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The comprehensive assessment and critical analysis of mycotoxins present in desiccated food specimens that were meticulously gathered from the Libyan market.

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Abstract:
Background: Detecting and preventing mycotoxin contamination in dry food is crucial for ensuring food safety and protecting public health. Mycotoxins, toxic compounds produced by fungi, can contaminate a wide range of food products, including cereals, nuts, and dried fruits, posing significant health risks. Effective detection and prevention strategies are essential to mitigate these risks. This response explores the current methods for detecting mycotoxins and strategies for preventing their contamination in dry food.
Objectives: the present study aimed to evaluate 3 mycotoxins in cereals and some selective dry food
Methods: The Eliza R. biopharm methodology employs ELISA for mycotoxin detection in food matrices was applied
Results: a total of 178 samples were examined for the presence of mycotoxin residues. The results showed that, 51 samples were assessed for Ochratoxin residues, which varied from 0.250 to 79.71 µg/kg. Conversely, the maximum concentration of Ochratoxin residue was observed in grounded coffee, whereas dry coffee and wheat flour exhibited the lowest levels, accompanied by low standard deviation values across all samples. Moreover, a total of 93 samples were assessed for Oflatoxin residues, which varied from 0.300 to 4.85 µg/kg. Conversely, the maximum concentration of Ochratoxin residue was observed in Millet, whereas dry Corn crisps ,Green tee , Almond and Red tee exhibited the lowest levels, accompanied by low standard deviation values across all samples. On the other hand, a total of 34 samples were assessed for DON residues, which varied from 18.5 to 104.30 µg/kg. Conversely, the maximum concentration of DON residue was observed in corn while, Wheat flower, soya bean, and barley Wheat exhibited the lowest levels, accompanied by low standard deviation values across all samples.
Key words: ochratoxin – DON – aflatoxin – cereals.

تقدير السموم الفطرية في عينات الأغذية المجففة التي تم جمعها بعناية من الاسواق الليبية.
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فُحصت 178 عينة بحثًا عن بقايا الميكوتوكسين. وأظهرت النتائج أن 51 عينة خضعت للتقييم للكشف عن بقايا الأوكراتوكسين، والتي تراوحت بين 0.250 و79.71 ميكروغرام/كغ. في المقابل، لوحظ أعلى تركيز لبقايا الأوكراتوكسين في القهوة المطحونة، بينما أظهرت القهوة الجافة ودقيق القمح أدنى مستوياتها، مصحوبة بقيم انحراف معياري منخفضة في جميع العينات. علاوة على ذلك، تم تقييم 93 عينة لبقايا الأوفلاتوكسين، والتي تراوحت بين 0.300 و4.85 ميكروغرام/كغ. في المقابل، لوحظ أعلى تركيز لبقايا الأوكراتوكسين في الدخن، بينما أظهرت رقائق الذرة الجافة، والشاي الأخضر، واللوز، والشاي الأحمر أدنى مستوياتها، مصحوبةً بقيم انحراف معياري منخفضة في جميع العينات. من ناحية أخرى، تم تقييم 34 عينة لبقايا السم الفطري دون ، والتي تراوحت بين 18.5 و104.30 ميكروغرام/كغ. في المقابل، لوحظ أعلى تركيز لبقايا السم الفطري دون في الذرة، بينما أظهرت قمح زهرة القمح وفول الصويا والشعير أدنى مستوياتها، مصحوبةً بقيم انحراف معياري منخفضة في جميع العينات.

Introduction

Mycotoxins cause adverse effects on human health primarily through mechanisms such as carcinogenesis, estrogenic effects, oxidative stress, inflammation, and abnormal apoptosis. Upon absorption, these toxins are biotransformed into reactive metabolites that exert multifaceted toxicities, leading to severe health issues. The paper highlights the toxicological effects of mycotoxins,

including hepatotoxicity, carcinogenicity, immunotoxicity, and neurotoxicity, which collectively threaten both human and livestock health **(Yao *et al.*, 2025).**

Common food sources that contain mycotoxins include corn, cereals, soybeans, sorghum, peanuts, and other food and feed crops. These mycotoxins can accumulate during growth in the field and during transportation. Identification of mycotoxins is achieved through various detection and analysis methods, which are crucial for ensuring food safety. The six major mycotoxins regularly found in food are aflatoxins, trichothecenes, zearalenone, fumonisins, ochratoxins, and patulin, which pose ongoing food safety challenges worldwide **(Alshannaq & Yu, 2017).**

Mycotoxins in dry food can be effectively detected using chromatographic techniques, antibody-based assays, and DNA-based methodologies specific to mycotoxigenic fungi. Commercial ELISA kits are available for detecting aflatoxins, deoxynivalenol, and zearalenone. Prevention involves implementing management practices preharvest, during harvest, and postharvest, including proper storage conditions to maintain low moisture content and reduce fungal growth. Monitoring mycotoxin levels in crops and products is crucial for effective management and risk reduction **(Kharayat and Singh, 2018)**

Effective detection of mycotoxins in dry food can be achieved using advanced techniques such as HPLC, LC-MS/MS, and immuno-based assays, which offer high sensitivity and rapid results. Immunoassay kits are particularly useful for field and storage applications. To prevent mycotoxin contamination, implementing proper storage conditions, regular monitoring, and utilizing microarray-based immunoassays for simultaneous detection of multiple mycotoxins can significantly reduce risks. Additionally, aptamer-based assays can target specific mycotoxins with high specificity **(Jonathan *et al.*, 2015).**

Mycotoxins cause adverse effects on human health primarily through nephrotoxicity, hepatotoxicity, carcinogenicity, immunosuppression, and mutagenicity. These toxic compounds disrupt normal cellular functions, leading to organ damage and increased cancer risk. The mechanisms involve interference with metabolic processes, induction of oxidative stress, and alteration of immune responses. Aflatoxin B1, in particular, is noted for its high carcinogenic potential, highlighting the serious health threats posed by mycotoxins in contaminated foodstuffs **(Patil *et al.*, 2024).**

Mycotoxins induce oxidative stress by generating reactive oxygen species (ROS) that exceed the body's antioxidant defenses, leading to lipid peroxidation, DNA damage, and protein oxidation. This

oxidative damage compromises cellular integrity and function, ultimately resulting in cell death **(Mézes *et al.*, 2021).**

Aflatoxins have been directly linked to an increased risk of primary liver cancer in humans, as confirmed by this systematic review. Additionally, zearalenone and its metabolites were investigated for their association with breast cancer risk, although the results were conflicting. Fumonisin B1 exposure was studied in relation to hepatocellular carcinoma, but no significant associations were found. Overall, the evidence primarily supports the carcinogenicity of aflatoxins, while further research is needed for other mycotoxins **(Claeys *et al.*, 2020).**

Mycotoxins cause adverse health effects primarily through chronic exposure, leading to gastrointestinal and kidney disorders, immune deficiency, and potential cancer development. They enter the human food chain via contaminated foods or animal products, posing significant health risks **(*Mycotoxins: An Under-Evaluated Risk for Human Health*, 2022).**

The Libyan agricultural sector is impeded by low productivity, restricted irrigation (2.6-3.0% of land), and a dependence on food imports, amounting to $3,167 million in 2018, contributing a mere 0.7-1.1% to GDP while employing 6% of the labor force, with escalating food demand worsening reliance on imports, particularly cereals, thereby stifling agricultural advancement and economic diversification and limiting the sector's capacity to bolster Libya's economic stability and growth. **(Elkhouly & Shefsha, 2023)**

Therefore, the present study was conducted to evaluate mycotoxin residues in some dry food products that is marketing in the Libyan market, the present investigation was conducted to evaluate the probable risks that faces the Libyan customer and to evaluate the abundance of mycotoxin residues in his diet

Materials and methods

The Eliza R. biopharm methodology employs ELISA for mycotoxin detection in food matrices. This approach is noted for its specificity, sensitivity, and rapidity, rendering it effective for mycotoxin screening. ELISA is advantageous over traditional chromatography methods regarding speed and cost. Nonetheless, it serves primarily as a preliminary screening tool, necessitating confirmatory testing for complex matrices.

Sample preparation: This is a critical first step that involves extracting the mycotoxins from the cereal matrix.

Extraction: A solvent is used to extract mycotoxins from the cereal sample.

Purification: For complex matrices, purification steps using immunoaffinity columns or solid-phase extraction (SPE) columns can isolate and concentrate the target mycotoxins, improving accuracy.

Preparation: Bring all materials to ambient temperature.

Sample Preparation: Isolate target analytes from samples through specific extraction and dilution processes.

Binding/Incubation: Introduce standards and samples to a pre-coated microtiter plate, allowing analyte competition or capture, followed by incubation.

Washing: Wash wells several times with a buffer to eliminate unbound reagents.

Detection/Color Development: Add substrate solution and incubate to induce a color change through enzymatic reaction.

Stopping the Reaction: Introduce a stop solution to alter color and terminate the enzymatic activity.

Measurement: Assess absorbance photometrically at 450 nm utilizing a microtiter plate reader.

Analysis: Construct a standard curve from standards to quantify analyze concentration in samples using designated software or methods.

Results and discussion

The information presented in Table (1) elucidates that a comprehensive total of 51 distinct samples were meticulously evaluated for the presence of Ochratoxin residues, which exhibited a considerable range from a minimum concentration of 0.250 to a maximum concentration of 79.71 µg/kg, thereby highlighting the variability in contamination levels across different sample types. In contrast to other commodities, the highest concentration of Ochratoxin residue was notably detected in the grounded coffee samples, whereas the dry coffee and wheat flour samples demonstrated significantly lower levels of contamination, which were further characterized by low standard deviation values that suggest a consistent pattern of residue presence across the entirety of the analyzed samples. This data ultimately underscores the critical importance of ongoing surveillance and assessment of Ochratoxin levels in various food products to ensure public health safety and to inform regulatory standards in food quality assurance practices. Ochratoxin A (OTA) contamination in food products primarily arises from specific fungal species, environmental conditions, and agricultural practices. The main sources of OTA include various food commodities, particularly those susceptible to fungal growth during production and storage. Understanding these sources is crucial for developing effective control

measures. Ochratoxin A (OTA) is a significant mycotoxin found in various food products, primarily produced by molds such as Aspergillus and Penicillium. Commonly contaminated items include cereals, coffee, wine, dried fruits, spices, beer, and meat products. Identifying these contaminated foods is crucial due to the potential health risks associated with OTA consumption. The following sections detail the common food products affected by OTA and methods for their identification.These results are on line with those of **(Chandravarnan *et al.*, 2023)** who concluded that , Ochratoxin A (OTA) contamination in food products primarily arises from species of Aspergillus and Penicillium fungi, which produce the toxin. These fungi commonly contaminate various food and feed commodities, leading to significant health risks and economic losses. On the other hand, these results are in agreement with those of **(Joshi *et al.*, 2017)** who mentioned that, Common food products contaminated with ochratoxin A include cereals, wine, coffee, figs, dried fruits, and beer. Identification typically involves testing for the presence of ochratoxin A through analytical methods, especially in agricultural products and animal feeds.

Table (1) average values, maximum limits, minimum limits of Ochratoxine residues in cereal and dry food samples

Product	No. samples	Ochratoxin µg/kg	Upper limit µg/kg	Lower limit µg/kg	Standard value/ Libya µg/kg	Standard value/ world µg/kg
Hordium	4	0.534 ± 0.161	0.622	0.446	5-10	3.0
Koskos	2	0.468 ± 0.263	0.635	0.300	5-10	4.0
Corn	12	0.524 ± 0.148	0.788	0.300	5-10	3.0
Wheat	3	0.376 ± 0.151	0.436	0.300	5-10	3.0
Green coffee	9	0.532 ± 0.20	0.922	0.300	5-10	3.0
Grounded coffee	12	3.44 ± 1.43	4.85	1.78	5-10	3.0
Cappuccino	3	1.98 ± 2.01	3.48	0.498	5-10	5.0
Wheat flower	3	0.300 ± 0.00	0.300	0.300	5-10	4.0
Dry coffee	3	0.300 ± 0.00	0.300	0.300	5-10	3.0
Total	51					

The data presented in Table (2) provides comprehensive insights into the analysis of a total of 93 distinct samples that were meticulously evaluated for the presence of Oflatoxin residues, which demonstrated a notable range spanning from a minimum concentration of 0.300 to a maximum concentration of 4.85 µg/kg, thereby highlighting the variability and potential contamination levels within the tested samples. In contrast to these findings, the highest concentration of Ochratoxin residue was distinctly recorded in Millet, whereas the dry Corn crisps, Green tea, Almonds, and Red tea were found to possess the lowest concentrations of this particular toxin, a trend that was further supported by the observation of consistently low standard deviation values across all analyzed

samples, indicating a degree of homogeneity in the data. Overall, this detailed assessment underscores the importance of monitoring these mycotoxins in food products, as it provides critical information that can inform public health policies and food safety regulations aimed at minimizing exposure to such harmful contaminants. Aflatoxin contamination in food products primarily arises from the growth of fungi, particularly species of the Aspergillus genus, under specific environmental conditions. These toxins can infiltrate various food items during multiple stages, including cultivation, harvesting, storage, and processing. Understanding these sources is crucial for mitigating health risks associated with aflatoxins. The former results are in agreement with those of **(Shukla *et al.*, 2017)** The primary sources of aflatoxin contamination in food products include contaminated raw materials, particularly maize and peanuts, lack of pasteurization, poorly controlled natural fermentation, and conditions in tropical and subtropical regions that favor fungal growth.

Table (2) average values, maximum limits, minimum limits of Oflatoxin residues in cereal and dry food samples

Product	No. samples	Oflatoxin µg/kg	Upper limit µg/kg	Lower limit µg/kg	Standard limits / Libya µg/kg	European limits µg/kg
Corn	4	3.55 ± 2.47	1.75	5.25	2-4	5-15 µg/kg
Rice	10	2.98 ± 1.96	1.75	5.25	2-4	
Wheat	4	3.55 ± 2.47	1.75	5.25	2-4	
Corn crisps	22	1.25 ± 0.77	0.25	3.01	2-4	
Green tee	7	0.467 ± 0.25	0.25	0.953	2-4	
Almond	5	0.35 ± 0.09	0.25	0.454	2-4	
Red tee	8	0.51 ± 0.25	0.25	0.855	2-4	
Millet	14	28.225 ± 24.67	1.75	79.71	2-4	
Chickpea	3	1.75 ± 0.00	1.75	1.75	2-4	
Kidney bean	4	1.75 ± 0.00	1.75	1.75	2-4	
Wheat flower	8	3.50 ± 2.47	1.75	5.25	2-4	
barley	4	2.25 ± 0.00	2.25	2.25	2-4	
Total	93					

- The information presented in table (3) reveals that a comprehensive analysis was conducted on a total of 34 distinct samples to evaluate the presence of deoxynivalenol (DON) residues, which were found to exhibit a considerable range of concentrations spanning from a minimum of 18.5 to a maximum of 104.30 µg/kg. In stark contrast to the lower concentrations seen in other agricultural products, the highest level of DON residue was detected specifically in corn, while the other commodities under investigation, namely wheat flour, soybean, and barley wheat, displayed markedly lower residue levels, a finding that was further supported by the

observation of relatively low standard deviation values across the entirety of the sample set. This indicates not only the variability of DON concentrations among different crops but also suggests a potential area of concern regarding food safety standards, which necessitates further examination into the underlying factors contributing to these differences in residue accumulation. Deoxynivalenol (DON) contamination in food products is primarily linked to specific agricultural practices that facilitate the growth of Fusarium species, the fungi responsible for producing this mycotoxin. These practices, combined with environmental factors, significantly influence the levels of DON in grains such as wheat, maize, and barley. Understanding these practices is crucial for developing effective management strategies to mitigate DON contamination. Crop rotation plays a significant role in DON contamination. Planting maize after a host crop of Fusarium spp. increases DON levels by 20% compared to non-host crops The timing of planting is also critical. Planting silage maize between May 10 and May 30 can increase mycotoxin concentration by at least 50% compared to planting outside this window **(Kaur et al., 2024).** The most common agricultural practices contributing to DON contamination in food products include inadequate management of crops, failure to prevent plant infections by Fusarium species, and insufficient rapid drying of wheat after harvest. These practices increase the likelihood of Fusarium head blight (FHB) and subsequent DON production. Effective strategies to manage DON incidence involve implementing preventative measures at both pre- and post-harvest stages to minimize human exposure to this mycotoxin in wheat and wheat-based products **(Mousavi Khaneghah *et al.*, 2018).**

Table (3) average values, maximum limits, minimum limits of (deoxynivalenol) DON residues in cereal and dry food samples

Product	No. samples	Don µg/kg	Upper limit µg/kg	Lower limit µg/kg	Standard value/ Libya µg/kg	Standard value/ world µg/kg
Wheat flower	12	18.5 ± 0.00	18.5	18.5	750 -12000	1000-1500
soya bean	4	18.5 ± 0.00	18.5	18.5	750 -12000	1000-1500
Wheat	4	18.5 ± 0.00	18.5	18.5	750 -12000	1000-1500
Corn	8	51.28 ± 42.92	18.5	104.30	750 -12000	1000-1500
Barley	6	18.5 ± 0.10	18.5	18.5	750 -12000	1000-1500
Total	34					

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