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# Assessment of the Exposure Risk to Mycotoxins from Stored Maize (*Zea mays* L.) in Triple Bags with Aromatic Plants Leaves (*Lippia multiflora* and *Hyptis suaveolens*) in Côte d'Ivoire

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author YVG designed the study, wrote the protocol, fitted the data and wrote the first draft of the manuscript. Author KKC checked the first draft of the manuscript and achieved the submitted manuscript. Authors CA and SD performed the statistical analysis and assisted the experiments implementation. Author GHMB expertized the results interpretations. All authors managed the literature, read and approved the submitted manuscript.*

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## ABSTRACT

In Côte d'Ivoire, maize is second cereal most cultivated and consumed after rice. In bad storage conditions, corn may be contaminated by mycotoxins (aflatoxin B1, total aflatoxins, ochratoxin A, fuminosin B1, zearalenone). The aim of this study was to assess the exposure risk of these

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mycotoxins for maize stored in triple bags in presence of aromatic plants leaves (*Lippia multiflora* and *Hyptis suaveolens*). The contents of water activity, aflatoxin B1 (AFB1), total aflatoxins (AFT), ochratoxin A (OTA), fuminosin B1 (FB1) and zearalenone (ZEA) were studied and monitored. The levels of AFB1, AFT, OTA, FB1 and ZEA resulted from maize grains treated with plants leaves were significantly lower than those recorded with untreated maize of control bags. The estimated daily intakes in AFB1, AFT, OTA, FB1 and ZEA, deriving with consumption of maize from experimental batches stored for 18 months are respectively 1.69 ± 0.00 - 2.09 ± 0.01 ng/kg bw/day, 8.66 – 10.91 ng/kg bw/day, 1.86 ± 0.01 - 2.47 ± 0.01 ng/kg bw/day, 2.01 ± 0.05 - 3.01± 0.05 ng/kg bw/day and 1.89 ± 0.12 - 3.56 ± 0.04 ng/kg bw/day. These levels are lower than the estimated intakes from maximal reference value (EDILM) for OTA, FB1 and ZEA. For aflatoxin B1 and total aflatoxins, the estimated daily intakes are lower than the estimated intakes from maximal reference value (EDILM) during, respectively, 15 storage months and 10 storage months. However, after 18 storage months, exposure risk of aflatoxin B1 is higher than the estimated intakes from maximal reference value. This inexpensive and easy-to-use treatment should be popularized among farmers

*Keywords: Mycotoxins; exposure risk; stored maize; aromatic plant; triple bagging.*

## 1. INTRODUCTION

Ranked third in the world after wheat and rice, maize (*Zea mays* L.) is one of the most widely grown cereals in the world. In Côte d'Ivoire, of all food crops, it is the second most cultivated cereal after rice (Oryza spp.), with an annual national production of 1.006.000 t in 2018 [1]. It plays an essential role as subsistence, commercial and socio-cultural culture [2]. Hence, maize is the staple food of a large segment of the Ivorian populations. In Côte d'Ivoire, the mean daily consumption of maize grains is estimated at 28.4 g [3]. It allows diverse dishes such as porridge, couscous or dense paste (tô) eaten with sauce [4]. Despite the growth in its production and its socio-economic importance, post-harvest losses during storage remain a real challenge for farmers [5]. Indeed, post-harvest losses can reach more than 60% in maize stored in traditional storage structures [6]. These losses are mainly due to insects and molds under inadequate storage conditions. The activity of insect pests creates an environment favorable to the growth of molds of the genus *Aspergillus*, *Penicillium* and *Fusarium* [7]; [8].These molds produce mycotoxins responsible for many diseases in humans and animals such as cancer [9]. Maize can be contaminated with two or more mycotoxins. In Côte d'Ivoire, studies revealed mycotoxin co-contamination in maize [10]; [11]. The consumption of maize contaminated by mycotoxins could represent an increased risk with carcinogenic and hepatotoxic effects for consumer [12]. There are reports that infants and children are even more sensitive to the effects of mycotoxins in general due to their immature immune systems coupled with high ingestion of maize-based foods [13]; [14]. It is very difficult or almost impossible to eliminate mycotoxins (aflatoxins, ochratoxin A…) from raw foods such as maize, however a good storage system would help maintain food safety. Studies showed the efficiency of aromatic plants *Lippia multiflora* and *Hyptis suaveolens* on sanitary quality of maize stored in granaries, polypropylene bags, and triple bags thanks to their insecticidal and fungicidal effects [15]; [16]; [17]. However, the exposure risk to mycotoxins from maize grains stored in triple bags containing aromatic plants has not yet been assessed. Thus, the current study was initiated to assess the exposures risk to aflatoxin B1, total aflatoxins, ochratoxin A, fuminosin B1 and zearalenone by the consumption of stored maize in triple bags in presence of leaves of *Lippia multiflora* and *Hyptis suaveolens* during 18 months by the ivorian adult.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

The experiment was carried out in the storeroom of Research Unit Laboratory of Biochemistry and Food Sciences (URBSA) UFR Biosciences at the University Félix HOUPHOUET-BOIGNY. The different bags were kept in a laboratory storeroom to 27.78 ± 0.19°C temperature and 75.0 ± 0.99% relative humidity. Wooden pallets were arranged floored as support for triple bagging system.

### 2.2 Collection of Maize Grains and Aromatic Plants used in the Study

Maize grains and leaves of *L. multiflora* and *H. suaveolens* were collected in March 2016 from producers of Gbêkê region (7°50 North and 5°18

West in center of Côte d'Ivoire). Prior to the storage, maize were sun-dried for 2-3 days before being used for the experiment. While, the *L. multiflora* and *H. suaveolens* leaves were drying at an average temperature of 30◦C for 6-7 days and kept away from direct sun exposure. The dried leaves were chopped into fine particles before being used for the experiment.

## 2.3 Implementation of Experiment

### 2.3.1 Using the triple bagging

Storage bags used in our study, were made of polypropylene bags and polyethylene bags (Purdue Improved Cowpea Storage: PICS) developed by Purdue University for storing cowpeas from Niger. These bags, obtained from suppliers, are composed of a triple bagging system.

### 2.3.2 Treatments

The storage method is based on the mixture of plants leaves. Method tested in this study, consisted in adding of aromatics plants leaves (0 - 5% w/w) in the polypropylene bags and the triple bagging system containing 50 kg maize grains and storing on pallets in warehouses for 18 months. The filling of the bags was performed by alternately as maize grains strata and aromatics plants. The maize grains were stored as follows:

- 1 control batch of 50 kg of maize grain in polypropylene bag without plants leaves (TPPB0);
- 1 control batch of 50 kg of maize grain in triple bagging system without plants leaves (TPB0);
- 1 experimental batch of 50 kg of maize grain in triple bagging system with 2.5% of plants leaves (0.625kg *L. multiflora* and 0.625kg *H. suaveolens*) (TB1);
- 1 experimental batch of 50 kg of maize grain in triple bagging system with 3.99% of plants leaves (0.40 kg *L. multiflora* and 1.60 kg *H. suaveolens*) (TB2);
- 1 experimental batch of 50 kg of maize grain in triple bagging system with 3.99% of plants leaves (1.60 kg *L. multiflora* and 0.40 kg *H. suaveolens*) (TB3);
- 1 experimental batch of 50 kg of maize grain in triple bagging system with 1.01% of plants leaves (0.10 kg *L. multiflora* and 0.40 kg *H. suaveolens*) (TB4);
- 1 experimental batch of 50 kg of maize grain in triple bagging system with 1.01% of plants leaves (0.40 kg *L. multiflora* and 0.10 kg *H. suaveolens*) (TB5);
- 1 experimental batch of 50 kg of maize grain in triple bagging system with 5% of plants leaves (2.5 kg *L. multiflora* and 2.5 kg *H. suaveolens*) (TB6);
- 1 experimental batch of 50 kg of maize grain in triple bagging system with 2.5% of plants leaves (1.25 kg *L. multiflora*) (TB7);
- 1 experimental batch of 50 kg of maize grain in triple bagging system with 2.5% of plants leaves (1.25 kg *H. suaveolens*) (TB8).

## 2.4 Sampling

The sampling was performed at the beginning of the storage (0 month), then 5, 10, 15 and 18 months later, in triplicate. Thus, 2 kg of maize samples from each bag was gathered through the top, the center and the bottom opening sides.

### 2.4.1 Determination of water activity

The water activity was ascertained using a hygrometer from HygroLab Rotronic according to the method of [18]. Thus, a sample of 5 g of maize grains was placed in 10 Aw containers void of any trace of water. After two minutes, value of water activity was directly carried out in the device.

### 2.4.2 Analysis of aflatoxin B1, total aflatoxins, ochratoxin A, fuminosin B1 and zearalenone

Aflatoxins B1 (AFB1), total aflatoxins (AFT), ochratoxin A (OTA), fuminosin B1 (FB1) and zearalenone (ZEA) was made by HPLC following, respectively, official AOAC method [19], the European community regulation [20], the method AFNOR [21] and the methods of AOAC [22] and Miraglia and Brera [23].

## 2.5 Estimate of Intakes in Aflatoxin B1, Total Aflatoxins, Ochratoxin A, Fuminosin B1 and Zearalenone from Maize Stored

According to the definition of the Codex Alimentarius, the estimate of the exposure is the assessment of the quantitative exposure of the probable ingestion of chemical dangers through foods [24]. The mycotoxin intake was estimated from the data of maize consumption in Côte d'Ivoire [25]. The maize consumed daily by an Ivorian adult of 70 kg is estimated at 28.4 g per capita / day [3]. The mycotoxin intake was calculated using the following equation. The estimated values of the exposure were compared to estimated daily intakes calculated from limits maximal (EDILM). These limits were set at 5 µg/kg, 4 µg/kg, 5 µg/kg, 2000 µg/kg, and 500 µg/kg respectively for aflatoxin B1, for total aflatoxins, for ochratoxin A, for fuminosine B1 and for zearalenone [20]; [26]; [27]; [28].

EAI = (T x Q) / BW

With EAI: the estimated daily intake of AFB1, AFT, OTA, FB1 and ZEA in ng $kg^{-1}$ of body weight (b.w.) $day^{-1}$T. The AFB1, AFT, OTA, FB1 and ZEA contents in maize stored (ng/kg); Q: the daily Intake of maize grains (g/day); BW: the Body weight of an adult person (70 kg).

## 2.6 Characterization of the Risk of Exposure Risk to Aflatoxin B1, Total Aflatoxins, Ochratoxin A, Fuminosin B1 and Zearalenone

The characterization of the Risk of Exposure (RE) to aflatoxin B1, total aflatoxins, ochratoxin A, fuminosin B1 and zearalenone is calculated with the following formula. This result allows only concluding on the potential occurrence of effects but not on their importance.
RE = (EDI) / (EDILM)
If:

- RE <1 means that the exposed population is theoretically out of danger, that is, this exposed population is not likely to develop the health effects studied.
- RE> 1 means that the toxic effect can occur without it being possible to predict the probability of the occurrence of this event.

## 2.7 Statistical Analysis

All analyses were performed in triplicate and the full data were statistically treated using SPSS software (version 20.0). It consisted in Analysis of Variance at repeated measures. Means derived from parameters were compared with the Tukey High Significant Difference test at 5% significance level.

# 3. RESULTS

## 3.1 Determination of Water Activity, Aflatoxin B1, Total Aflatoxins, Ochratoxin A, Fuminosin B1 and zearalenone of Stored Maize

Table 2 presents the results of water activity, aflatoxin B1, total aflatoxins, ochratoxin A, fuminosin B1 and zearalenone contents of stored maize. For all mycotoxins, these parameters increase progressively during storage. Control batches (TPPB0 and TPB0) have high values than experimental batches (TB1, TB2, TB3, TB4, TB5, TB6, TB7 and TB8) after 18 months of storage for all parameters.

## 3.2 Estimated Intake of Aflatoxin B1, Ochratoxin A, Fuminosin B1 and Zearalenone of Stored Maize

The ratio of Estimated Daily Intake (EDI) to estimated daily intakes calculated from limits maximal (EDILM) was determined to assess the risk of exposure to consumers.

### 3.2.1 Estimated intake of aflatoxin B1

Table 3 presents the results of the estimated intake of aflatoxin B1 (AFB1) obtained from the concentrations of AFB1 determined after 18 months of storage. Estimated intakes for all batches are between 1.69 and 13.81 ng/kg of bw/d. These contributions are all higher than the estimated daily intakes from limits maximal of AFB1 (2.02 ng/kg of bw/d). 50% of the lots present a high risk after 18 months for the exposure risk in AFB1. After 18 months of storage, all batches have a significant exposure risk.

### 3.2.2 Estimated intake of total aflatoxins

In control batches, the estimated intakes of total aflatoxins (AFT) increase significantly during 18 storage months. These intakes vary from 1.68 to 67.99 ng/kg of bw/d for TPPB0 and from 0.05 to 16.51 ng/kg of bw/d for TPB0. In experimental batches, estimated intakes increase significantly at 10th storage's month and the means are lower than control batches. At ten months, the lots TB2, TB3 and TB6 have lower estimated intakes of AFT compared to the estimated daily intakes from limits maximal (1.62 ng/kg of bw/d). After 18 months of storage, values in experimental lots are between 8.66 and 10.91 ng/kg of bw /d. These values are higher than the estimated daily intakes from limits maximal (1.62 ng/kg of bw/d). Thus, exposure risk of total aflatoxins is high for control and treated lots after 18 storage months.

### 3.2.3 Estimated intake of ochratoxin A

The estimated intake of ochratoxin A (OTA) increase significantly during 18 storage months in control batches. These intakes vary from 0.63

to 7.51 ng/kg of bw/d for TPPB0 and from 0.03 to 3.10 ng/kg of bw/d for TPB0. In experimental batches, estimated intakes increase significantly at 10th storage's month but the means are lower than control batches. After 10 months of storage, values are between 0.22 and 0.34 ng/kg of bw/d. After 18 months of storage, estimated intakes for experimental batches varies respectively from 1.86 to 2.47 ng/kg of bw/d. The lot TB6 has the lowest intake in OTA. However, the contributions of experimental batches TB2, TB3, TB6 and TB8 are lower than the estimated daily intakes from limits maximal (2.02 ng/kg of bw/d). These lots have a low exposure risk for OTA (Table 3).

#### 3.2.4 Estimated intake of fuminosin B1

Estimated intake of fuminosin B1 (FB1) in control batches TPPB0 and TPB0 varies respectively from 0.04 to 18.63 ng/ kg of bw /d and from 0.04 to 4.22 ng/kg of bw/d during storage. Estimated intakes increase significantly at 10$^{th}$ storage's month in experimental batches. After 10 months of storage, intakes of FB1 in experimental batches are between 0.29 and 0.38 ng/kg of bw/d. After 18 months of storage, experimental batches vary between 2.01 from 3.01 ng/kg of bw/d. These contributions are lower than the estimated daily intakes from limits maximal (811.43 ng/kg of bw/d) (Table 3).

#### 3.2.5 Estimated intake of zearalenone

Estimated intake of zearalenone (ZEA) in control batches TPPB0 and TPB0 varies respectively from 0.10 ± 0.00 to 10.27 ± 0.05 ng/ kg of bw /d and from 0.10 ± 0.00 to 4.93 ± 0.12 ng/ kg of bw /d during storage. After 10 months of storage, intake of ZEA in experimental batches are between 0.24 ± 0.01 and 0.42 ± 0.01 ng/ kg of bw /d. After 18 months of storage, experimental batches varies from 1.89 ± 0.12 to 3.56 ± 0.04 ng/ kg of bw /d. The estimated daily intakes from limits maximal (202.86 ng/kg of bw/d) is higher than intakes of zearalenone.

### 3.3 Risk Exposure in Aflatoxin B1, Total Aflatoxins, Ochratoxin A, Fuminosin B1 and Zearalenone

For every mycotoxin, the ratio of Estimated Daily Intake (EDI) to Estimated Daily Intake from limits maximal (EDILM) was determined to assess the risk of exposure to consumers after 18 months of storage. Table 4 shows the risk of exposure during storage. The results show that the risks of exposure to aflatoxin B1 and total aflatoxins are low up to, respectively, 15 and 10 months of storage in experimental batches. After 18 months of storage, for aflatoxin B1 and total aflatoxins, exposure risk is high in all batches (control and experimental). Exposure risk to ochratoxin A are lower than 1 up to 15 months of storage. Only, experimental lots TB2, TB3, TB6 and TB8 showed lower risk after 18 months of storage, with RE <1. For FB1 and ZEA, all batches have a low risk with RE <1.

## 4. DISCUSSION

The results observed in this study showed that the system bags in the presence of *Lippia multiflora* and/or *Hyptis suaveolens* used for the storage of corn slow down the evolution of the concentrations of aflatoxin B1 (AFB1), total aflatoxins (AFT), ochratoxin A (OTA), fuminosin B1 (FB1) and zearalenone (ZEA) by inhibiting the development of mycotoxinogenic germs. Thus, the concentrations of AFB1, AFT, OTA, FB1 and ZEA in the samples of maize stored in bags in triple bagging in the presence of aromatic plants are low compared to those stored in the polypropylene bag without aromatic plants (TPPB0) and in triple bagging without aromatic plants (TPB0). The combination of plants and the triple bagging system would reduce the metabolism of insects and molds thanks to the reduction of oxygen (O2) and the insecticidal and fungicidal activity of plants [29]; [30]. These results are in agreement with those of [31] who also observed a small change in OTA concentrations in cowpea stored in triple bags with the addition of *L. multiflora* in different proportions after eight months. The results of our study are equally agreement with the work of [16]. These authors observed low concentrations of aflatoxin B1 and ochratoxin A in maize stored in polypropylene bags with *L. multiflora* and *H. suaveolens* after nine months. Compared to the standard set by the European Union on OTA (5 µg/kg), the OTA concentrations in the treated batches are all lower until the fifteenth month of storage. While in the eighteenth month of storage, the level of OTA in the treated batches increased significantly and exceeded the standard with the exception of TB2, TB3, TB6 and TB8. For FB1 and ZEA, the concentrations in the treated lots are all below the respective standards of 2000 and 500 µg/kg until the 18th month of storage. These observations could also be explained by the evolution of water activity (Aw). Indeed, Aw is an important parameter in the preservation of food. For the prevention of fungal development, the corn grains must have an Aw lower than 0.65 being the accepted limit value [32]. In addition, authors have shown the correlation between the evolution of Aw and mycotoxins (OTA, FB1, ZEA) in studies on the storage of corn in granaries in the presence of *L. multiflora* and *H. suaveolens* [33] and storing cowpeas in bags with triple bagging in the presence of *L. multiflora* [31]. The mycotoxins contamination observed in this study was revealed in previous studies in Côte d'Ivoire [10]; [11]. Authors showed frequent co-exposure of major mycotoxins (AF, FB1 and OTA) [11]. For these authors, this co-exposure is related to the frequency of consumption of corn, peanuts, millet and attiéké. Co-exposure to these mycotoxins could cause negative effects on human health such as teratogenic, immunotoxic effects, etc [10]; [11]. For aflatoxin B1 (AFB1) and total aflatoxins, the estimated intakes, respectively, after 15 and 10 months of storage are lower than the estimated intakes from reference value (EDILM). The exposure risk is significantly high for AFB1 and total aflatoxins after storage time. The International Agency for Research into Cancer (IARC) has classified aflatoxin B1 as a Class 1 carcinogen [34]. Dietary aflatoxin exposure is considered to be an important risk factor in the development of hepatocellular cancer in some regions of the world [35]; [36]. If the IARC classifications are accepted, any aflatoxin contamination in maize destined for human consumption can be clearly identified as a hazard to human health. Zhang et al., in their researches on the probabilistic risk assessment of dietary exposure to aflatoxin B1 in Guangzhou (China) estimated the cancer risk of AFB1 [37]. These results indicated that foods currently contaminated by AFB1 had low health risks for residents and that dietary exposure to AFB1may not account for the occurrence of liver cancer in Guangzhou (China). In our study, the risk of exposure remains low for FB1 and ZEA in batches treated after 18 months of storage. While the estimated adult exposure for FB1 is extremely low and appears as little risk, the estimated exposure of children may be of concern. The standard child's body weight at 15 kg is one fifth that of the average adult and yet the amount of maize-based food products consumed has been assumed to be similar based on their consumption of corn-based breakfast cereal and snack food such as corn chips. This results in the exposure of children being substantially higher than adults [38]. Some factors increasing risk of contamination such as weather variables are not entirely controllable, although there are a number of good agricultural practices (GAP) that will assist in reducing contamination [39]. Other factors such as insect pressure and storage conditions can be controlled [38]. The results of our work could contribute to control the storage conditions such as water activity.

**Table 1. Statistical data for water activity, aflatoxin B1, total aflatoxins, ochratoxin A, fuminosin B1 and zearalenone in maize grains according to the type of packaging during the storage period**

| Source of variation | | Parameters | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Aw** | **AFB1** | **AFT** | **OTA** | **FB1** | **ZEA** |
| **Types** | **df** | 9 | | | | | |
| | **SS** | 0.24 | 2063.28 | 31153.43 | 557.59 | 4921.60 | 1448.78 |
| | **F-value** | 180.77 | 13268.84 | 29871.53 | 5945.53 | 13709.41 | 71734.65 |
| | **P-value** | **< 0.001** | | | | | |
| **Error Types** | **df** | 20 | | | | | |
| | **SS** | 0.00 | 0.35 | 2.32 | 0.20 | 0.80 | 0.05 |
| **Duration (months)** | **df** | 2.37 | 1.33 | 1.36 | 1.06 | 1.65 | 1.84 |
| | **SS** | 0.20 | 1442.79 | 35768.55 | 981.61 | 2385.85 | 1703.49 |
| | **F-value** | 257.44 | 10856.12 | 29871.53 | 15101.48 | 21722.98 | 83752.59 |
| | **P-value** | **< 0.001** | | | | | |
| **Error Duration** | **df** | 47.37 | 26.56 | 27.12 | 1.30 | 32.92 | 36.83 |
| | **SS** | 0.01 | 2.65 | 5.86 | 21.20 | 2.20 | 0.41 |
| **Type x Storage duration** | **df** | 21.32 | 11.95 | 12.2 | 9.54 | 14.81 | 16.57 |
| | **SS** | 0.01 | 1883.70 | 40000.15 | 394.01 | 3613.81 | 963.96 |
| | **F-value** | 14.62 | 1574.86 | 121999.45 | 673.52 | 3655.93 | 5265.94 |
| | **P-value** | **< 0.001** | | | | | |

*SS: sum of squares; F-value: value of the statistical test; P-value: probability value of the statistical test; df: degree of freedom, Aw: water activity, AFB1: aflatoxin B1, AFT: Total aflatoxins, OTA: ochratoxin A, FB1: fuminosin B1, ZEA: zearalenone*

**Table 2. Evolution of water activity, Aflatoxin B1 (AFB1), Total aflatoxin (AFT), Ochratoxin A (OTA), Fuminosin B1 (FB1) and Zearalenone (ZEA) of stored maize during 18 months**

| Parameters | Storage duration (month) | TPPB0 | TPB0 | TB1 | TB2 | TB3 | TB4 | TB5 | TB6 | TB7 | TB8 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Water activity (Aw) | 0 | 0.69 ± 0.02$^{aA}$ | 0.69±0.02$^{aA}$ | 0.69±0.02$^{aA}$ | 0.69±0.02$^{aA}$ | 0.69 ±0.02$^{aA}$ | 0.69±0.02$^{aA}$ | 0.69±0.02$^{aA}$ | 0.69±0.02$^{aA}$ | 0.69±0.02$^{aA}$ | 0.69±0.02$^{aA}$ |
| | 1 | 0.75 ±0.02$^{bB}$ | 0.72±0.01$^{aA}$ | 0.70±0.02$^{aA}$ | 0.71±0.01$^{aA}$ | 0.70 ±0.03$^{aA}$ | 0.71±0.02$^{aA}$ | 0.70±0.01$^{aA}$ | 0.70±0.01$^{aA}$ | 0.71±0.02$^{aA}$ | 0.70±0.01$^{aA}$ |
| | 5 | 0.88 ±0.01$^{cC}$ | 0.73±0.01$^{aA}$ | 0.72±0.01$^{aA}$ | 0.72±0.01$^{aA}$ | 0.72 ±0.01$^{aA}$ | 0.73±0.01$^{aA}$ | 0.72±0.00$^{aA}$ | 0.72±0.00$^{aA}$ | 0.72±0.01$^{aA}$ | 0.72±0.01$^{aA}$ |
| | 10 | 0.90 ±0.02$^{dD}$ | 0.76±0.03$^{bB}$ | 0.75±0.01$^{bB}$ | 0.73±0.01$^{aB}$ | 0.72 ±0.00$^{aA}$ | 0.75±0.00$^{bB}$ | 0.75±0.00$^{bB}$ | 0.73±0.01$^{aB}$ | 0.73±0.00$^{aB}$ | 0.73±0.01$^{aB}$ |
| | 15 | 0.94 ±0.01$^{eE}$ | 0.80±0.02$^{cC}$ | 0.76±0.00$^{bC}$ | 0.73±0.00$^{aB}$ | 0.73 ±0.00$^{aB}$ | 0.77±0.01$^{bC}$ | 0.76±0.01$^{bC}$ | 0.73±0.00$^{aB}$ | 0.74±0.01$^{aB}$ | 0.73±0.00$^{aB}$ |
| | 18 | 0.96 ± 0.01$^{fF}$ | 0.85±0.01$^{dD}$ | 0.79±0.01$^{bD}$ | 0.75±0.01$^{aC}$ | 0.75 ±0.01$^{aC}$ | 0.80±0.01$^{bD}$ | 0.79±0.01$^{bD}$ | 0.74±0.01$^{aC}$ | 0.76±0.00$^{abC}$ | 0.75±0.00$^{aB}$ |
| AFB1 (µg/kg) | 0 | 0.04 ±0.00$^{aA}$ | 0.04±0.00$^{aA}$ | 0.04±0.00$^{aA}$ | 0.04±0.00$^{aA}$ | 0.04 ±0.00$^{aA}$ | 0.04±0.00$^{aA}$ | 0.04±0.00$^{aA}$ | 0.04±0.00$^{aA}$ | 0.04± 0.00$^{aA}$ | 0.04±0.00$^{aA}$ |
| | 1 | 1.30 ± 0.01$^{bB}$ | 0.04±0.01$^{aA}$ | 0.04±0.00$^{aA}$ | 0.04±0.00$^{aA}$ | 0.04 ±0.01$^{aA}$ | 0.04±0.00$^{aA}$ | 0.04±0.01$^{aA}$ | 0.04±0.00$^{aA}$ | 0.04± 0.01$^{aA}$ | 0.04±0.01$^{aA}$ |
| | 5 | 5.28 ±0.05$^{cC}$ | 0.05±0.00$^{aA}$ | 0.04±0.00$^{aA}$ | 0.04±0.01$^{aA}$ | 0.04 ±0.01$^{aA}$ | 0.04±0.01$^{aA}$ | 0.04±0.01$^{aA}$ | 0.04±0.00$^{aA}$ | 0.04± 0.01$^{aA}$ | 0.04±0.01$^{aA}$ |
| | 10 | 11.32 ± 0.60$^{dD}$ | 1.25±0.06$^{bB}$ | 1.21±0.01$^{bB}$ | 0.75±0.02$^{aB}$ | 0.73 ±0.03$^{aB}$ | 1.15±0.04$^{bB}$ | 1.18±0.05$^{bB}$ | 0.70±0.01$^{aB}$ | 0.82± 0.08$^{aB}$ | 0.7 ± 0.02$^{aB}$ |
| | 15 | 23.87 ±0.12$^{eE}$ | 4.25±0.08$^{dD}$ | 2.85±0.05$^{bC}$ | 1.71±0.02$^{aC}$ | 1.59 ±0.09$^{aC}$ | 3.28±0.01$^{cC}$ | 2.94±0.04$^{bC}$ | 1.58±0.05$^{aC}$ | 2.44 ±0.36$^{bC}$ | 1.75±0.03$^{aC}$ |
| | 18 | 34.05 ± 0.07$^{fF}$ | 7.33±0.05$^{eE}$ | 5.01±0.00$^{cD}$ | 4.22±0.02$^{aD}$ | 4.20 ±0.01$^{aD}$ | 5.15±0.06$^{cD}$ | 5.07 ±0.05$^{cD}$ | 4.17 ± 0.05$^{aD}$ | 4.46± 0.11$^{aD}$ | 4.30±0.05$^{aD}$ |
| AFT (µg/kg) | 0 | 0.11± 0.00$^{aA}$ | 0.11±0.00$^{aA}$ | 0.11±0.00$^{aA}$ | 0.11±0.00$^{aA}$ | 0.11± 0.00$^{aA}$ | 0.11±0.00$^{aA}$ | 0.11± 0.00$^{aA}$ | 0.11± 0.00$^{aA}$ | 0.11± 0.00$^{aA}$ | 0.11±0.00$^{aA}$ |
| | 1 | 4.14± 0.09$^{bB}$ | 0.13±0.00$^{aA}$ | 0.13±0.00$^{aA}$ | 0.12±0.00$^{aA}$ | 0.12± 0.01$^{aA}$ | 0.12±0.01$^{aA}$ | 0.12± 0.00$^{aA}$ | 0.12± 0.00$^{aA}$ | 0.12± 0.01$^{aA}$ | 0.13±0.00$^{aA}$ |
| | 5 | 16.95± 0.20$^{cC}$ | 0.18±0.01$^{bB}$ | 0.14±0.00$^{bB}$ | 0.12±0.00$^{aA}$ | 0.12± 0.00$^{aA}$ | 0.14±0.01$^{bB}$ | 0.15± 0.00$^{bB}$ | 0.12± 0.00$^{aA}$ | 0.12± 0.00$^{aA}$ | 0.13±0.01$^{aA}$ |
| | 10 | 34.59± 0.38$^{dD}$ | 4.12±0.08$^{bC}$ | 3.90±0.06$^{bC}$ | 2.40±0.02$^{aB}$ | 2.38 ±0.06$^{aB}$ | 3.94±0.06$^{bC}$ | 3.89± 0.13$^{bC}$ | 2.26 ± 0.04$^{aB}$ | 2.70 ± .11$^{aB}$ | 2.54±0.03$^{aB}$ |
| | 15 | 76.01± 0.21$^{eE}$ | 15.11±0.36$^{dD}$ | 9.17±0.04$^{bD}$ | 6.27± 0.05$^{aC}$ | 5.46± 0.26$^{aC}$ | 10.93±0.19$^{bD}$ | 9.64± 0.07$^{bD}$ | 5.26± 0.08$^{aC}$ | 8.63±0.36$^{abC}$ | 6.72±0.07$^{aC}$ |
| | 18 | 114.58±1.81$^{fF}$ | 33.70±0.23$^{eE}$ | 26.27±0.11$^{cE}$ | 22.07±0.11$^{aD}$ | 21.97±0.12$^{aD}$ | 26.90±0.08$^{cE}$ | 26.51±0.03$^{cE}$ | 21.34±0.07$^{aD}$ | 23.66±0.17$^{abD}$ | 22.65±0.11$^{aD}$ |
| OTA (µg/kg) | 0 | 0.08 ± 0.00$^{aA}$ | 0.08 ± 0.00$^{aA}$ | 0.08 ±0.00$^{aA}$ | 0.08±0.00$^{aA}$ | 0.08 ± 0.00$^{aA}$ | 0.08 ± 0.00$^{aA}$ | 0.08±0.00$^{aA}$ | 0.08±0.00$^{aA}$ | 0.08 ±0.00$^{aA}$ | 0.08 ± 0.00$^{aA}$ |
| | 1 | 1.55 ± 0.01$^{bB}$ | 0.08 ± 0.00$^{aA}$ | 0.08 ±0.00$^{aA}$ | 0.08±0.00$^{aA}$ | 0.08 ± 0.00$^{aA}$ | 0.08 ± 0.00$^{aA}$ | 0.08±0.00$^{aA}$ | 0.08±0.00$^{aA}$ | 0.08 ± 0.00$^{aA}$ | 0.08 ± 0.00$^{aA}$ |
| | 5 | 3.00 ± 0.02$^{cC}$ | 0.10 ± 0.01$^{aA}$ | 0.09± 0.00$^{aA}$ | 0.09 ± 0.00$^{aA}$ | 0.09 ± 0.01$^{aA}$ | 0.09 ± 0.00$^{aA}$ | 0.09± 0.01$^{aA}$ | 0.09 ± 0.00$^{aA}$ | 0.09 ± 0.00$^{aA}$ | 0.09 ± 0.01$^{aA}$ |
| | 10 | 7.35 ± 0.11$^{dD}$ | 1.32 ± 0.05$^{bB}$ | 0.75 ±0.01$^{bB}$ | 0.54 ± 0.02$^{aB}$ | 0.54 ± 0.00$^{aB}$ | 0.85 ± 0.01$^{bB}$ | 0.79± 0.02$^{bB}$ | 0.55 ± 0.03$^{aB}$ | 0.57 ± 0.02$^{abB}$ | 0.57 ± 0.01$^{aB}$ |
| | 15 | 12.14±0.06$^{eE}$ | 3.27 ± 0.02$^{dD}$ | 1.51 ±0.02$^{bC}$ | 1.02 ± 0.03$^{aC}$ | 1.01 ± 0.01$^{aC}$ | 1.68 ± 0.02$^{cC}$ | 1.57±0.02$^{bcC}$ | 1.00 ± 0.01$^{aC}$ | 1.20 ± 0.01$^{bC}$ | 1.13 ± 0.04$^{aC}$ |
| | 18 | 18.50±0.41$^{fF}$ | 7.64 ± 0.25$^{fF}$ | 5.75 ±0.27$^{bD}$ | 4.78 ± 0.22$^{aD}$ | 4.67 ± 0.03$^{aD}$ | 6.10 ± 0.01$^{bD}$ | 5.88± 0.23$^{bD}$ | 4.58 ± 0.25$^{aD}$ | 5.01 ± 0.10$^{aD}$ | 4.66 ± 0.50$^{aD}$ |
| FB1 (µg/kg) | 0 | 0.11 ± 0.00$^{aA}$ | 0.11 ± 0.00$^{aA}$ | 0.11± 0.00$^{aA}$ | 0.11± 0.00$^{aA}$ | 0.11± 0.00$^{aA}$ | 0.11± 0.00$^{aA}$ | 0.11± 0.00$^{aA}$ | 0.11± 0.00$^{aA}$ | 0.11± 0.00$^{aA}$ | 0.11 ± 0.00$^{aA}$ |
| | 1 | 3.34 ± 0.16$^{bB}$ | 0.13 ± 0.00$^{aA}$ | 0.12 ±0.00$^{aA}$ | 0.12 ± 0.00$^{aA}$ | 0.12 ± 0.00$^{aA}$ | 0.12 ± 0.00$^{aA}$ | 0.12± 0.00$^{aA}$ | 0.12 ± 0.00$^{aA}$ | 0.12 ± 0.00$^{aA}$ | 0.12 ± 0.00$^{aA}$ |

| Parameters | Storage duration (month) | TPPB0 | TPB0 | TB1 | TB2 | TB3 | TB4 | TB5 | TB6 | TB7 | TB8 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 7.21 ± 0.08$^{cC}$ | 0.16 ± 0.00$^{bB}$ | 0.15 ±0.01$^{aA}$ | 0.15 ± 0.00$^{aA}$ | 0.15± 0.00$^{aA}$ | 0.15 ± 0.00$^{aA}$ | 0.15± 0.00$^{aA}$ | 0.15 ± 0.00$^{aA}$ | 0.15 ± 0.00$^{aA}$ | 0.15 ± 0.00$^{aA}$ |
| | 10 | 24.60±0.27$^{dD}$ | 1.28 ± 0.04$^{cC}$ | 0.93±0.02$^{bB}$ | 0.72 ± 0.01$^{aB}$ | 0.73± 0.03$^{aB}$ | 0.94 ± 0.02$^{bB}$ | 0.93± 0.02$^{bB}$ | 0.71 ± 0.01$^{aB}$ | 0.75 ± 0.03$^{abB}$ | 0.77±0.07$^{abB}$ |
| | 15 | 32.98±0.14$^{eE}$ | 4.43±0.12$^{dD}$ | 2.36±0.04$^{bcC}$ | 1.59± 0.02$^{aC}$ | 1.52± 0.06$^{aC}$ | 2.62± 0.04$^{cC}$ | 2.51± 0.13$^{cC}$ | 1.42 ± 0.02$^{aC}$ | 1.74 ± 0.04$^{bC}$ | 1.62 ±0.02$^{bC}$ |
| | 18 | 45.93±0.52$^{fF}$ | 10.41±0.47$^{eE}$ | 7.34 ±0.11$^{cD}$ | 5.20± 0.24$^{aD}$ | 5.20± 0.26$^{aD}$ | 7.36± 0.02$^{cD}$ | 7.42 ±0.06$^{cD}$ | 4.96 ± 0.07$^{aD}$ | 5.45± 0.02$^{bD}$ | 5.39±0.03$^{abD}$ |
| ZEA (µg/kg) | 0 | 0.24 ± 0.00$^{aA}$ | 0.24 ± 0.00$^{aA}$ | 0.24 ±0.00$^{aA}$ | 0.24 ± 0.00$^{aA}$ | 0.24 ± 0.00$^{aA}$ | 0.24 ± 0.00$^{aA}$ | 0.24± 0.00$^{aA}$ | 0.24 ± 0.00$^{aA}$ | 0.24 ± 0.00$^{aA}$ | 0.24 ± 0.00$^{aA}$ |
| | 1 | 2.37 ± 0.07$^{bB}$ | 0.26 ± 0.02$^{aA}$ | 0.25 ±0.00$^{aA}$ | 0.25 ± 0.00$^{aA}$ | 0.25 ± 0.00$^{aA}$ | 0.25 ± 0.00$^{aA}$ | 0.25± 0.00$^{aA}$ | 0.25 ± 0.00$^{aA}$ | 0.25 ± 0.00$^{aA}$ | 0.25 ± 0.00$^{aA}$ |
| | 5 | 4.99 ± 0.02$^{cC}$ | 0.36 ± 0.03$^{bB}$ | 0.30 ±0.02$^{bB}$ | 0.29 ± 0.02$^{aA}$ | 0.29 ± 0.01$^{aA}$ | 0.30 ± 0.00$^{bB}$ | 0.30 ±0.00$^{bB}$ | 0.30 ± 0.00$^{aA}$ | 0.30 ± 0.00$^{aA}$ | 0.30 ± 0.01$^{aA}$ |
| | 10 | 15.30±0.03$^{dD}$ | 1.21 ± 0.01$^{bC}$ | 0.95 ±0.05$^{bC}$ | 0.63 ± 0.03$^{aB}$ | 0.62 ± 0.03$^{aB}$ | 1.04 ± 0.05$^{bC}$ | 0.98 ±0.01$^{bC}$ | 0.59 ± 0.07$^{aB}$ | 0.67 ± 0.02$^{aB}$ | 0.64 ± 0.04$^{aB}$ |
| | 15 | 18.99±0.04$^{eE}$ | 5.58 ± 0.22$^{dD}$ | 3.40 ±0.16$^{bD}$ | 2.26 ± 0.06$^{aC}$ | 2.10 ± 0.01$^{aC}$ | 3.52 ± 0.06$^{bD}$ | 3.44 ±0.05$^{bD}$ | 2.01 ± 0.01$^{aC}$ | 2.39 ± 0.04$^{abC}$ | 2.32 ± 0.02$^{aC}$ |
| | 18 | 25.31±0.07$^{fF}$ | 12.16±0.20$^{eE}$ | 8.32 ± 0.08$^{cE}$ | 5.34 ± 0.04$^{aD}$ | 4.93 ± 0.05$^{aD}$ | 8.78 ± 0.14$^{cE}$ | 8.56 ± 0.16$^{cE}$ | 4.66± 0.10$^{aD}$ | 5.45 ± 0.07$^{abD}$ | 5.44±0.02$^{aD}$ |

*The mean (± SD) with different lowercase / uppercase letters on the same line / in the same column are different test probability of 5%. AFB1, AFT, OTA. FB1 and ZEA: Aflatoxin B1, total aflatoxins, Ochratoxin A. Fuminosin B1 and Zearalenone. TPPB0 = Control with polypropylene bag; TPB0 = Control with triple bag (no plants); TB1 = Triple bag with 2.5% of plants (0.625kg L. multiflora and 0.625kg H. suaveolens) (w / w); TB2 = triple bag with 3.99% of plants (0.40 kg L. multiflora and 1.60 kg H. suaveolens) (w / w); TB3 = triple bag with 3.99% of plants (1.60 kg L. multiflora and 0.40 kg H. suaveolens) (w / w); TB4 = triple bag with 1.01% of plants (w / w) (0.10 kg L. multiflora and 0.40 kg H. suaveolens) ; TB5= triple bag with 1.01% of plants (0.40 kg L. multiflora and 0.10 kg H. suaveolens ; TB6= triple bag with 5% of plants (2.5 kg L. multiflora and 2.5 kg H. suaveolens) ; TB7= triple bag with 2.5% of plants (1.25kg L. multiflora); TB8= triple bag with 2.5% of plants (1.25kg H. suaveolens)*

**Table 3. Estimated intakes of Aflatoxin B1, Total aflatoxins, Ochratoxin A, Fuminosin B1 and Zearalenone of Ivorian adults by consumption of stored maize**

| Mycotoxins | Storage duration (Month) | Treatments | | | | | | | | | | Estimated intakes from limits maximal (EDILM) (ng/kg bw/d) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TPPB0 | TPB0 | TB1 | TB2 | TB3 | TB4 | TB5 | TB6 | TB7 | TB8 | |
| **AFB1** | 1 | 0.53 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 2.02 |
| | 5 | 2.14 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | |
| | 10 | 4.59 | 0.51 | 0.49 | 0.30 | 0.30 | 0.47 | 0.48 | 0.28 | 0.33 | 0.31 | |
| | 15 | 9.68 | 1.72 | 1.16 | 0.69 | 0.65 | 1.33 | 1.19 | 0.64 | 0.99 | 0.71 | |
| | 18 | 13.81 | 2.97 | 2.03 | 1.71 | 1.70 | 2.09 | 2.06 | 1.69 | 1.81 | 1.74 | |
| **AFT** | 1 | 1.68 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 1.62 |
| | 5 | 6.88 | 0.07 | 0.06 | 0.05 | 0.05 | 0.06 | 0.05 | 0.05 | 0.05 | 0.05 | |
| | 10 | 14.03 | 1.67 | 1.58 | 0.97 | 0.97 | 1.60 | 1.58 | 0.92 | 1.10 | 1.03 | |
| | 15 | 30.84 | 6.13 | 3.72 | 2.54 | 2.22 | 4.43 | 3.91 | 2.13 | 3.50 | 2.73 | |
| | 18 | 67.99 | 16.51 | 10.66 | 8.95 | 8.91 | 10.91 | 10.76 | 8.66 | 9.60 | 9.19 | |
| **OTA** | 1 | 0.63 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 2.02 |
| | 5 | 1.22 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | |
| | 10 | 2.98 | 0.54 | 0.30 | 0.22 | 0.22 | 0.34 | 0.32 | 0.22 | 0.23 | 0.23 | |
| | 15 | 4.93 | 1.33 | 0.61 | 0.41 | 0.41 | 0.68 | 0.64 | 0.41 | 0.49 | 0.46 | |
| | 18 | 7.51 | 3.10 | 2.33 | 1.94 | 1.89 | 2.47 | 2.39 | 1.86 | 2.03 | 1.89 | |
| **FB1** | 1 | 1.36 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 811.43 |
| | 5 | 2.93 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | |
| | 10 | 9.98 | 0.52 | 0.38 | 0.29 | 0.30 | 0.38 | 0.38 | 0.29 | 0.30 | 0.31 | |
| | 15 | 13.38 | 1.80 | 0.96 | 0.65 | 0.62 | 1.06 | 1.02 | 0.58 | 0.71 | 0.66 | |
| | 18 | 18.63 | 4.22 | 2.98 | 2.11 | 2.11 | 2.99 | 3.01 | 2.01 | 2.21 | 2.19 | |
| **ZEA** | 1 | 0.96 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 202.86 |
| | 5 | 2.02 | 0.15 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | |
| | 10 | 6.21 | 0.49 | 0.39 | 0.26 | 0.25 | 0.42 | 0.40 | 0.24 | 0.27 | 0.26 | |
| | 15 | 7.70 | 2.26 | 1.38 | 0.92 | 0.85 | 1.43 | 1.40 | 0.82 | 0.97 | 0.94 | |
| | 18 | 10.27 | 4.93 | 3.38 | 2.17 | 2.00 | 3.56 | 3.47 | 1.89 | 2.21 | 2.21 | |

*The mean (± SD) with different lowercase / uppercase letters on the same line / in the same column are different test probability of 5%. AFB1, AFT, OTA. FB1 and ZEA: Aflatoxin B1, total aflatoxins, Ochratoxin A. Fuminosin B1 and Zearalenone. TPPB0 = Control with polypropylene bag; TPB0 = Control with triple bag (no plants); TB1 = Triple bag with 2.5% of plants (0.625kg L. multiflora and 0.625kg H. suaveolens) (w / w); TB2 = triple bag with 3.99% of plants (0.40 kg L. multiflora and 1.60 kg H. suaveolens) (w / w); TB3 = triple bag with 3.99% of plants (1.60 kg L. multiflora and 0.40 kg H. suaveolens) (w / w); TB4 = triple bag with 1.01% of plants (w / w) (0.10 kg L. multiflora and 0.40 kg H. suaveolens) ; TB5= triple bag with 1.01% of plants (0.40 kg L. multiflora and 0.10 kg H. suaveolens ; TB6= triple bag with 5% of plants (2.5 kg L. multiflora and 2.5 kg H. suaveolens) ; TB7= triple bag with 2.5% of plants (1.25kg L. multiflora); TB8= triple bag with 2.5% of plants (1.25kg H. suaveolens)*

**Table 4. Risk of exposure in aflatoxin B1, total aflatoxins, ochratoxin A, fuminosin B1 and zearalenone of stored maize during 18 months (EDI/EDILM)**

| Mycotoxins | Storage duration (Months) | Treatments | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TPPB0 | TPB0 | TB1 | TB2 | TB3 | TB4 | TB5 | TB6 | TB7 | TB8 |
| **AFB1** | 1 | 0.26 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| | 5 | 1.06 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| | 10 | 2.27 | 0.25 | 0.24 | 0.15 | 0.15 | 0.23 | 0.24 | 0.14 | 0.16 | 0.15 |
| | 15 | 4.79 | 0.85 | 0.57 | 0.34 | 0.32 | 0.66 | 0.59 | 0.32 | 0.49 | 0.35 |
| | 18 | 6.84 | 1.47 | 1.01 | 0.85 | 0.84 | 1.03 | 1.02 | 0.84 | 0.90 | 0.86 |
| **AFT** | 1 | 1.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| | 5 | 4.24 | 0.05 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| | 10 | 8.66 | 1.03 | 0.98 | 0.60 | 0.60 | 0.99 | 0.97 | 0.57 | 0.68 | 0.64 |
| | 15 | 19.04 | 3.78 | 2.30 | 1.57 | 1.37 | 2.74 | 2.41 | 1.32 | 2.16 | 1.68 |
| | 18 | 41.97 | 10.19 | 6.58 | 5.53 | 5.50 | 6.74 | 6.64 | 5.34 | 5.93 | 5.67 |
| **OTA** | 1 | 0.31 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| | 5 | 0.60 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| | 10 | 1.48 | 0.26 | 0.15 | 0.11 | 0.11 | 0.17 | 0.16 | 0.11 | 0.11 | 0.11 |
| | 15 | 2.44 | 0.66 | 0.30 | 0.20 | 0.20 | 0.34 | 0.31 | 0.20 | 0.24 | 0.23 |
| | 18 | 3.72 | 1.53 | 1.15 | 0.96 | 0.94 | 1.22 | 1.18 | 0.92 | 1.10 | 0.94 |
| **FB1** | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 10 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 15 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 18 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **ZEA** | 1 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 5 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 10 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 15 | 0.04 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| | 18 | 0.05 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |

*The mean (± SD) with different lowercase / uppercase letters on the same line / in the same column are different test probability of 5%. AFB1, AFT, OTA. FB1 and ZEA: Aflatoxin B1, total aflatoxins, Ochratoxin A. Fuminosin B1 and Zearalenone. TPPB0 = Control with polypropylene bag; TPB0 = Control with triple bag (no plants); TB1 = Triple bag with 2.5% of plants (0.625kg L. multiflora and 0.625kg H. suaveolens) (w / w); TB2 = triple bag with 3.99% of plants (0.40 kg L. multiflora and 1.60 kg H. suaveolens) (w / w); TB3 = triple bag with 3.99% of plants (1.60 kg L. multiflora and 0.40 kg H. suaveolens) (w / w); TB4 = triple bag with 1.01% of plants (w / w) (0.10 kg L. multiflora and 0.40 kg H. suaveolens) ; TB5= triple bag with 1.01% of plants (0.40 kg L. multiflora and 0.10 kg H. suaveolens ; TB6= triple bag with 5% of plants (2.5 kg L. multiflora and 2.5 kg H. suaveolens) ; TB7= triple bag with 2.5% of plants (1.25kg L. multiflora); TB8= triple bag with 2.5% of plants (1.25kg H. suaveolens)*

## 5. CONCLUSION

This study contributes to improving corn storage and preserving the health of corn consumers. The results showed that the leaves of *L. multiflora* and *H. suaveolens* in the triple bagging system reduce exposure risk of mycotoxins (Aflatoxin B1, total Aflatoxin, Ochratoxin A, Zearalenone and Fuminosin B1). However, exposure risk to aflatoxin B1 (AFB1) and ochratoxin A (OTA) is low until 15 months of storage in experimental batches. The exposure risk to total aflatoxins (AFT) is low until 10 months of storage. The batches of maize stored in polypropylene bag (TPPB0) and triple bag without plants (TPB0), exposure risk is very high for AFB1, AFT and OTA. The storage technology used is inexpensive, easily applicable and environmentally friendly. However, for greater efficiency, it would be important to encourage good post-harvest practices.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

It is not applicable.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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