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Evaluation of the Content of Cd and Pb in the Extruded Products with the Addition of Broad Bean Post-fermentation Meal and Herbs

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Abstract. The aim of this study was to evaluate the content of Cd and Pb in the novel food products (NFPs) obtained by extrusion of maize corn with the addition of broad bean post-fermentation meal and herbs, such as: control based on ground maize (C) and with the addition of 25% broad bean post-fermentation meal (B), with the addition of broad bean post-fermentation meal and lovage herb (B+L), as well as with the addition of broad bean post-fermentation meal and thyme herb (B+T). The content of Cd and Pb were determined after dry ashing of samples by the GF-AAS method.
The content of Cd and Pb were relatively low and did not exceed the permitted levels specified by the EU Commission Regulation. The highest content of Cd was found in the extruded product (B+L): 0.0179±0.0009 mg/kg, lower in the extruded product (B) 0.0168±0.0014 mg/kg and (B+T) 0.0146±0.0002 mg/kg, while the lowest in the control extruded product (C) (0.0061±0.0010 mg/kg). The content of Pb ranged from 0.020±0.002 mg/kg in the extruded product (B), to 0.042±0.001 mg/kg in the extruded product (B+T), while the levels of this metal in the extruded products control (C) and (B+L) were: 0.039±0.001 mg/kg and 0.024±0.004 mg/kg, respectively.

Keywords: cadmium, lead, broad bean meal, lovage, thyme

1. Introduction

The presence of heavy metals in food products has become a global problem. Due to a major threat to human health, the content of Cd (cadmium) and Pb (lead) in food products has been limited by EU (European Union) standards [1]-[3]. Cadmium and lead are the most common toxic metals that have become a matter of concern due to the reports of their contamination in various foodstuffs. The knowledge of the degree of environmental pollution with Cd and Pb, reflected in the level of these metals in food products, is extremely important from the point of view of food safety [4]-[8]. Cadmium and lead ingested with food are absorbed from the GI tract, pass through biological barriers and accumulate in internal organs. It is believed that chronic exposure to small amounts of Cd and Pb may cause metabolic disorders. For example, chronic exposure of cadmium causes kidney damage, decalcification and deformation of bones, respiratory distress, lung and breast cancers, haemorrhagic injuries, anemia and cardiovascular disorders, anosmia, impotence and hypertension. Cd has been classified as carcinogenic to humans by International Agency for Research on Cancer (IARC) [9], [10]. Pb is known to cause anemia, leukemia, irreversible damage to the nervous system, miscarriage, lower sperm count and hepatotoxicity in higher concentration [9]-[11].

Almost all kinds of food products can contain some (usually very small) amounts of Cd and Pb. Cereal grains and legumes and their products together with vegetables are considered as the main sources of these metals in human diet [9].

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The aim of this study was to assess the content of Cd and Pb in the prototypes of Novel Food Products (NFP) obtained from maize grains, broad bean post-fermentation meal and herbs.

2. Material and Methods

2.1. Material Preparation

The preparation stages of NFP production included the following processes: grinding of seeds, moistening (addition till 50% of water), bacterial fermentation (*Lactobaccillus planatarum* ATCC 8004 strain, at temperature of 37^{o}C for 18 hrs), drying at 50°C (until final content of water 15 - 17%). The crude plant materials were suspended in water (50 mg/mL) and extracted by shaking for 30 min. at 150 rpm. The extracts were sterilized by micro-filtration using 0.45 μm Millipore filters. The details of the thermoplastic treatment were given in our previous article [12]. The extruded NFPs were obtained from the ground maize corn, broad bean post-fermentation meal and herbs, mixed at the ratio of 74.5 : 25: 0.5 (mass units), while the control sample contained only the ground maize corn (100%). Finally the studied prototypes of NFPs were: control ground maize corn (C), ground maize corn with the addition of 25% broad bean post-fermentation meal (B), ground maize corn with the addition of broad bean post-fermentation meal and lovage herb (B+L), and ground maize corn with the addition of broad bean post-fermentation meal and thyme herb (B+T).

The content of Cd and Pb in NFPs was determined after dry ashing of samples (in a muffle furnace at 450^{o}C), by the graphite furance atomic absorption spectrometry (GF-AAS), using spectrometer AAS-5 EA with background correction (Jenoptic, Germany). The accuracy of the method was assured by simultaneous determination of the certified reference materials such as Basma Tabacco Leaves (INCT-OBTL-5) and Virginia Tabacco Leaves (CTA-VTL-2). The average recovery for Cd and Pb was 106.5% and 99.1%, respectively.

2.2. Statistical Analysis

The results were presented as arithmetic means and standard deviation and analyzed by one-way analysis of variance, post hoc Turkey's test, at the $p \leq 0.05$, using the Statistica for Windows 10.0 (StatSoft, Inc., Poland) computer program.

3. Results and Discussion

The evaluation of safety of food products involves determination of various chemical relevant chemical pollutants, e.g. pesticide residues, heavy metals, polychlorinated compounds.

The content of heavy metals in plant foods depends on variety of factors, such as: the kind of the material and its composition, origin, climate, atmospheric depositions, the concentrations of heavy metals in soil, the nature of soil, as well as the technological processes applied during food production [13].

The contents of Cd and Pb in NFPs are presented in Table 1. The determined values are relatively low and do not exceed the permitted levels specified by the European Union Commission Regulation (No. 420/2011 of 29 April 2011) [1]. The highest content of Cd was found in the extruded product (B+L): 0.0179 ± 0.0009 mg/kg d.m., lower in the extruded product (B) 0.0168 ± 0.0014 mg/kg d.m. and (B+T) 0.0146 ± 0.0002 mg/kg d.m., while the lowest in the control extruded product (C) (0.0061 ± 0.0010 mg/kg d.m.). Addition of 25% broad bean post-fermentation meal (B) alone or with herbs lovage (B+L), as well as thyme (B+T) increased Cd content in comparison to control product.

The content of Pb ranged from 0.020 ± 0.002 mg/kg d.m. in the extruded product (B), to 0.042 ± 0.001 mg/kg d.m. in the extruded product (B+T), while the levels of this metal in the extruded products control (C) and (B+L) were: 0.039 ± 0.001 mg/kg d.m. and 0.024 ± 0.004 mg/kg d.m, respectively. The extruded products control (C) and (B+L) had significantly higher content of Pb versus products with the addition of broad bean post-fermentation meal (B) alone and with thyme (B+T).

Table 1. The content of Cd and Pb in the NFPs.

Lp.	Product	The content of heavy metals in NFPs (mean ± SD; in mg/kg d.m.)			
		Cd	Anova	Pb	Anova
1	C	0.0061 ± 0.0010[a]	p<0.05	0.039 ± 0.001[b]	p<0.05
2	B	0.0168 ± 0.0014[bc]		0.020 ± 0.002[a]	
3	B+L	0.0179 ± 0.0009[c]		0.024 ± 0.004[a]	
4	B+T	0.0146 ± 0.0002[b]		0.042 ± 0.001[b]	

Agenda: (C) – extruded product control based on ground maize, (B) - with the addition of 25% broad bean post-fermentation meal, (B+L) - with the addition of broad bean post-fermentation meal and lovage herb, (B+T) - with the addition of broad bean post-fermentation meal and thyme herb
Different letter superscripts indicate a statistically significant difference at $p < 0.05$.

The content of Cd and Pb in food products are usually very low. Tohvonen and Kumpulainen [14], [15] reported that the content of Cd and Pb in cereal flakes were 0.042 mg/kg and 0.022 mg/kg, respectively. The contents of these metals in muesli cereals were 0.027 mg Cd/kg and 0.034 mg Pb/kg. The corn products contained 0.002 mg Cd/kg and 0.017 mg Pb/kg, rice products 0.010 mg Cd/kg and 0.031 mg Pb/kg, while oat products 0.026 mg Cd/kg and 0.019 mg/kg. In the study of Orzeł and Styczyńska [16], the levels of Cd and Pb in in the corn and wheat flakes ranged for Cd from 0.007 to 0.021 mg/kg, and for Cd from 0.028 to 0.082 mg/kg. The content of Cd in cereal products ranged from non-detectable to 0.100 mg/kg, with the highest value in pastas (0.058 ± 0.0330 mg/kg. The content of Pb in groats was 0.042 ± 0.0306 mg/kg [2], [17]. Kot et al. [18] determined the content of Cd and Pb of pastas and found that the mean Cd values from 0.004 mg/kg in nonglutenic pasta to 0.063 mg/kg in Spanish pasta, while the mean Pb levels from 0.034 mg/kg in Polish pasta to 0.082 mg/kg in Italian pasta. The obtained results are in agreement with other studies [19]-[22].

Gebologlu et al. [23] reported that the content of Cd in fruit and leaves of been were 0.07 mg/kg and 0.18 mg/kg, while Pb levels were 0.38 and 0.52 mg/kg, respectively. Orisakwe et al. [24] found that the content of heavy metals in beans grown in Nigeria were: 0.22 mg Cd/kg and 0.22 mg Pb/kg, in soybean 0.024 mg Cd/kg and 0.46 mg Pb/kg, and maize not detectable for Cd and 1.01 mg Pb/kg.

Salama and Radwan [25] found that some foodstuffs available on the Egyptian market can contain increased levels of heavy metals. For example, the content of Cd and Pb levels in cereals ranged from 0.091 to 0.142 mg/kg of Cd, 0.116 to 0.398 mg/kg of Pb, with the highest values of Cd and Pb in maize (0.142 mg Cd/kg d.m.; 0.116 mg Pb/kg d.m.) and wheat (0.131 mg Cd/kg d.m.; 0.398 mg Pb/kg d.m.), respectively. On the other hand, the mean content of Cd and Pb in legumes ranged from 0.010 to 0.178 mg Cd/kg and 0.013 to 0.281 mg Pb/kg, respectively. The highest Cd levels in legumes were found in common bean (0.178 mg Cd/kg d.m.; 0.217 mg Pb/kg d.m.) and the highest Pb content in broad bean (0.281 mg Pb/kg d.m.; 0.063 mg Cd/kg d.m.).

In the study of Al-Oud [26], the content of Cd and Pb in tea and herb leaves ranged from 0.03 to 4.84 mg/kg and from non-detectable to 0.37 mg/kg, respectively. Gasser et al. [27] reported that the levels of Cd and Pb in herbs were: in lovage root from 0.07 to 0.61 mg/kg and 0.04 to 1.15 mg/kg, respectively. The thyme contained 0.07- 0.7 mg Cd/kg and 0.4-4.73 mg Pb/kg.

4. Conclusions

The contents of Cd and Pb in NFPs are relatively low and do not exceed the permitted limits specified by the European Union Commission Regulation (No. 420/2011 of 29 April 2011).

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6. References

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