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OCCURRENCE AND QUANTIFICATION OF AFLATOXINS IN IMPORTED RAW-MAIZE AND MAIZE-BASED CEREAL PRODUCTS AVAILABLE IN SRI LANKAN MARKET: A TEMPORAL ASSESSMENT (2022-2024)

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ABSTRACT:
Maize and its products are staple dietary components of all age groups in Sri Lanka. However, contamination of these with aflatoxins (AFs), secondary metabolites produced by certain fungal species, has raised significant concern due to their high toxicity on human health. This study aimed to investigate the occurrence and quantification the level of total-aflatoxins (AF_{Total}) and constituent-aflatoxin B_1 (AF_{B1}) in imported raw-maize samples (n=20) and maize-based cereal products available under four different brand names in the local market (n=80) over a three-year period (2022-2024), using immunoaffinity column clean-up followed by analysis with Liquid Chromatography coupled with Florescence Detector (LC-FLD). The European Union (EU) regulatory maximum permissible limits for maize (10 µg/kg for AF_{Total}; 5 µg/kg for AF_{B1}) were used as reference threshold in this study. Data were statistically analysed by one-way ANOVA using Minitab 17 software. According to the results, from 2022 to 2024, imported raw-maize samples consistently exhibited significantly higher levels of AF_{Total} and AF_{B1} contamination compared to all four brands of maize-based cereal products ($p<0.05$). Although a gradual decline in mean contamination levels of AF_{Total} and AF_{B1} in imported raw-maize samples was observed over the three years, these reductions were not statistically significant. All four brands of maize-based cereal products showed higher mean levels of AF_{Total} and AF_{B1} contaminations in 2022 compared to 2023 and 2024, with Brands 1, 2, and 3 demonstrated significant reductions in 2024, while Brand 4 showed a non-significant decline in 2024. Notably, samples of Brand 2 in both 2023 and 2024 did not exceed EU regulatory limits for AF_{Total}. The overall downward trend in AF_{Total} and AF_{B1} contamination observed in 2024 was attributed to the routing monitoring of cereal-based products and the enforcement of regulatory measures implemented in collaboration with relevant government authorities in Sri Lanka, following the findings reported in 2022. However, notable aflatoxin contamination was still detected in certain imported raw-maize samples and maize-based cereal products. Therefore these findings underscore the importance of enforcing effective food regulations and provide critical evidence to support the strengthening of national food safety policies in Sri Lanka, thereby contributing to enhanced food security.

Keywords: Imported raw-maize, maize-based cereal products, total-aflatoxin, aflatoxin B_1, food safety

I. INTRODUCTION

Zea mays, generally known as maize is a major cereal staple in the human diet worldwide including Sri Lanka. Maize and maize-based cereal products hold a prominent place in daily meals across all age groups, consumed either in raw form or as processed foods such as flour, bread, cookies and snacks [1]. Apart from human consumption, maize is also widely used as a key ingredient in animal feed [2]. Due to high domestic demand, a substantial quantity of raw-maize is imported annually into Sri Lanka for the production of various maize-based products.

Despite its nutritional importance, cereal likes maize is highly susceptible to contamination by toxigenic fungi and the associated production of mycotoxins, particularly during the post-harvest storage [3, 4, 5]. In terms of current agricultural practices, the presence of mycotoxins in cereals seems to be unavoidable [6], because these mycotoxins are chemically stable and are not completely degraded even at high temperatures [7]. Consequently, these toxic compounds can persist in processed cereal products and pose a significant risk to human health through entry into the food chain [1, 4]. According to the Food and Agricultural Organization (FAO), it is estimated that at least 25% of the world's food crops are contaminated with mycotoxins, posing a significant threat to food safety and public health [4, 8].

Among various mycotoxins, aflatoxins (AFs) are the most common contaminants of maize and its products [5,9], particularly under warm and humid conditions typical of tropical regions such as Sri Lanka [10]. AFs are a group of toxic secondary metabolites that naturally produced by certain fungal species in food and are produced under favorable environmental conditions, including elevated temperature, high relative humidity, and poor storage conditions [10, 11]. AFs are primarily produced by the fungi *Aspergillus flavus* and *Aspergillus parasiticus* [2, 11]. Although twenty different types of AFs have been identified, four most significant in terms of cereal maize contamination are aflatoxin B_1 (AF_{B1}), B_2 (AF_{B2}), G_1 (AF_{G1}), and G_2 (AF_{G2}) [1]. The toxicity levels of constituent aflatoxins decrease in order of, $AF_{B1}>AF_{G1}>AF_{B2}>AF_{G2}$ [1, 12]. Among them, *A. flavus* typically produces AF_{B1} and AF_{B2}, while *A. parasiticus* known to produces AF_{B1}, $AF_{B2,}$ AF_{G1} and AF_{G2} [13]. However, in 1993, the International Agency for Research on Cancer listed AF_{B1} as a Group 1 human carcinogen, recognizing it as the most toxic and prevalent AFs due to its carcinogenic, mutagenic, teratogenic, immunotoxic, and hepatotoxic properties [1, 4, 14, 15]. Further, chronic exposure to AF_{B1} has been associated with hepatocellular carcinoma, immune suppression, and growth retardation in children [15].

Due to the potential health risks associated with aflatoxins (AFs), various national and international public health organizations including the International Agency for Research on Cancer (IARC) of the World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the European Union (EU) have established maximum permissible limits for different mycotoxins, including AFs, in foods such as cereals and their derived products [8, 16]. The initial EU regulation (EU Regulation 466/2001) was subsequently updated and replaced by Regulation 1881/2006, which was further revised in 2007 and 2010 to reflect evolving scientific knowledge and risk assessments [17,18]. As a result, many countries have implemented strict regulatory limits to control AFs contamination in cereal grains and their products [1, 5, 10]. These regulations define maximum levels (MLs) of AFs permitted in food commodities, as complete elimination of AFs is challenging. Thus, maximum levels are enforced to reduce human exposure and ensure food safety.

Depending on the country, the regulatory limits for AFs concentration in food vary, typically ranging from 4 to 30 µg/kg [15,19]. According to EU regulations, the maximum permissible limits for total-aflatoxins ($AF_{Total=}AF_{B1}+AF_{B2}+ AF_{G1}+AF_{G2}$) and AF_{B1} in all cereals and their derived products excluding maize intended for direct human consumption are 4 µg/kg and 2 µg/kg, respectively [5, 20]. For maize intended for direct consumption, the EU sets limits of 10 µg/kg for AF_{Total} and 5 µg/kg for AF_{B1} [10, 20]. In the United States, the maximum acceptable level for AF_{Total} in maize is 20 µg/kg [1]. China has also established a regulatory limit of 20 µg/kg for AF_{B1} in cereals intended for human consumption [6]. In Sri Lanka, the maximum limit for total-aflatoxins in all foods is 30 µg/kg as stipulated in the Labeling and Miscellaneous Regulations, 1993. However, most of these regulations do not specify individual maximum limits for AF_{B2}, AF_{G1}, and AF_{G2}, except for the combined total.

Due to the significant health risks associated with aflatoxin contamination in maize and its derived products, it is essential to establish effective control and monitoring programs to support risk assessment efforts. Although numerous international studies have addressed aflatoxin contamination in maize, there is a notable lack of localized research on this issue in Sri Lanka. Therefore, the objectives of the present study was to detect and quantify total-aflatoxins (AF_{Total}) and aflatoxin B1 (AF_{B1}) in maize and maize-based cereal products, with the aim of evaluating the current contamination levels in imported raw-maize and processed products available in Sri Lankan market, and determining whether these levels comply with the limits stipulated by EU regulations. Currently, Sri Lanka lacks specific regulations on maximum permissible limits for total-aflatoxins and aflatoxin B1 in maize and other cereals, applying only a limit of 30 µg/kg stipulated under the Labeling and Miscellaneous Regulations for all foods. The findings of this study provide insights into the levels of aflatoxin contamination in imported raw-maize and maize-based cereal products, and are expected to support dietary risk assessments and strengthen national food safety policies.

II. MATERIALS AND METHODS

2.1 *Sample Collection*

Twenty samples of imported raw-maize (1kg per each) which were received to the laboratory from consignments by Public Health Inspectors (PHIs) and 80 maize-based cereal products representing four different brand names (20 samples per each) commonly available in the local market of Sri Lanka were used for this analysis. All these samples were randomly collected over three consecutive years (2022, 2023 and 2024). All maize samples were observed in good condition and free from visible mold. The imported raw-maize samples were placed in labeled polyethylene bags and all samples were transported to the food laboratory of the Government Analyst's Department in Battaramulla, Sri Lanka by PHIs. All the samples were stored at ambient temperature (22-28 °C) until analysis.

2.2 *Chemicals and Reagents*

All chemicals and reagents including sodium chloride (NaCl), methanol, acetonitrile, phosphate-buffered saline (PBS) and aflatoxin stock standards (AF_{B1}, AF_{B2}, AF_{G1}, and AF_{G2}; 2.0 µg/mL purity≥98%) were purchased from Sigma Aldrich (St. Louis, USA). Ultrapure water was produced using a purification system (LD-UPW-10-30LPH, China). All glassware was sterilized prior to use.

2.3 *Apparatus Used*

Immunoaffinity columns (R-Biopharm Rhone Ltd., Scotland) were used for sample extraction and clean-up, following the procedures described in the manual, Analysis and Manual, 2012 [21], prior to injection into the LC-FLD system. For the quantitative estimation of aflatoxins, Liquid Chromatography system with Fluorescence Detector (LC-FLD) Shimadzu LC system (Shimadzu Corporation, Japan) was used.

2.4 *Extraction, Isolation and Clean-up Aflatoxin*

A homogenized 25.0 g sample was blended with 5.0 g of NaCl and 100 mL of 80% methanol at 22,000 rpm for 2 minutes using a laboratory blender (Waring 8010ES, Waring Commercial, USA), following a modified manual of Analysis and Manual, 2012. The resulting mixture was filtered through Whatman No. 113 filter paper (GE Healthcare UK Limited, UK) and 2.0 mL filtrate was diluted with 14.0 mL PBS for analysis. Diluted extract was passed through immunoaffinity columns (R-Biopharm Rhone Ltd., Scotland) at 0.5 mL/min. The column was then washed twice with 10 mL PBS (5.0 mL/min), and dried with nitrogen gas using a Visidry™ drying attachment (57100-U, Sigma Aldrich, USA), and aflatoxins eluted with 1.0 mL methanol (1 drop/s) into amber colour vials. Following elution, 1.0 mL of deionized water was passed through the column and made a final 2.0 mL volume. Finally, 10 µL eluate was injected into the Liquid Chromatography with Fluorescence Detection (LC-FLD) system.

2.5 *LC-FLD Analysis*

The Liquid Chromatography (LC) analysis was conducted on a Shimadzu LC system (Shimadzu Corporation, Japan) with quaternary pump (LC-20AD XR), auto-sampler (SIL-20AC XR), column oven (CTO-20AC), and a fluorescence detector (RF-20AXS), and photochemical reactor (PHRED, LC Tech GmbH, Germany). Chromatographic separation was carried out using a Raptor C18 column (150×4.6 mm, 5 µm; Restex, US) at 40 °C. The mobile phase consisted of water-methanol-acetonitrile (60:28:12, v/v/v) at 1.2 mL/min flow rate and prior to analysis mobile phase was filtered with 0.20 µm Phenex™ nylon filter (47mm diameter; Phenomenex Inc., Torrence, USA). PHRED reactor was used for AF_{B1} and AF_{G1} derivatization. Injection volume was 10 µL and run time was 20 min. The fluorescence detector was set at 360 nm for excitation and 450 nm for emission. Data were processed with ChemStation LC 3D software (Rev. A.10.02).

2.6 *Method Validation*

The LC-FLD method was validated for linearity, sensitivity, accuracy and precision, and selectivity. Linearity was assessed using six concentrations (0.2–20 µg/L) of standard solutions, and the calibration curves showed strong linearity with correlation coefficients (R^2) greater than 0.995. The limits of detection (LOD) and limits of quantification (LOQ) were determined at signal-to-noise ratios of 3:1 and 10:1, respectively and further confirmed by spiked matrices. Accuracy was tested by spiking blank maize samples (0.2, 4, 10 µg/L), yielding recoveries of 70–110%. Precision was confirmed by repeatability (intra-day) and reproducibility (inter-day) tests, with acceptable relative standard deviation (RSD) values (<17%). Selectivity was confirmed by absence of interfering peaks in blanks.

2.7 Statistical Analysis

Descriptive statistics, including mean, standard error (SE), minimum, maximum and median values were calculated for the AF_{Total} and AF_{B1} for all samples using LC-FLD quantification data. The resulting data were statistically analyzed by One-way analysis of variance (ANOVA) using Minitab 17.0® software to determine the level of significance ($p<0.05$ considered significant).

III. RESULTS

3.1 LC Analytical Method Validation

The LC-FLD method for aflatoxin determination was validated according to international guidelines, assessing linearity, sensitivity, accuracy and precision, and recovery. Calibration curves for AF_{B1} and AF_{Total} (0.2–20 µg/L) showed strong linearity ($R^2>0.995$). The method achieved low LOD (0.04–0.06 µg/kg) and LOQ (0.13–0.21 µg/kg), with recovery rates of 70–110% (Table 1) compliant with Commission Regulation (EC) No. 401/2006. Repeatability and reproducibility were acceptable (RSD ≤17% intra-day, <8% inter-day). Four aflatoxins were separated within 12 min in order of AF_{G2}, AF_{G1}, AF_{B2} and AF_{B1} with mean retention times of 6.34±0.01, 7.29±0.01, 8.56±0.01, and 10.07±0.01 min, respectively with clean chromatograms (Figure 1). Overall, the method demonstrated accuracy, reliability, and suitability for quantifying AF_{Total} and AF_{B1} in maize (Table 1).

Table 1: LC-FLD method validation parameters for determining aflatoxins in raw-maize.

Analyte	Spike Levels (µg/kg)	Mean Recovery (%)	RSDr (%)	RSD_R (%)	LOD (µg/kg)	LOQ (µg/kg)
AF_{B1}	0.2	92.83	7.93	8.18	0.04	0.13
	4	80.84	2.56	1.31		
	10	80.65	4.94	2.43		
AF_{B2}	0.2	86.08	5.96	8.39	0.06	0.21
	4	80.85	1.80	4.50		
	10	78.61	3.99	3.15		
AF_{G1}	0.2	87.33	4.44	16.26	0.05	0.16
	4	73.89	3.49	1.22		
	10	75.97	3.84	7.33		
AF_{G2}	0.2	84.53	4.30	12.36	0.06	0.20
	4	79.77	2.73	1.99		
	10	75.50	4.50	4.67		

RSDr= Relative standard deviation calculated under repeatability;
RSD_R=Relative standard deviation calculated under reproducibility;
LOD=Limit of detection; LOQ=Limit of quantification.

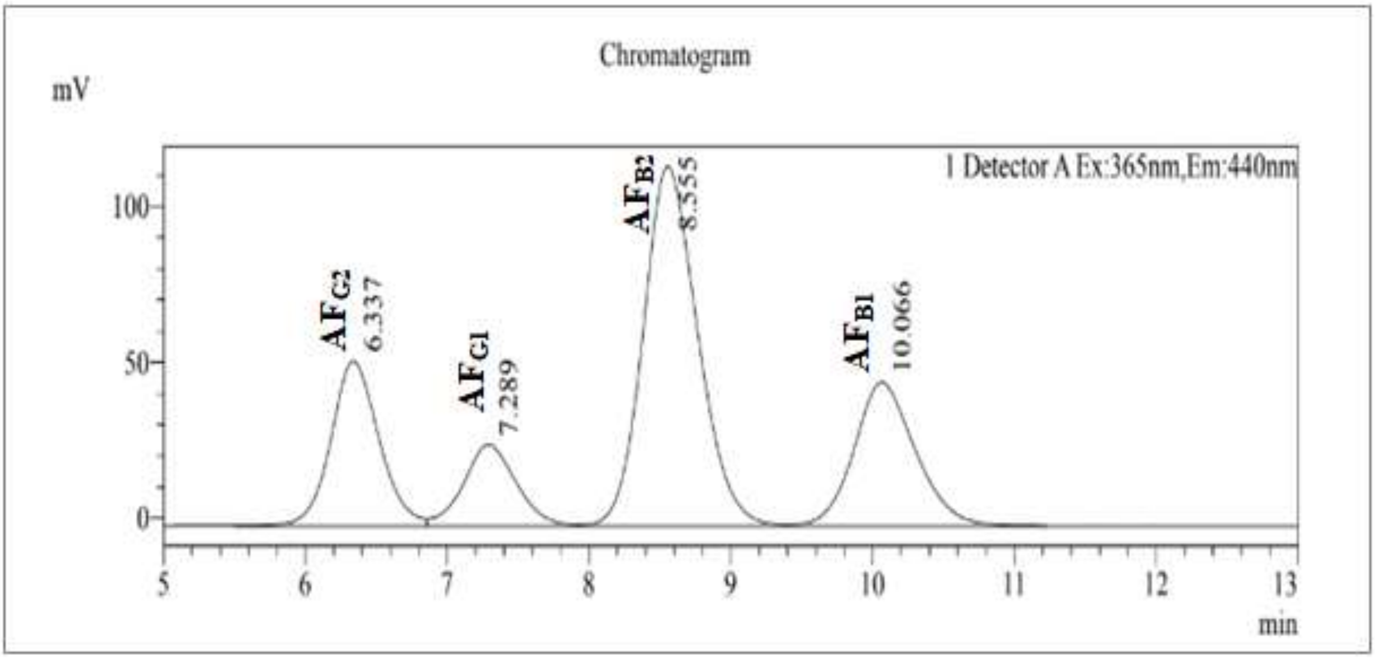


Figure 1: LC-FLD chromatograms of mixed calibration standard containing AF_{B1}, AF_{B2}, AF_{G1} and AF_{G2}.

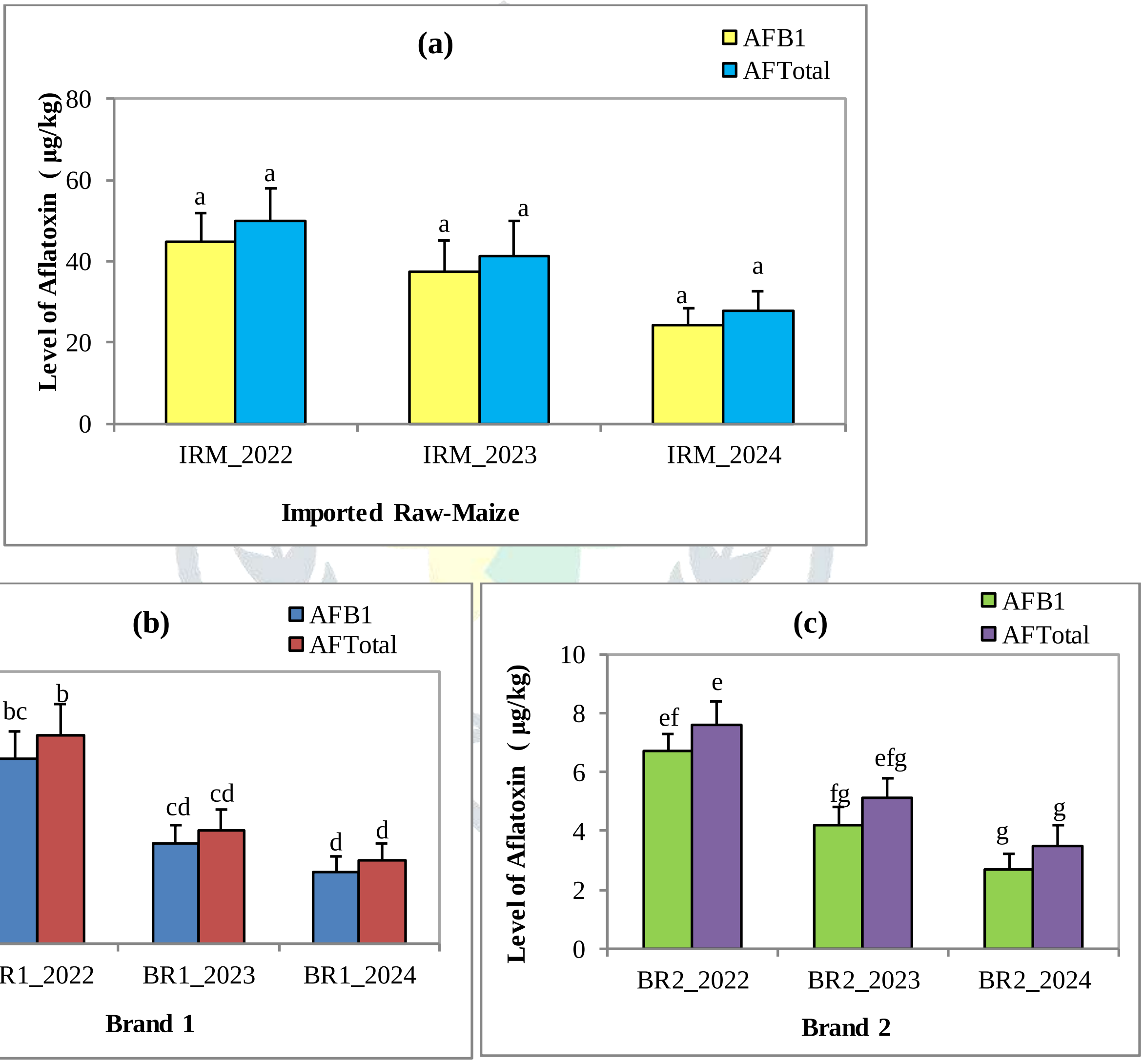
3.2 Occurrence and Quantification of Total-Aflatoxins (AF_{Total}) and Aflatoxin B1 (AF_{B1}) in Imported Raw-Maize Samples and Maize-Based Cereal Products

The results were obtained from the analysis of 20 imported raw-maize samples and 80 maize-based cereal products, representing four different brand names available in the local market each year, collected over three consecutive years (2022–2024). The present study applied the European Union (EU) regulatory maximum permissible limits of 10 µg/kg for total aflatoxins (AF_{Total}) and 5 µg/kg for aflatoxin B1 (AF_{B1}) as reference benchmarks. The findings are summarized in Table 2. Across all three years, imported raw-maize samples exhibited significantly higher mean levels of AF_{Total} and AF_{B1} contaminations compared to the four brands of maize-based cereal products ($p<0.05$). In 2022, all 20 imported raw-maize samples were contaminated with aflatoxins, of which 15 samples (75%) exceeded the EU regulatory limit of 10 µg/kg for AF_{Total}, while 17 samples (85%) exceeded the limit of 5 µg/kg for AF_{B1} (Table 2). In 2022, the mean levels of AF_{Total} and AF_{B1} in imported raw-maize samples were 49.9±7.9 µg/kg and 44.9±7.0 µg/kg, respectively and the levels of contamination ranged from 0.8 to 107.3 µg/kg for AF_{Total} and from 0.8 to 96.3 µg/kg for AF_{B1} (Table 2). However, in 2023 and 2024, six and three imported raw-maize samples respectively were free from aflatoxin contaminations. The mean levels of AF_{Total} and AF_{B1} in imported raw-maize samples in 2023 were 41.3±8.5 µg/kg and 37.4±7.6 µg/kg, respectively with contamination levels ranged from 1.5 to 96.1 µg/kg for AF_{Total} and from 1.5 to 86.1 µg/kg for AF_{B1} (Table 2). Further, in 2023, out of 14 samples, 12 samples (55%) and 11 samples (55%) exceeded the EU regulatory limit for AF_{Total} and AF_{B1} respectively (Table 2). In 2024, the mean levels of AF_{Total} and AF_{B1} decreased further to 27.9±4.8 µg/kg and 24.1±4.4 µg/kg, respectively, with contamination levels ranging from 2.4 to 67.1 µg/kg for AF_{Total} and from 2.4 to 58.8 µg/kg for AF_{B1} (Table 2). Moreover, in 2024, out of 17 samples, 13 samples (65%) exceeded the EU regulatory limit for both AF_{Total} and AF_{B1}. Although a gradual decline in mean levels and the percentages of contaminated raw-maize samples was observed in 2023 and 2024, the differences in aflatoxin contamination among the three years were not statistically significant (F=2.24; P=0.057) (Figure 2a).

Although the four brands of maize-based cereal products recorded significantly lower mean levels of aflatoxin contamination compared to imported raw-maize samples over three year period ($p<0.05$), notable levels of aflatoxins contamination were still recorded. Among the four brands, Brand 3 and Brand 4 consistently exhibited higher mean levels and higher percentages of contamination for AF_{Total} and AF_{B1} than Brand 1 and Brand 2 throughout 2022 to 2024 (Table 2). All four brands of maize-based cereal products showed higher mean levels of AF_{Total} and AF_{B1} contaminations in 2022 compared to 2023 and 2024 (Table 2), indicating a gradual decline in contamination levels over the study period (Figure 2b-e). Specifically, Brands 1, 2, and 3 recorded significantly lower levels of AF_{Total} and AF_{B1} contaminations in 2024 compared to 2022 (Figure 2b-d). In 2022, 50% (AF_{Total}) and 65% (AF_{B1}) of Brand 1 samples (n=18) exceeded EU regulatory limits, whereas in 2024, only 5% (AF_{Total}) and 20% (AF_{B1}) of samples (n=17) exceeded these limits (Table 2). For Brand 2, EU regulatory limits exceeding rates in 2022 were 20% (AF_{Total}) and 70%

(AF_{B1}) from the analysed samples (n=17), while in 2024 only 5% exceeded the limit for AF_{B1}, with none exceeding for AF_{Total} from the analysed samples (n=14) (Table 2). Similarly, for Brand 3, 80% (AF_{Total}) and 85% (AF_{B1}) exceeded the EU regulatory limits in 2022 (n=18), whereas in 2024, 30% (AF_{Total}) and 45% (AF_{B1}) of samples (n=18) exceeded these limits (Table 2). Although Brand 4 also exhibited a declining trend in contamination levels of AF_{Total} and AF_{B1} over the three years, this reduction was not statistically significant (Figure 2e). However, Brand 4 (n=18) showed the highest mean level of contamination for AF_{Total} (18.0±3.4 µg/kg) and AF_{B1} (16.8±3.8 µg/kg) among all four brands in 2022, with 60% (AF_{Total}) and 80% (AF_{B1}) exceeding EU regulatory limits, which declined to 35% (AF_{Total}) and 45% (AF_{B1}) of analysed samples (n=15) in 2024 (Table 2).

Based on the 2022 findings of AF_{Total} and AF_{B1} in both imported raw-maize and maize-based cereal products, monitoring and enforcement of regulatory measures were implemented. As a result of these interventions, by the end of 2024, most manufacturers had made significant efforts to ensure that aflatoxin levels remained within the prescribed limits for both AF_{Total} and AF_{B1}.



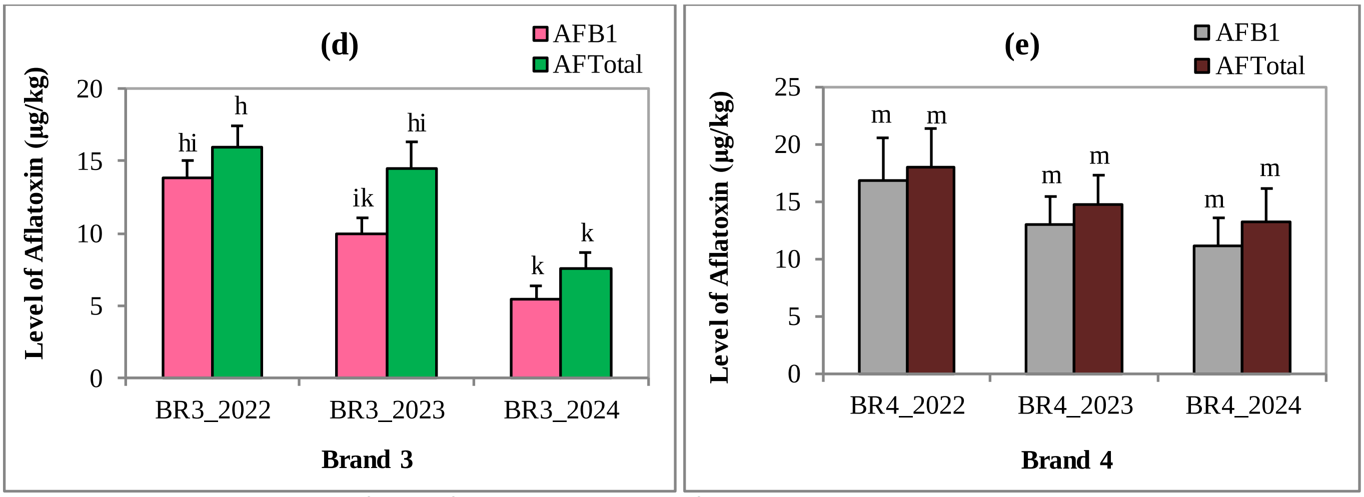


Figure 2: Mean levels (±SE) of total-aflatoxin (AF_{Total}) and aflatoxin B1 (AF_{B1}) in raw-maize samples and maize-based cereal products under four different brand names over three consecutive years 2022, 2023 and 2024. Error bars sharing the same letters are significantly not different ($p<0.05$). IRM=Imported raw-maize; BR1=Brand 1; BR2=Brand 2; BR3=Brand 3; BR4=Brand 4.

Table 2: Summary of AF_{Total} and AF_{B1} levels of imported raw-maize samples and four brands of maize-based cereal products available in local market of Sri Lanka in year 2022 to 2024.

Year	Sample Type	No. of analyzed samples	No. of positive samples	No. of non-positive samples	AF_{Total} (µg/kg)					AF_{B1} (µg/kg)				
					No. of samples $AF_{Total} \geq 10$ µg/kg	% of samples $AF_{B1} \geq 10$ µg/kg	Mean (±SE)	Median	Range	No. of samples $AF_{B1} \geq 5$ µg/kg	% of samples $AF_{B1} \geq 5$ µg/kg	Mean (±SE)	Median	Range
2022	Imported Raw-Maize	20	20	0	15	75%	49.9 (± 7.9)	53.9	0.8 - 107.3	17	85%	44.9 (± 7.0)	48.9	0.8 - 96.3
	Brand-1	20	18	2	10	50%	12.3 (± 1.8)	11.4	2.1 - 23.2	13	65%	10.9 (± 1.6)	9.9	2.1 - 20.7
	Brand-2	20	17	3	4	20%	7.6 (± 0.8)	8.4	1.9 - 12.6	14	70%	6.7 (± 0.6)	7.3	1.9 - 10.8
	Brand-3	20	18	2	16	80%	16.0 (± 1.4)	14.7	3.9 - 26.8	17	85%	13.8 (± 1.2)	12.8	3.9 - 23.3
	Brand-4	20	18	2	12	60%	18.0 (± 3.4)	15.7	3.4 - 80.7	16	80%	16.8 (± 3.8)	14.3	2.2 - 76.7
2023	Imported Raw-Maize	20	14	6	11	55%	41.3 (± 8.5)	47.6	1.5 - 96.1	12	60%	37.4 (± 7.6)	42.2	1.5 - 86.1
	Brand-1	20	16	4	2	10%	6.7 (± 1.2)	5.2	2.4 - 21.4	8	40%	5.9 (± 1.1)	4.8	2.4 - 19.7
	Brand-2	20	13	7	0	0	5.1 (± 0.7)	3.9	2.2 - 9.1	4	20%	4.2 (± 0.6)	3.9	2.0 - 7.8
	Brand-3	20	15	5	11	55%	14.5 (± 1.8)	12.1	6.7 - 33.9	15	75%	10.0 (± 1.1)	8.9	5.6 - 19.5
	Brand-4	20	19	1	12	60%	14.7 (± 2.6)	12.1	1.3 - 46.0	14	70%	13.0 (± 2.4)	11.3	1.3 - 42.1
2024	Imported Raw-Maize	20	17	3	13	65%	27.9 (± 4.8)	25.2	2.4 - 67.1	13	65%	24.1 (± 4.4)	22.5	2.4 - 58.8
	Brand-1	20	17	3	1	5%	4.9 (± 1.0)	3.4	1.0 - 18.7	4	20%	4.2 (± 0.9)	2.6	1.0 - 16.1
	Brand-2	20	14	6	0	0	3.5 (± 0.7)	2.3	1.3 - 8.9	1	5%	2.7 (± 0.5)	2.1	1.3 - 8.3
	Brand-3	20	18	2	6	30%	7.6 (± 1.1)	6.5	2.1 - 20.9	9	45%	5.5 (± 0.9)	5.0	1.2 - 18.1
	Brand-4	20	15	5	7	35%	13.2 (± 2.9)	8.8	1.7 - 33.9	9	45%	11.1 (± 2.5)	5.7	1.7 - 29.5

AF_{Total}= Total-aflatoxins level (Sum of AF_{B1}, AF_{B2}, AF_{G1} and AF_{G2}); AF_{B1}= Level of constituent-aflatoxin B1.

IV. DISCUSSION

Aflatoxin contamination continues to be a major food safety issue globally, with maize and maize-based products identified as highly vulnerable commodities [12, 22]. Primarily four types of aflatoxins including AF_{B1}, AF_{B2}, AF_{G1}, and AF_{G2} were reported in different food commodities worldwide [24]. Among them, AF_{B1} remains the most concerning due to its extreme toxicity and classified as a Group 1 human carcinogen [4]. In Sri Lanka also AF_{B1} is a predominant mycotoxin contaminant in most agricultural products [23], where such occurrences have been reported in different foods since the early 1980s to date [24]. Generally, cereal like maize is highly susceptible to aflatoxin contamination worldwide [25], because maize is carbohydrates rich product and it provides a good growth medium for the fungus like *Aspergillus* species [12]. Maize and its products are considered as one of major cereal staple in the human diet in Sri Lanka. Therefore considerable quantity of raw-maize also imported to Sri Lanka annually to manufacture different maize-based cereal products.

The findings revealed that imported raw-maize samples had significantly higher levels of AF_{Total} and AF_{B1} contamination compared to four brands of maize-based cereal products. This can be attributed to favorable conditions for fungal growth and toxin accumulation during bulk harvesting, handling, drying, and storage, whereas processing steps such as mechanical cleaning, kernel sorting, and controlled storage in cereal production reduce contamination [26]. Over the three year period, 85% of raw-maize samples (51 out of 60) were contaminated, with the majority exceeding European Union (EU) regulatory thresholds of 10 µg/kg for AF_{Total} and 5 µg/kg for AF_{B1}. Although a gradual reduction in aflatoxin levels was observed between 2022 and 2024, this decline was not statistically significant. The persistence of elevated aflatoxin levels in imported raw-maize suggests that contamination likely occurs prior to importation, possibly during pre-harvest or storage stages, as also highlighted in earlier studies [2, 9, 11].

By contrast, all four brands of maize-based cereal products showed comparatively lower AF_{Total} and AF_{B1} contamination levels, with a noticeable year-on-year decline in both mean aflatoxin levels and the proportion of samples exceeding EU regulatory thresholds. Among them, Brands 1, 2, and 3 demonstrated significant declines in AF_{Total} and AF_{B1} by 2024, suggesting enhanced quality control measures in processing, storage and sourcing. These findings are encouraging, as they reflect industry-level interventions that may have reduced exposure risks for consumers. However, though Brand 4 also maintained the relatively lower aflatoxin contamination levels over the three years, underscoring the need for brand-specific monitoring and stricter compliance enforcement.

The observed non-compliance highlights the need for stronger quality control measures and import monitoring systems for raw-maize in Sri Lanka. Currently, the country lacks maize-specific aflatoxin regulations, including limits for AF_{B1}, applying only a maximum limit of 30 µg/kg for all foods stipulated under the Labeling and Miscellaneous Regulations. Since AF_{B1} is the most potent and frequently detected aflatoxin, the absence of specific standards poses a significant gap in consumer protection. Using EU regulatory limits in this study provided a stricter benchmark and highlighted the urgency of updating local standards in line with international best practices. Therefore, the findings of this study highlight the urgent need for stronger regulatory enforcement to support dietary risk assessments and strengthen national food safety policies.

V. CONCLUSION

This study revealed that most analyzed samples were contaminated with aflatoxins at levels exceeding EU maximum limits, with AF_{B1} posing the greatest concern. Aflatoxin contamination in maize and its products thus remains a growing food safety challenge in Sri Lanka. Over the three-year period, AF_{Total} and AF_{B1} levels were consistently higher in imported raw-maize than in locally available maize-based cereal products. Although contamination levels were highest in 2022, both imported raw-maize and four brands of maize-based cereal products showed a gradual decline by 2024, likely reflecting the impact of monitoring and enforcement of regulatory measures. To mitigate dietary exposure risks, it is essential to strengthen surveillance systems, establish maize-specific national standards, and ensure compliance with international benchmarks. The implementation of stricter import monitoring system for raw-maize in Sri Lanka, together with industry-level interventions targeting maize-based products, is essential for mitigating aflatoxin contamination and ensuring consumer health protection.

VI. ACKNOWLEDGEMENT

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