Research Article

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Chemical safety of *Acheta domesticus* powders: a cross-country study of trace elements, mycotoxins and feed-derived pesticide residues

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Abstract: Among edible insect species, the house cricket (*Acheta domesticus*) has gained particular prominence in commercial insect farming and various food applications. Since insects intended for use as food or feed can bioaccumulate biological and chemical contaminants, rigorous safety monitoring is essential. The objective of this study was to assess the levels of trace elements, mycotoxins, and pesticide residues in commercially available house cricket powders (CP) sourced from six countries: England (CP1), Scotland (CP2), Vietnam (CP3), Thailand (CP4), Canada (CP5), and Poland (CP6). Trace elements (As, Cd, Cr, I, Ni, Se, Zn, Hg, Pb, and Sb) were quantified following microwave digestion of samples in nitric acid, using inductively coupled plasma mass spectrometry (ICP-MS). Mycotoxins, including aflatoxins B1 and B2, fumonisins B1 and B2, ochratoxin A, and trichothecenes such as DON, 3-AcDON, and NIV, were determined using chromatographic methods appropriate for each analyte group, including GC-MS and HPLC with fluorescence detection. Pesticide residues were analysed via liquid chromatography–tandem mass spectrometry (LC-MS/MS). The results indicated that the majority of CP samples exhibited low and relatively safe levels of the targeted contaminants. However, elevated concentrations were observed in one sample, specifically arsenic (0.35 ± 0.01 mg/kg d.m.) and boscalid residue (3.95 ± 2.1 mg/kg d.m.). These findings warrant particular attention to the rearing conditions, including feed quality and environmental factors, to minimize potential bioaccumulation risks in future production.

Keywords: house crickets; insect powder; trace elements; mycotoxins; pesticides; safety

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1 Introduction

The global food system faces growing pressure from population growth, climate change, environmental degradation, and the resource intensity of conventional livestock production. These challenges have increased interest in alternative protein sources that can contribute to food security while reducing environmental burdens [1,2].

Edible insects are widely consumed in many regions and have attracted increasing attention in Western markets. Their potential advantages include efficient feed conversion, comparatively low water and land requirements, and a favourable nutritional profile that may include high-quality protein, essential amino acids, polyunsaturated fatty acids, minerals, and vitamins [3–7]. Among edible insects, the house cricket (*Acheta domesticus*) is particularly relevant for commercial production because it can be reared under controlled conditions, has a short production cycle, and can be processed into powders suitable for incorporation into bars, bakery products, pasta, and other composite foods [8–13]. In the European Union, frozen, dried, and powder forms of *A. domesticus* have been authorized as novel foods following EFSA safety assessment [14].

The safe use of cricket powder requires attention not only to nutrition and allergenicity but also to chemical hazards. Contaminants may originate from feed, rearing substrates, environmental dust, water, or post-harvest processing. Potentially toxic elements, mycotoxins, and pesticide residues are particularly relevant because whole insects are commonly processed, and residues present in the digestive tract or tissues may be retained in the final powder [15–18].

Chemical contamination may vary between suppliers and geographic regions because production systems differ in feed composition, substrate quality, environmental exposure, and regulatory oversight. The international trade of insect-derived ingredients therefore creates a need for comparable analytical data across origins, especially for products intended for direct incorporation into foods [19].

Given the increasing interest in insect-based foods in various markets, understanding the chemical safety of commercially available CPs is critical to safeguarding consumer health. This study addresses a critical knowledge gap by conducting a comprehensive cross-country analysis of chemical hazards in commercially produced *A. domesticus* powder. By examining trace element concentrations, mycotoxin levels, and pesticide residues across multiple geographic origins, this research aims to (i) characterize the chemical safety profile of commercially available CPs, (ii) identify potential geographic or production-related patterns in contamination, and (iii) evaluate potential health risks associated with CP consumption. The findings will contribute to the safe development of the edible insect industry, support informed regulatory decision-making, and ultimately facilitate the sustainable integration of insect-based proteins into global food systems. To support a robust cross-country comparison, this study employs standardized analytical approaches for trace elements, mycotoxins, and pesticide residues, ensuring data comparability across production systems and geographic origins.

2 Materials and methods

2.1 Cricket powder samples

Commercially produced house cricket (*A. domesticus*) powders sourced from England (CP1), Scotland (CP2), Vietnam (CP3), Thailand (CP4), Canada (CP5), and Poland (CP6) were investigated. Each product was analysed in three independent batches.

2.2 Trace elements determination

Cricket powder (ca. 0.5 g) was pre-digested in 65 % HNO_3 (Merck KGaA, Darmstadt, Germany) and then mineralized using a Speedwave XPERT microwave digestion system (Berghof Products, Instruments GmbH, Eningen, Germany). Mineralizates were diluted with Milli-Q water (resistivity ≥18 MΩ cm; Merck Millipore, Darmstadt, Germany) before analysis.

Element concentrations (As, Cd, Cr, I, Ni, Se, Zn, Hg, Pb, and Sb) were determined by ICP-MS using a PlasmaQuant MS Q spectrometer (Analytik Jena GmbH + Co. KG, Jena, Germany). Argon, helium, and hydrogen (N-5.0; Linde Gaz Polska, Kraków, Poland) were used as plasma and collision/reaction gases. Measurements were performed with an internal standard solution containing Sc, Y, Rh, and Bi (5 µg/L). The integrated collision/reaction cell was operated in He mode for Hg, Ni, and Zn; H2 mode for As, Cr, and Se; and no-gas mode for I, Pb, and Sb.

Calibration was performed using ICP-certified elemental standards (PrimAg®, ROMIL Ltd, Cambridge, UK). Detection limits, calculated according to the 3-sigma criterion and accounting for sample preparation and final dilution, were: As 0.023, Cd 0.0045, Cr 0.0069, Hg 0.044, I 0.093, Ni 0.093, Pb 0.032, Sb 0.029, Se 0.059, and Zn 0.29 µg/g. Method performance was verified using matrix-varied certified reference materials (CRMs), including mushroom (IPE 120, CS-M-3) and skimmed milk (ERM-BD150). Recoveries were within 80–120 % for most elements, and the relative expanded uncertainty (k = 2) was below 20 %.

2.3 Mycotoxins analysis

Ochratoxin A (OTA), aflatoxins B1 and B2, fumonisins B1 and B2, and trichothecenes (DON, 3-AcDON, NIV) were extracted using toxin-specific solvent systems and purified using immunoaffinity columns or SPE, depending on the analyte. OTA was extracted with 80 % methanol and purified on OchraTest WB columns. Aflatoxins were extracted with

acetonitrile/water (90:10, v/v) and purified on AflaTest WB SR + columns. Fumonisins were extracted with methanol/water (75:25, v/v) and purified on FumoTest columns. Trichothecenes were extracted with acetonitrile/water (82:18, v/v), purified by SPE, and derivatized with BSTFA.

Trichothecenes, OTA, and fumonisins were analysed by GC-MS using a Hewlett Packard 6890 gas chromatograph coupled to a Hewlett Packard 5972A mass detector and an HP-5MS capillary column. Aflatoxins B1 and B2 were analysed using a Waters HPLC system with fluorescence detection (excitation 360 nm; emission 440 nm) and a Nova-Pak C18 analytical column (4 µm, 3.9 × 150 mm). Analyte identification was based on retention behavior and diagnostic ions or fluorescence response, as appropriate.

Quantification was based on multipoint external calibration prepared from certified analytical standards. The LOD for trichothecenes and OTA was 0.001 mg/kg; the LOD for aflatoxins using IAC + HPLC-FLR was 0.1–1 ng/g. Trichothecene recoveries were 84 ± 3.8 % for DON, 78 ± 4.8 % for 3-AcDON, and 81 ± 3.8 % for NIV. Fumonisin calibration covered 0.05–5 mg/kg, and results were recovery-corrected based on immunoaffinity-column performance.

2.4 Pesticide residues analysis

All samples were ground to <1 mm and homogenized. Pesticide residues were extracted according to a QuEChERS-based procedure [20]. Briefly, 2.5 g of sample was hydrated with 10 mL of water, spiked with isotopically labelled internal standards, extracted with 10 mL acetonitrile, treated with citrate-buffered extraction salts, centrifuged, and diluted prior to filtration into LC vials. The final dilution factor was 8.

Residues were analysed by LC-MS/MS using an ExionLC UPLC system coupled to a SCIEX Triple Quad 7500 MS detector with an Optiflow PRO ESI source. Separation was performed on a Kinetex C18 column (2.6 µm, 100 × 2.1 mm) using water and methanol phases containing formic acid and ammonium formate. Compounds were detected in positive and negative ionization modes using scheduled multiple reaction monitoring.

The analytical scope comprised 490 pesticide standards (Dr. Ehrenstorfer/LGC). Matrix workflow quality was controlled using isotopically labelled standards (atrazine-D5, carbendazim-D4, and linuron-D6). Five-point calibration curves covered 0.5–50 ng/mL, corresponding to 0.004–0.42 mg/kg in the samples. Fortification at 0.01 mg/kg gave recoveries within 70–120 % with satisfactory repeatability, and coefficients of determination were ≥0.995.

2.5 Statistical analysis

Statistical analysis was performed using one-way analysis of variance (ANOVA), with the country/sample origin as the grouping factor. When significant differences were detected, Tukey's HSD post hoc test was applied. Differences were considered statistically significant at $p < 0.05$. Results are presented as mean ± standard deviation from three independent batches.

3 [20] Results and discussion

The safety assessment of cricket powder should address both biological and chemical hazards; however, the present study focused specifically on chemical contaminants relevant to feed, rearing substrates, environmental exposure, and post-harvest processing. Therefore, the discussion below is structured according to the three analysed contaminant groups: trace elements, mycotoxins, and pesticide residues, with emphasis on their toxicological relevance and implications for consumer safety [21–26].

3.1 Trace elements

The concentrations of selected trace elements in the investigated powders are presented in Table 1.

The results show considerable variation in trace element including PTEs levels, depending on the element and the origin of CPs. The highest levels were generally observed for Zn, Se and I. The content of PTEs, such as Hg, Pb, Sb, was below LOD; for Cd 0.02–0.05 (mg/kg d.m.), for Ni 0.13–0.41 (mg/kg d.m.), for Cr 0.017–0.68 (mg/kg d.m.), whereas for As 0.03–0.35 (mg/kg d.m.) with significantly higher level of this toxic element (approached the upper range of maximum levels commonly applied in EU regulations) was found in CP2 sample, which may result from feeding insects with ingredients contaminated with As (i.e. cereal bran, wheat, rice, barley). Notably, elevated levels were also observed for Cd in CP5 (0.05 ± 0.00 mg/kg) and for nickel in CP4 (0.41 ± 0.02 mg/kg), both of which were significantly higher than in all other samples. Nevertheless, the concentrations of trace elements across the tested CPs remained within the ranges typically reported for this type of food product [14, 27].

No specific mandatory maximum levels have been established for the analysed trace elements (As, Cd, Cr, I, Ni, Se, Zn, Hg, Pb, Sb) in CPs or other food products for human consumption that are derived from edible insects, in accordance with a Commission Regulation (EU) 2023/915 and its subsequent amendments. Consequently, the safety of such

Table 1: Concentrations of trace elements in analysed samples.

Mineral (mg/kg d.m.)	CP1	CP2	CP3	CP4	CP5	CP6
As	0.07 ± 0.0 c	0.35 ± 0.01 e	0.05 ± 0.0 b	0.05 ± 0.0 b	0.10 ± 0.0 d	0.03 ± 0.0 a
Cd	0.02 ± 0.0 a	0.03 ± 0.0 b	0.02 ± 0.0 a	0.03 ± 0.0 a	0.05 ± 0.0 c	0.03 ± 0.0 a
Cr	0.31 ± 0.0 c	0.17 ± 0.0 a	0.24 ± 0.0 b	0.68 ± 0.01 e	0.37 ± 0.0 d	0.31 ± 0.0 c
I	2.6 ± 0.19 c	2.33 ± 0.17 bc	2.02 ± 0.15 b	1.14 ± 0.08 a	0.71 ± 0.05 a	4.35 ± 0.32 d
Ni	0.19 ± 0.01 bc	0.13 ± 0.01 a	0.16 ± 0.01 ab	0.41 ± 0.02 e	0.26 ± 0.02 d	0.23 ± 0.01 cd
Se	0.41 ± 0.02 a	0.37 ± 0.01 a	0.37 ± 0.01 a	0.59 ± 0.02 d	0.47 ± 0.02 b	0.53 ± 0.02 c
Zn	152 ± 2.4 c	156 ± 2.5 c	141 ± 2.3 b	176 ± 2.8 e	131 ± 2.1 a	167 ± 2.7 d
Hg	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Pb	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Sb	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

All values are expressed as mean ± standard deviation. Mean values marked with different letters (a–e) within the same row indicate statistically significant differences ($p < 0.05$, Tukey's HSD).

products is governed differently, i.e. by the general requirements of Regulation (EC) No 178/2002, particularly the principle that contaminant levels must be kept as low as reasonably achievable (ALARA). In practice, official controls and safety assessments commonly refer to the maximum levels set for the most comparable food categories (e.g., food supplements, cereals and cereal products, or foods intended for infants and young children). Therefore, several of the analysed CPs warrant closer attention with regard to their trace element levels. It is well established that insects may naturally contain trace elements, including potentially toxic elements (PTEs), which are frequently accumulated through their diet or environmental exposure [23, 28–32]. According to the scientific literature, the potential for bioaccumulation tends to be increased for Cd and As compared with other PTEs [33, 34].

Recently, Ajdini et al. [35] investigated the content of selected PTEs in house crickets feed with diets supplemented at increasing levels of the red seaweed (*Palmaria palmata*) and the brown seaweed (*Ascophyllum nodosum*) across two feeding trials. The study found that PTE levels in all diets remained below the regulatory limits for animal feed. The measured concentrations spanned the following ranges: Ni (0.64–1.20 mg/kg d.m.), Cd (0.069–0.127 mg/kg d.m.), Hg (0.0065–0.0141 mg/kg d.m.), Cr (0.16–0.58 mg/kg d.m.), As (0.08–0.36 mg/kg d.m.), Pb (0.05–0.12 mg/kg d.m.), and Al (17–61 mg/kg d.m.).

Bioaccumulation of As and Hg was observed in the insects. However, the concentrations of all assessed potentially toxic elements remained below the maximum levels established by European Union food safety legislation. The authors therefore concluded that insects reared on seaweed-enriched diets constitute a safe and nutritionally valuable food source for human consumption, associated with a low risk of chemical contamination.

Evaluation of heavy metals (As, Cd, Hg, Pb) content in edible insects (*A. domesticus*, *Tenebrio molitor*, *Alphitobius diaperinus*, *Locusta migratoria*) and in defatted cakes obtained by supercritical fluid extraction was recently reported by Ramos et al. [36]. The findings indicated that Cd concentrations in the insect species exceeded the relevant regulatory thresholds, reaching values of up to 0.219 mg/kg. Pb levels in crickets also surpassed the permissible limit, at 0.1 mg/kg.

3.2 Mycotoxins residues

Mycotoxins are a structurally diverse class of low-molecular-weight secondary metabolites predominantly synthesised by species of *Aspergillus*, *Fusarium*, and *Penicillium*. They are associated with a broad spectrum of adverse effects in humans and animals [37] and are frequently present in agricultural products such as seeds, nuts, and cereal grains [38]. Considering their toxicological relevance, the European Union has introduced legally binding maximum levels for selected mycotoxins in food under Commission Regulation (EC) No. 1881/2006 [39]. Permissible concentrations and recommended guidance values for feed materials, as well as for complementary and complete feeding stuffs, are established under the Directive 2002/32/EC and Commission Recommendation 2006/576/EC [40, 41]. The levels of selected mycotoxins in investigated samples are presented in Table 2.

Analysis of ochratoxin A levels revealed in CP5 (0.04 ± 0.01 µg/kg), whereas it was below the LOD in CP1, CP2, and CP3. In samples CP1, CP2, and CP3, there were also no aflatoxins detected. Regarding fumonisins, significantly elevated concentrations were observed only in two samples: CP5 (fumonisin B1; 0.047 ± 0.006 µg/kg) and CP3 (fumonisin B2; 0.043 ± 0.006 µg/kg), compared with the all other samples.

Table 2: Concentrations of selected mycotoxins in analysed cricket powder samples.

	Mycotoxin (µg/kg d.m.)	CP1	CP2	CP3	CP4	CP5	CP6
	Ochratoxin A	<LOD	<LOD	<LOD	0.023 ± 0.006 ab	0.040 ± 0.010 b	0.013 ± 0.006 a
Aflatoxins	Aflatoxin B1	<LOD	<LOD	<LOD	<LOD	<LOD	0.010 ± 0.000
	Aflatoxin B2	<LOD	<LOD	<LOD	0.017 ± 0.006	0.010 ± 0.000	<LOD
Fumonisins	Fumonisin B1	0.017 ± 0.006 a	0.013 ± 0.006 a	0.027 ± 0.006 a	0.017 ± 0.006 a	0.047 ± 0.006 b	0.013 ± 0.006 a
	Fumonisin B2	0.027 ± 0.006 a	0.017 ± 0.006 a	0.043 ± 0.006 b	0.017 ± 0.006 a	0.023 ± 0.006 a	0.030 ± 0.000 ab
Trichothecenes	Deoxynivalenol	1.097 ± 0.006 e	0.627 ± 0.025 d	0.233 ± 0.042 b	0.420 ± 0.026 c	0.017 ± 0.006 a	0.040 ± 0.010 a
	3-Acetyldeoxy-nivalenol	0.020 ± 0.010 a	0.047 ± 0.006 a	1.103 ± 0.025 d	1.220 ± 0.026 e	0.893 ± 0.021 c	0.527 ± 0.021 b
	Nivalenol	0.030 ± 0.010 a	0.063 ± 0.006 b	<LOD	<LOD	0.030 ± 0.010 a	<LOD

All values are expressed as mean ± standard deviation. Mean values marked with different letters (a–e) within the same row indicate statistically significant differences ($p < 0.05$, Tukey's HSD).

Deoxynivalenol was detected at a significantly higher level in CP1 (1.097 ± 0.006 µg/kg) relative to all other samples. Similarly, 3-acetyldeoxynivalenol (3-AcDON) was present at a significantly higher concentration in CP4 (1.22 ± 0.026 µg/kg) compared with the rest of the analysed samples. Nivalenol was either below the limit of detection (CP3, CP4, CP6) or present at levels ranging from ~0.03 µg/kg (CP1 and CP5) to 0.063 ± 0.006 µg/kg (CP2). To sum up, the mycotoxin contamination of CPs was generally at very low levels, from undetected (<LOD), or a fraction of µg/kg d.m., to 1.22 µg/kg d m. (3-acetyldeoxy-nivalenol, in CP4), within the safety limits, thus can be considered as safe in this regard.

Available evidence indicates that insects are generally unlikely to bioaccumulate mycotoxins from contaminated feed substrates. Instead, these compounds may undergo metabolic conversion or other biotransformation processes within the insect organism, potentially yielding metabolites whose toxicological implications for consumers remain insufficiently characterised [42].

Previously quoted work by Ramos et al. [36] also considered mycotoxins (aflatoxins, ochratoxin A, and Enniatins) content in edible insects (*A. domesticus*, *T. molitor*, *A. diaperinus*, *L. migratoria*) and in defatted cakes obtained by supercritical fluid extraction. Authors indicated that aflatoxin G2 was detected in *Locusta* at a level of 115.5 µg/kg, whereas *Tenebrio* samples showed contamination exclusively with ochratoxin A, measured at 58.1 µg/kg. Furthermore, newly emerging mycotoxins, including ENNA, ENNA1, ENNB, and ENNB1, were identified only in trace amounts, all below 2.2 µg/kg.

Niermans et al. [43] conducted systematic reviews on mycotoxin exposure in selected insect species, concluding that the extent of mycotoxin accumulation is generally limited. This is largely attributed to metabolic processes within insects, although the degree of transformation varies depending on both the specific mycotoxin and the insect species involved. The principal enzymatic system implicated in mycotoxin biotransformation in certain species is the cytochrome P450 family. Overall, the findings of the review support a favourable perspective on the potential use of mycotoxin-contaminated waste streams as substrates for insect rearing.

3.3 Pesticide residues

The pesticide residue results are presented in Table 3.

Performed analysis revealed that concentrations of nearly all analysed pesticides were below the limit of detection (<LOD). The only exception was boscalid, which was detected in CP2 sample (0.0395 ± 0.0021 mg/kg) (Figure 1), exceeding the safety standard in food and feed (EU) 2021/590, set up to 0.01 mg/kg [44].

Evidence regarding the uptake of pesticides by insects from their substrates remains inconsistent as the degree of

Table 3: Concentrations of target pesticides in analysed samples.

Pesticide (mg/kg d.m.)	CP1	CP2	CP3	CP4	CP5	CP6
Boscalid	<LOD	0.0395 ± 0.0021	<LOD	<LOD	<LOD	<LOD
All other results	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

Values are presented as mean ± standard deviation.

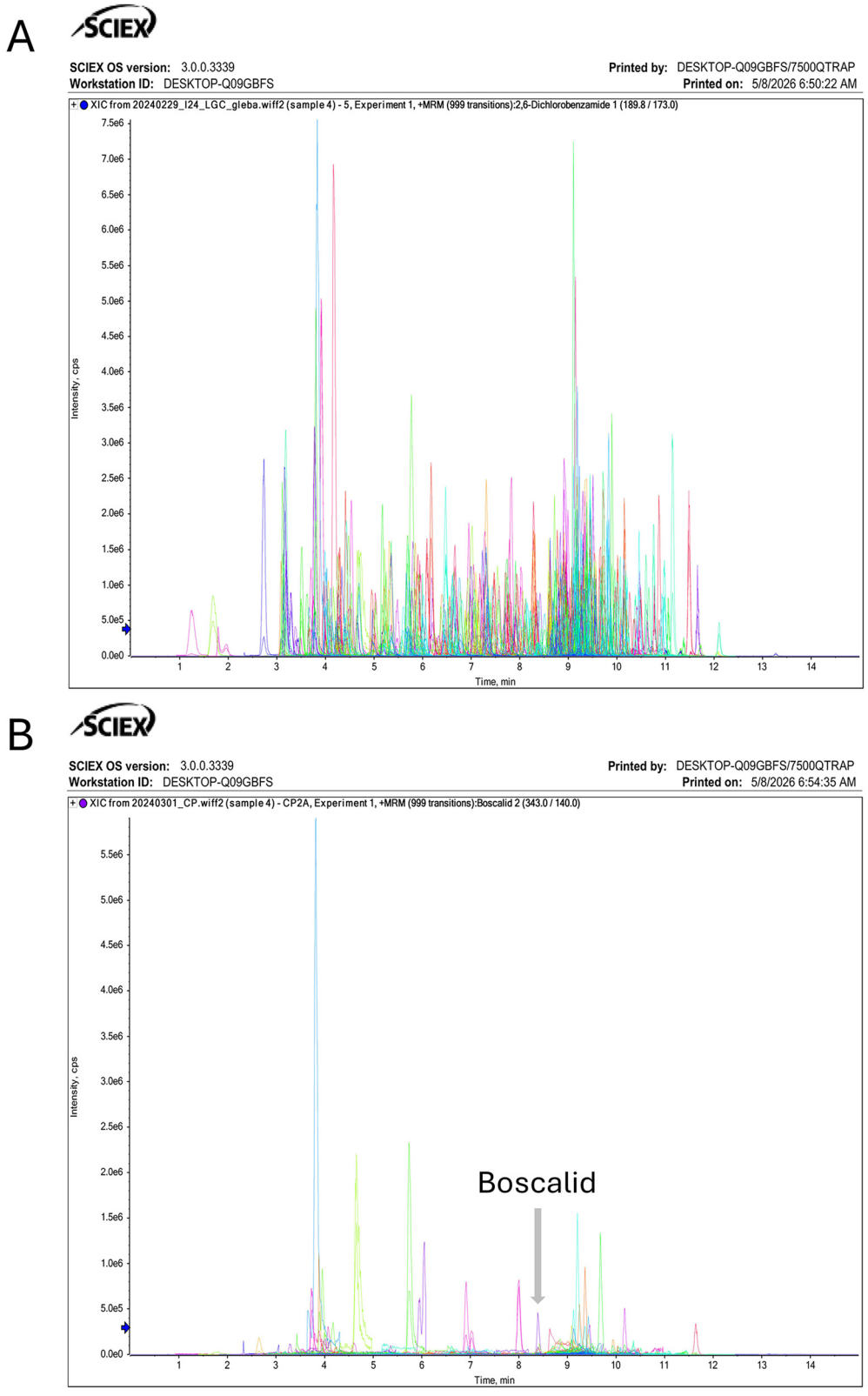

Figure 1: LC–MS/MS chromatograms acquired in the multi residue pesticide method. (A) Representative chromatogram of the 493 compound calibration standard mixture at 5 ng/mL. (B) Chromatogram of the cricket powder sample CP2, showing the boscalid signal (transition m/z 343.0 → 140.0) as a distinct peak at approximately 8.4 min. In both panels, the x axis shows retention time (min) and the y axis shows detector signal intensity (counts per second, cps). The blue arrow on the y axis indicates the software defined minimum intensity threshold for monitoring MRM transitions; peaks below this line are not considered for quantitative evaluation.

bioaccumulation appears to be influenced by multiple variables [45]. Labu et al. [46] investigated six edible insect species sourced from various natural habitats and laboratory rearing systems in Uganda and Kenya, assessing their safety with respect to agrochemical contamination using liquid chromatography-tandem mass spectrometry. The findings indicated the presence of insecticide, fungicide, and herbicide residues in most of the analysed species, although exceedances of toxic thresholds were limited and varied according to specific species, developmental stage, and the nature of the sampling substrate. The pathways by which pesticide residues were incorporated into the insects remain uncertain. To ensure the safety of insects intended for food and feed purposes, the implementation of controlled, regulated indoor rearing systems is therefore considered essential. Kitahara et al. [47] conducted pesticide residue analysis of edible insects, including method development and a market survey in Japan. Quantitative analysis of 50 commercial edible insect products available in Japan revealed quantifiable pesticide residues in nine samples, with 20 pesticides detected above the LOQs and several exceeding 0.01 mg/kg in dried products. The results of this work revealed that all the analysed CP samples did not contain quantifiable levels of variety of pesticides, with the exception of boscalid that was found elevated in one sample (CP2: 3.95 ± 2.1 mg/kg d.m.), exceeding the safety standard in food and feed [44], set up to 0.01 mg/kg, which may come from certain malpractice in treating the crop materials used for feeding insects. It is considered that the most efficient strategy for reducing the toxic compounds bioaccumulation risks in insects and their products is to maintain proper hygienic conditions in the substrate and rearing enclosure, particularly by ensuring the safety of insect feed. Another approach suggested by some authors is to starve insects prior to harvesting. For example, a study conducted by Houbraken et al. [48] demonstrated that insects subjected to a 24-h fasting period exhibited reduced accumulation of pesticide residues.

To ensure the biological and chemical safety of insect materials used for food or feed, risk mitigation strategies should be implemented, such as Good Farming Practices, including feed safety controls, hygienic rearing, and monitoring pathogen loads. It is also important to consider post-harvest treatments.

4 Conclusions

This study provides a cross-country screening of chemical contaminants in commercially available *A. domesticus* powders. Most analysed samples showed low levels of the investigated contaminants. Among trace elements, Hg, Pb and Sb were below the LOD in all samples, whereas Cd, Ni and Cr occurred at low concentrations. Cadmium remained below the EU novel-food specification limit for dried/powdered *A. domesticus*, and Pb was not detected. The main trace-element finding was the elevated total arsenic concentration in CP2 (0.35 ± 0.01 mg/kg d.m.), which was higher than in all other samples. Because the current *A. domesticus* novel-food specification does not define a maximum level for arsenic, and because total arsenic does not distinguish inorganic from organic forms, this result should be interpreted as a toxicologically relevant screening signal rather than a direct regulatory exceedance. Further arsenic speciation and feed-source verification are recommended.

Mycotoxin contamination was generally negligible. OTA, aflatoxins, fumonisins and trichothecenes were either below the LOD or detected at very low µg/kg levels. The highest values were observed for DON in CP1 (1.097 ± 0.006 µg/kg) and 3-AcDON in CP4 (1.220 ± 0.026 µg/kg). The measured concentrations of OTA, aflatoxin B1, total aflatoxins and DON were far below the EU specification values for dried/powdered *A. domesticus*, indicating no safety concern for the analysed samples in relation to these mycotoxin markers.

Pesticide residues were not detected in most samples. The only exception was boscalid in CP2 (3.95 ± 2.10 mg/kg d.m.), which was markedly higher than the general EU default MRL screening benchmark of 0.01 mg/kg. Although formal compliance assessment requires consideration of product form and processing factors, this result indicates a clear need for supplier verification and control of feed and rearing substrates. Overall, the results support the chemical safety of most analysed cricket powders, but they also show that individual batches may contain elevated contaminant levels. Routine monitoring of feed, substrates and final powders should therefore be included in quality-assurance systems for insect-derived food ingredients.

Research ethics: The conducted research is not related to either human or animal use.

Informed consent: Not applicable.

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