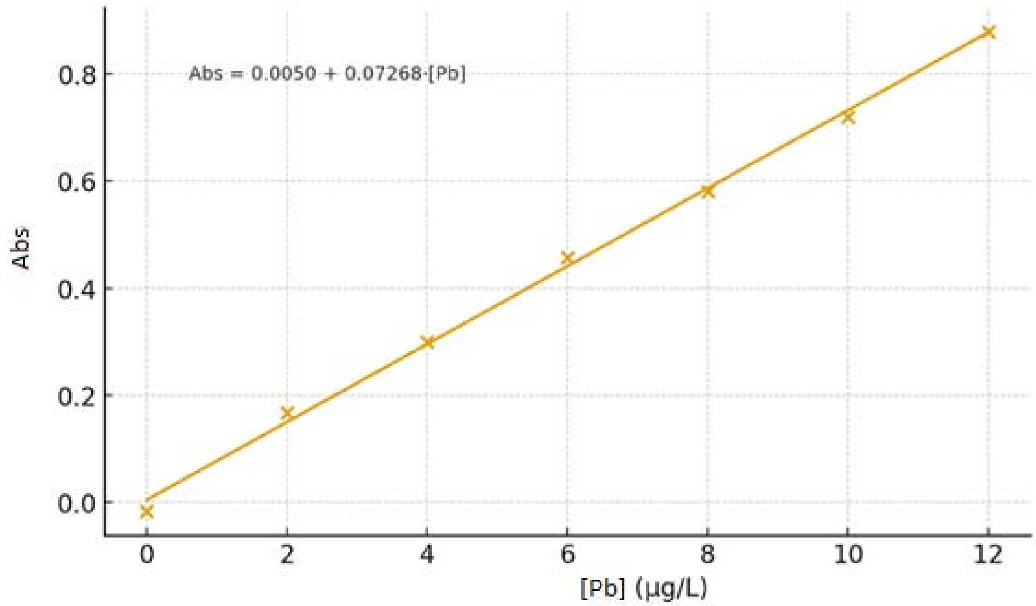

Figure 2. Calibration curve for Pb

The experimental results in the case of Pb determination are contained in the Table 2.

Table 2. The concentration of Pb in Pleurotus ostreatus mushrooms determined by Atomic Absorption Spectrometry

Fertilizer	Pleurotus weight (g)	[Pb] from liquid sample (µg/L)	Weight of Pb from 200 ml of liquid sample (µg)	[Pb] from mushrooms (µg/g)	MPC for Pb (µg/g)
Folibor	14.33	11.25	2.25	0.16	0.30
Polyactiv B	14.99	11.40	2.28	0.15	
Agribor	15.42	10.98	2.19	0.14	

We observe that Pb concentrations are about two times lower than the MPC of Pb for mushrooms.

4. Conclusions

By treating the substrates with the three boron-based foliar fertilizers (Folibor, Poliactiv B, and Agribor) in the usual concentrations for plants, the Pleurotus ostreatus mushrooms accumulated significant concentrations of Cd. The corresponding values are 0.79 µg/g, 0.77 µg/g, and 0.60 µg/g, respectively. These concentrations exceed at least four times the maximum permissible value for Cd in mushrooms, 0.15 µg/g. The Pb concentrations in Pleurotus ostreatus mushrooms determined from this study were 0.16 µg/g, 0.15 µg/g, and 0.14 µg/g for Folibor, Poliactiv B, and Agribor, respectively. We note that the Pb concentrations of mushrooms cultivated on a substrate fertilized with these fertilizers have values approximately two times lower than the maximum allowed value for Pb, 0.30 µg/g.

Although Pb concentrations are lower than the maximum permitted limit for Pb, taking into account that Cd concentrations exceed the maximum permitted value by approximately four times, it follows that mushrooms grown in this way cannot be consumed because they do not meet food safety standards.

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