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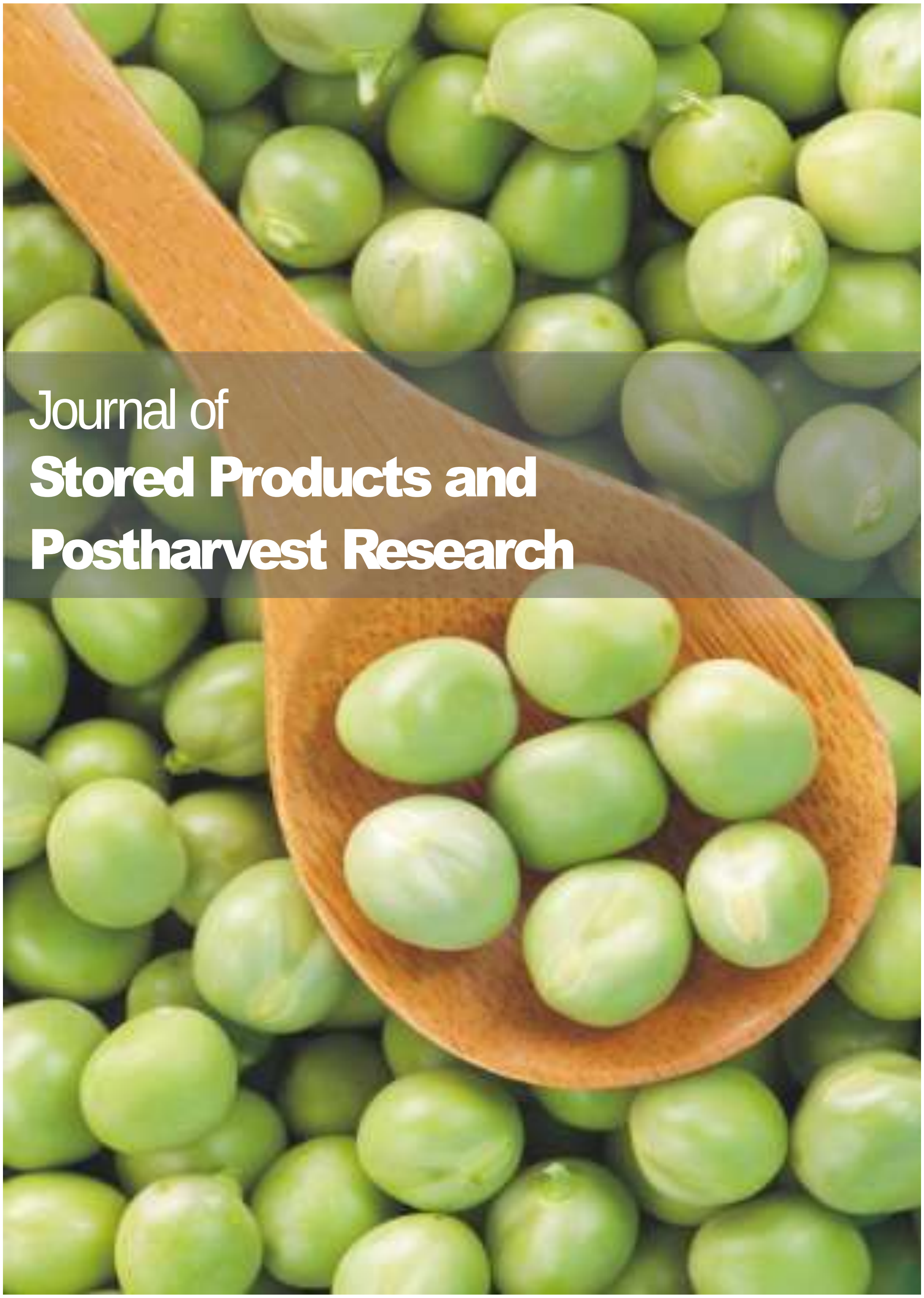

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Full Length Research Paper

Aflatoxin B1 contamination in raw peanuts sold in Maputo City, Mozambique and associated factors

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Peanut seeds (*Arachis hypogaea* L.) are consumed worldwide including Mozambique, due to good taste, high nutritional value and easy accessibility. When found in suitable conditions of humidity and high temperature, a fungus of the genus *Aspergillus* can contaminate peanuts and produce toxic secondary metabolites called "aflatoxins" (AFs) which are not destroyed by usual thermal processes, causing aflatoxicosis and liver cancer, when consumed frequently. This study aimed to identify the concentration of aflatoxins B1 (AFB1) in raw peanuts seeds marketed in Maputo city and to analyze the association with the storage conditions. Raw peanuts samples of 1 kg were acquired in 57 commercial establishments in Maputo city (63.16% markets and 36.84% supermarkets). AFB_1 concentration was analyzed by ELISA test. Peanut storage conditions were analyzed in each sampling spot. The results of the study showed that the average concentration of AFB1 on peanut was 2.71 µg/kg (0.00 to 72.93). The prevalence of AFB_1 above the limit of European Union (EU) legislation (8 µg/kg) was 3.5%. The significantly associated factors ($p<0.05$) were: Mozambican origin, presence of damaged kernels, storage time over 15 days and container where the peanut was stored. Most factors were associated with poor storage and measures should be taken to avoid the presence of these chemicals in peanuts. In conclusion, the concentration of AFB_1 in raw peanuts seeds was within the acceptable European Union (EU) standards at 96.49%. Similar studies should be made in the country to identity the concentration of these compounds and probable sources of contamination.

Key words: Aflatoxin B_1, peanut, markets, supermarkets, Maputo, Mozambique.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is the third most important oilseed crop in the world. It is cultivated in tropical, subtropical and temperate countries between 40°N and 40°S latitude. It is an important source of food oil and protein (Alagirisamy, 2016). More than a half of the world's peanut production is marketed for direct consumption or oil production, and 32% is used for food (Birthal et al., 2010). Peanut productivity in Mozambique is 380.91 kg / ha, with production cost per pound of $ 0.28 (Valentine, 2016).

The annual production in Mozambique revealed an increasing trend from the year 2000 to 2014, with peak

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production observed in 2010. The main producing countries in descending order are: China, India, Nigeria, United States of America and Sudan (FAOSTAT, 2017). Peanuts are widely consumed in the world (Alagirisamy, 2016) including Mozambique, mainly in raw, salty, dry or roasted forms. In addition, peanuts are used for confectionery and also used in the routine of many individuals through consumption in the form of curries accompanied with rice. Peanuts may contain physical, chemical and microbiological contaminants. Codex alimentarius has determined that peanut must be free of objectionable matters, micro-organisms, parasites and toxic substances from micro-organisms in levels that pose a health hazard (CODEX, 1995b).

There are abundant fungi in the tropics that have an affinity for oilseeds, such as peanuts. They grow as pathogens or commensals on the tissues of these plants and produce toxic, thermosetting metabolites called aflatoxins (AFs) (Pitt, 2014). AFs are the most toxic classes of naturally occurring mycotoxins (Iqbal and Asi, 2013). There are more than 20 different types of structurally identified AFs, but the main and most toxic forms are: B1 (AFB1), B2, G1 and G2 (Pittet, 1998).

Aspergillus flavus produces only AFB and *Aspergillus parasiticus* produces AFB and G (IARC, 2012). It has been reported that AFB1 is the most toxic form and has been classified as class 1 of carcinogenic compounds by the International Agency for Research on Cancer, mainly affecting the liver (IARC, 2002). Whereas aflatoxins are highly toxic and food products such as peanuts make up the ideal substrate for fungus growth, it is important to study the presence of these mycotoxins in food, taking into account the risks that they can cause in the human health. The European Union determined a limit of 8 μg/kg for AFB1 in peanuts intended to be subjected to a sorting or other physical treatment prior to human consumption or use as an ingredient in foodstuffs (CEC, 2006) and Codex alimentarius established a limit of 15 μg / kg for total aflatoxins in peanuts (CODEX, 1995a; CODEX, 2017).

The aim of this study was to evaluate the concentration of AFB1 in raw peanut seeds (*A. hypogaea* L.) commercialized in Maputo city and to analyze the effect of the storage conditions on the presence of these compounds.

MATERIALS AND METHODS

Description of the study area

Maputo is the capital and main city of Mozambique. It is also the main financial, corporate and commercial center of the country. It is located on the western shore of Maputo Bay, in the extreme south of the country, 120 km (75 miles) from the South African border at Ressano Garcia and 80 km (50 miles) from the border with Swaziland near the town of Namaacha. The municipality has an area of about 300 square kilometers and a population of 1.101.170 (Conselho Municipal de Maputo, 2008; Instituto Nacional de Estatística, 2017). The climate of Maputo is tropical dry. The hottest period of the year includes the months of November to April and the coldest months are from May to October. The period of the highest precipitation occurs in the hottest months. The average relative humidity is 77.0%, with little oscillation during the year. The month with the highest relative humidity is March with 80.0%, and the month with lower humidity is June with 71.0%. The city has seven municipal districts, a total of 45 supermarkets and 68 markets, according to 2017 City's Council data (Conselho Municipal de Maputo, 2010; Direcção Municipal de Mercados e Feiras, n.d.; Direcção da Indústria e Comércio, n.d.; Governo da Cidade de Maputo).

Sampling methods

Data was collected between April and July 2017. The peanut samples were acquired in Maputo city's municipal markets and supermarkets: 36 markets (32 formal and 4 informal) and 21 supermarkets. A random selection of one sample of raw peanuts seeds with 1kg was made in each commercial establishment. 250 g were packed for laboratory analysis. At each sampling point, the peanut storage conditions were registered. The samples were transported in hermetically sealed plastic bags and kept at room temperature.

Analytical methods/techniques

The physical and chemical analyzes were carried out in the chemistry laboratory of the Animal Sciences Division (Direcção de Ciências Animais: DCA) of the Institute of Agricultural Research of Mozambique (Instituto de Investigação Agrária de Moçambique: IIAM) in Maputo. The analyses included: identification of decayed peanut grains and extraneous material, determination of moisture content and AFB1 concentration (CODEX, 1995b; AOAC, 2000; BIOO Scientific Corp., 2016).

Determination of decayed grains and extraneous matter

In each sample it was first done a qualitative analysis of the presence of moldy or decayed grains and extraneous matter. Moldy kernels were defined as kernels with visible filaments. Decayed kernels were defined as those showing visibly significant decomposition. Extraneous matter was defined as organic and inorganic components other than peanuts and includes stones, dust, seeds, stems and other similar matter (CODEX, 1995b).

Moisture content

The moisture content was measured by the gravimetric method. Whole kernel samples were ground manually. 3 g of the ground peanut sample were weighed and dried at 105°C for 3 h, and transferred to a desiccator to cool. The net weight of the dried sample was determined after drying. Percentage of moisture content was calculated as the difference between final and original weight divided by original weight of sample, and multiplied by 100. Each sample was replicated thrice (AOAC, 2000).

Aflatoxin B1 analysis

Extraction of AFB1

Extraction of AFB1 from peanut was performed according to the recommendations of the ELISA kit manufacturer. 5g of each ground sample were blended with 25.0 ml of 70% methanol and vortexed vigorously for 10 min using a multi-vortexer. The samples were then centrifuged for 10 min at 4000× at room temperature (20 to 25°C). 300 µL of the supernatant were diluted with 900 µL of a mixture of 7 volumes of 100% methanol with 23 volumes of 1x sample extraction buffer and vortexed for 1 min (BIOO Scientific Corp., 2016).

Analysis of aflatoxin B1 in samples

The detection of AFB1 levels was made through ELISA method, using the AFB1 MaxSignal® commercial kit (1055-04, MaxSignal®, Bioo Scientific Corporation, Austin, TX, USA), which contains 96-well micro-titer plates sensitized with monoclonal antibody specific for AFB1. 50 µL of each aflatoxin B1 standard were added in duplicate into different wells. Standards were added to plate in the order from low concentration to high concentration. Then, 50 µL of each sample were added in duplicate into different sample wells. 100 µL of Aflatoxin B1-horseradish peroxidase conjugate were added to each well, and mixed by gently rocking the plate manually for 1 minute. The plate was incubated for 30 min at room temperature (20 to 25°C), then the solution was completely dumped. The solution was washed three times by adding 250 µL of 1X Wash Solution to each well, shaking the plate for about 10 s and was dried by dumping and tapping the plate onto a pile of paper towels. 100 µL of Tetramethylbenzidine (TMB) substrate was added and the solution was mixed by gently rocking the plate manually for 1 min. The plate was incubated for 15 min at room temperature. After incubation, 100 µL of stop buffer were added to stop the enzyme reaction. The plate was read as soon as possible on a plate reader with 450 nm wavelength (EL-800, BioTek®, Winooski, VT, USA). The absorption intensity was inversely proportional to AFB1 concentration in the sample. AFB1 concentrations, as well as standard curve determination, were processed on a specific aflatoxin MaxSignal® Excel analysis program (Bioo Scientific Corporation, Austin, TX, USA), considering a dilution factor = 20, as recommended in the kit procedures. Because there is no legislation for AFB1 limits on peanuts in Mozambique, the limit established for the study was 8 µg / kg according to European Union legislation (CEC, 2006). A comparison was also made with the Codex alimentarius limit (15µg / kg) (BIOO Scientific Corp., 2016; CODEX, 2017).

Statistical data analysis

The data was stored in a Microsoft Office Access version 2013 database. Initially, a descriptive analysis was carried out to characterize the sample, and analyzes were performed to find an association between the variables of interest in the study (hypothesized categorical risk factor and the outcome: AF concentration above 8 µg / kg). Chi-square, ANOVA and t-student tests were used through the statistical program Epi Info version 7.2.2.2. The significance level was set as 0.05.

RESULTS AND DISCUSSION

The average concentration of AFB1 in peanuts sold in Maputo city was 2.71µg/kg and the prevalence of these compounds above the upper limit of the EU legislation (8 µg/kg) was 3.5%, which shows that the concentration was low. The storage conditions were less adequate in the markets, and it was observed a statistically significant association ($p<0.05$) between some storage conditions and a high concentration of AFB1 (above 8 µg/kg). Table 1 presents a summary of the association between the variables in the study.

Aflatoxin B1 levels in raw peanuts from Maputo city

The average concentration of aflatoxins in the 57 analyzed samples was 2.71 µg/kg (0.00 - 72.93), which was a non - alarming result because it was below the limit of European and Codex alimentarius legislations (8 and 15 µg/kg respectively). The mean AFB1 concentration (Figure 1) was higher for the markets in comparison to the supermarkets, whose difference was also statistically significant (Bartlett's $\chi^2 = 54.13$, df = 1, p = 0.00). These data showed that there was higher concentration of AFB1 in the markets. 3.51% (n = 2) of the samples were above the acceptable EU and Codex alimentarius limit for AFB1 (above 8 and 15 µg / kg respectively), one of which was above the Codex alimentarius limit (72.93 µg / kg) and the other one above the EU limit (13.33 µg / kg). Both samples were from municipal markets, as shown in Table 2. The peanut AFB1 concentration of 1.2-5.5 ng / g reported in 2002 in Mozambique (Conzane et al., 2002; Leslie et al., 2008) was close to this study results of 2.71 µg / kg. The significant difference in the average in the markets and supermarkets (p = 0.00) showed that the markets were more likely to present this contaminated product (average of 4.00 µg / kg) compared to supermarkets (average of 0.51 µg / kg). The significantly associated factors with high levels of AFB1 (> 8µg / kg) were: Mozambican origin ($\chi^2 = 4.07$, p = 0.04), presence of damaged grains ($\chi^2 = 4.07$, p = 0.04), storage time above 15 days ($\chi^2 = 13.00$, p = 0.00) and primary packaging material (plastic basin) ($\chi^2 = 9.74$, p = 0.01) (table 1). Most of these factors were reported in other studies from the African continent as well as in many other studies (Kamika, 2012; Monyo et al., 2012; Mutegi et al., 2013a; Mutegi et al., 2013b; Bumbangi et al., 2016). The average concentration of AFB1 found in this study was relatively low, as the results found in China from 2010 to 2013: 0.43 µg / kg (Wu et al., 2016), 15-23.9 µg /kg in Egypt in 2014 (Ayejuyo et al., 2011), 0 µg / kg in the city of Lavras, MG, Brazil (Ferreira et al., 2014), 0.23 µg / kg in Lusaka, Zambia in 2015 (Bumbangi et al., 2016). Diligence should be taken to reduce the percentage of peanuts with AFB1 concentration above the EU legislation limit (8 µg/kg).

General data

Origin of groundnuts

The highest percentage of peanuts was originated from

Table 1. Summary analysis of association between AFB1 and study variables.

Parameter/AFB_1	0-8 μg/kg % (n)	> 8 μg/kg % (n)	Total % (n)	χ^2	p
Origin					
Mozambique	30.91 (17)	100.00 (2)	33.33 (19)	4.07	0.04
Extraneous	69.09 (38)	0.00 (0)	66.67 (38)		
Market type					
Market	61.82 (34)	100.00 (2)	63.16 (36)	1.19	0.28
Supermarket	38.18 (21)	0.00 (0)	36.84 (21)		
Decayed grains					
Decayed	30.91 (17)	100.00 (2)	33.33 (19)	4.07	0.04
Not decayed	69.09 (38)	0.00 (0)	66.67 (38)		
Storage time					
0-15 days	98.18 (54)	50.00 (1)	96.49 (55)	13.00	0.00
>15 days	1.82 (1)	50.00 (1)	3.51 (2)		
Shelf hygiene					
Clean	49.09 (27)	0.00 (0)	47.37 (27)	1.83	0.18
Dusty	50.91 (28)	100.00 (2)	52.63 (30)		
Roof cover					
Uncovered	5.45 (3)	0.00 (0)	5.26 (3)	0.11	0.74
Covered	94.55 (52)	100.00 (2)	94.74 (54)		
Presence of insects					
None	47.27 (26)	50.00 (1)	47.37 (27)	0.01	0.94
Present	52.73 (29)	50.00 (1)	52.63 (30)		
Air pollution					
None	76.36 (42)	100.00 (2)	77.19 (44)	0.60	0.44
Present	23.64 (13)	0.00 (0)	22.81 (13)		
Smell					
Normal	80.00 (44)	50.00 (1)	78.95 (45)	1.03	0.31
Unpleasant	20.00 (11)	50.00 (1)	21.05 (12)		
Container permeability					
Permeable	18.18 (10)	0.00 (0)	17.54 (10)	0.43	0.51
Impermeable	81.82 (45)	100.00 (2)	82.46 (47)		
Container hygiene					
Clean	65.45 (36)	0.00 (0)	63.16 (36)	1.83	0.18
Dusty	34.55 (19)	100.00 (2)	36.84 (21)		
Presence of label					
Present	38.18 (21)	0.00 (0)	36.84 (21)	1.19	0.28
Absent	61.82 (34)	100.00 (2)	63.16 (36)		
Moisture					
0-9%	98.18 (54)	100.00 (2)	98.25 (56)	0.04	0.85
>9%	1.82 (1)	0.00 (0)	1.75 (1)		

Table 1. Contd.

Packaging material					
Plastic bag	67.27 (37)	0.00 (0)	64.91 (37)		
Plastic basin	14.55 (8)	100.00 (2)	17.54 (10)	9.74	0.01
Sisal bag	18.18 (10)	0.00 (0)	17.54 (10)		
Total	96.49 (55)	3.51 (2)	100 (57)	-	

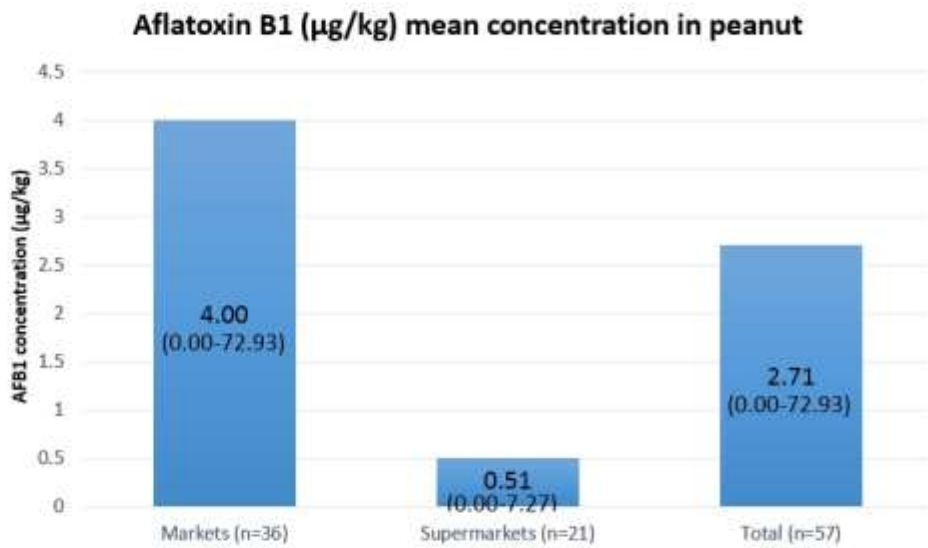

Figure 1. Aflatoxin B1 mean concentration in peanut from markets and supermarkets.

Table 2. Comparison of AFB1 levels found in different commercial establishments.

AFB1 (μg/kg)	Markets (n=36)	Supermarkets (n=21)	Total (n=57)
0-8	94.44% (34)	100.00% (21)	96.49% (55)
8-15	2.78% (1)	0.00% (0)	1.75% (1)
>15	2.78% (1)	0.00% (0)	1.75% (1)

South Africa (36.84%, n=21), followed by Mozambique – only represented by Nampula province (33.33%, n=19) and Swaziland (29.82%, n=17). A statistically significant association was found between origin of peanut (national or foreign) and high AFB1concentration (χ^2=4.07, p=0.04) (Table 1). All of the peanuts with AFB1 above the EU limit were of Mozambican origin. The peanuts origin from South Africa and Swaziland can be explained by the border with the south of the country, which facilitates commercialization in Maputo city. The representation of Nampula province in the commercialization of peanuts in Maputo city (33.33%) can be explained due to the fact that this province is considered to be the largest producer of this oilseed crop in the country. In Mozambique, previous studies reported a concentration of AFB1 ranging from 1.2-5.5 ng/g in 2002 (Leslie et al., 2008).

Storage time

The average storage time of peanuts in the commercial establishment was 10 days. The storage time in supermarkets ranged from 10 to 16 days while for the markets ranged from 1 to 150 days. In two commercial establishments (market and supermarket) peanut was stored for more than 15 days. A distinct data pointed to the storage of peanuts for 150 days in a market, which coincidentally had an AFB1 concentration of 72.93 μg/kg.

Significant association was detected between storage time over 15 days and high level of AFB1 ($\chi^2 = 13.00$, $p = 0.00$) (Table 1). Other studies report that peanut storage is directly related to high levels of AFB1, as *Aspergillus* species commonly produce aflatoxins during the storage of this food product (Kamika, 2012). Inadequate storage is considered a precursor to fungal growth and mycotoxin production (Kamika and Takoy, 2011; Iqbal et al., 2013; Torres et al., 2014; Bumbangi et al., 2016). Mutegi et al. (2013a) reported that storage time is a factor that leads to increased aflatoxin concentration in the post-harvest stages of peanuts and other grains. Similar data was observed in Malawi where a higher prevalence of aflatoxins above 20 µg/kg was observed in peanuts stored for long periods (8 to 11 months), compared to short periods (1 to 2 months) (21 and 8%, respectively) (Monyo et al., 2012).

Establishment conditions

The establishment conditions such as hygiene, roof cover, presence of insects, air pollution and smell had no influence on the high concentration of AFB1 ($p>0.05$). These conditions were better in the supermarkets in comparison to the markets, as described below.

Shelf hygiene

16.67% (n=6) of the markets had clean shelves (free of dust and dirt), while all the shelves found in the supermarkets were hygienic. No association was found between this parameter and high concentration of AFB1 ($\chi^2=1.83$, $p=0.18$) (Table 1). A lack of shelf hygiene can be a risk for bacteria and fungi growth in peanuts, as reported in the study on Egypt in 2014, where disinfected peanut seeds, that is, in good hygienic conditions, contained lower concentrations of fungi compared to infected seeds (Embaby and Abdel-Galel, 2014).

Roof cover and lighting

8.33% (n=3) of the markets did not have the roof covered, placing the peanuts exposed to intense solar radiation and high temperatures, while 100% (n = 21) of the supermarkets had the roof covered and artificial lighting. There was no significant association between this parameter and high concentration of AFB1 ($\chi^2=0.11$, $p=0.74$) (Table 1), probably because these are not the key factors for the production of aflatoxins during peanut storage. An important fact to analyze is that the lack of roof cover can facilitate rainfall in peanuts marketed on the uncovered markets and the high amount of water during peanut storage favors the growth of aflatoxigenic fungi (Ayejuyo et al., 2011). Bumbangi et al. (2016) reported that in Lusaka (Zambia), peanuts marketed in open markets were exposed to rainwater, as found in some markets in this study. These authors also affirm that mostly worldwide AF contamination occurs in countries with high temperatures and humidity. In this context, the lack of roof coverage causes the direct incidence of sunlight on commercialized peanuts, increasing the temperature and this fact probably also increases the risk of contamination by AFs.

Presence of insects, air pollution and smell

Insects were found in 75% (n = 27) of the markets but not in supermarkets (0%). The only type of insect found was the housefly (*Musca domestica* Linn, family Muscidae). In some markets, peanuts were marketed in the vicinity of stalls where fresh meat was being sold, which may be associated with the abundant presence of insects that are vectors of pathogenic microorganisms. No association was found between the presence of insects and high concentration of AFB1 ($\chi^2 = 0.01$, $p = 0.94$) (Table 1). Air pollution was measured by the presence of fumes or dust. 36.11% (n = 13) of the markets had air pollution, and this factor was not observed in supermarkets. No association was found between the air pollution and high AFB1 concentration ($\chi^2 = 0.60$, $p = 0.44$) (Table 1). 33.33% (n = 12) of the markets had an unpleasant smell in the areas where peanuts were sold. No supermarket had this factor and no association was found with high concentration of AFB1 ($\chi^2 = 1.03$, $p = 0.31$) (Table 1). These variables are more associated with adequate, hygienic and safe commercialization of peanut and consumer acceptability. This scenario of poor conservation of food products in markets is common in other countries of the African continent (Mutegi et al., 2013a; Bumbangi et al., 2016). Poor storage as observed in the markets make peanuts vulnerable to micotoxigenic fungal infection and aflatoxin production during storage (Mutegi et al., 2013b).

Container conditions

Packaging material

Of the total 57 samples, 64.91% (n = 37) were marketed in plastic bags, 17.54% (n = 10) in plastic basins and the same percentage in sisal bag (17.54%, n = 10) (Figure 2). All samples purchased from supermarkets were marketed in plastic bags. All samples with high levels of AFB1 were being marketed in plastic basins, and a statistically significant association was observed between these factors ($\chi^2 = 9.74$, $p = 0.01$) (Table 1). A study in Kenya, Africa, reported the storage of peanuts in

Figure 2. Different containers where peanut was sold.

polypropylene and polyethylene bags, with less than 1% of marketers storing their products in the recommended jute bags (Mutegi et al., 2013b). These authors state that jute bags easily absorb moisture but allow good air flow while polypropylene and polyethylene are non-absorbent and store heat inside. The popularity of plastic bags can be associated with low cost and high availability in the domestic markets of the African continent. The results of Mutegi et al. (2013b) corroborate with those found in the present study, in which a statistically significant association was observed between the material of the container where the peanut was stored and high levels of AFB1.

Permeability and hygiene of the container

17.54% (n = 10) of the containers were permeable and there was no statistically significant association with high concentration of AFB1 ($\chi^2 = 0.43$, $p = 0.51$). 63.16% (n = 36) containers were in good hygienic condition, corresponding to less than a half of the municipal markets (41.67%, n = 15) and 100% (n = 21) of the supermarkets. There was no association between this parameter and high levels of AFB1 ($\chi^2 = 1.83$, $p = 0.18$) (Table 1), probably because the strictly related factor is the type of material constituting the container where the peanut is stored (Bulaong and Dharmaputra, 2002; Mutegi et al., 2013a; Mutegi et al., 2013b). However, uncovered, impermeable and unhygienised containers pose a greater risk to peanut safety for the consumers (Bumbangi et al., 2016).

Presence of label

Only peanut from supermarkets had a label (Figure 2), corresponding to 36.84% (n = 21) of total samples. This parameter was not associated with high AFB1 concentration ($\chi^2 = 1.19$, $p = 0.28$) (Table 1). The labels included the following information in English: nutritional information, address, manufacturer's contacts, storage conditions, place of production, weight, lot identification and additional information (type of plastic bag and recycling instructions). Even though the presence of the label was not associated with the high concentration of AFB1 in this study ($\chi^2 = 1.19$, $p = 0.28$), it is important to mention that this factor is included on the Codex alimentarius standards for peanuts (CODEX, 1995b; CODEX, 2010). This shows that supermarkets met this requirement, probably due to the commercialization of peanuts of foreign origin. It should be ensured that all peanuts marketed in Maputo city and in the country meet these specifications in order to increase their safety for the consumer.

Laboratory analysis

Extraneous material and decayed grains

Decayed grains were detected in 33.33% (n = 19) of the total samples: 52.78% (n = 19) in markets and 0% in supermarkets (n=0). Branches and part of the peanut pericarp were observed as extraneous materials (Figure 3). 100% of the samples with concentration above 8µg/kg had decayed grains. This parameter was associated with high concentration of AFB1 ($\chi^2=4.07$, $p=0.04$). There was no association between storage time and this parameter ($\chi^2 = 0.25$, $p = 0.61$) (Table 1). These results were similar to other studies made in African continent, where decayed peanut grains had higher probability to have high levels of aflatoxins (Mutegi et al., 2013a; Mutegi et al., 2013b).

Figure 3. Extraneous matter and decayed peanut seeds**.**

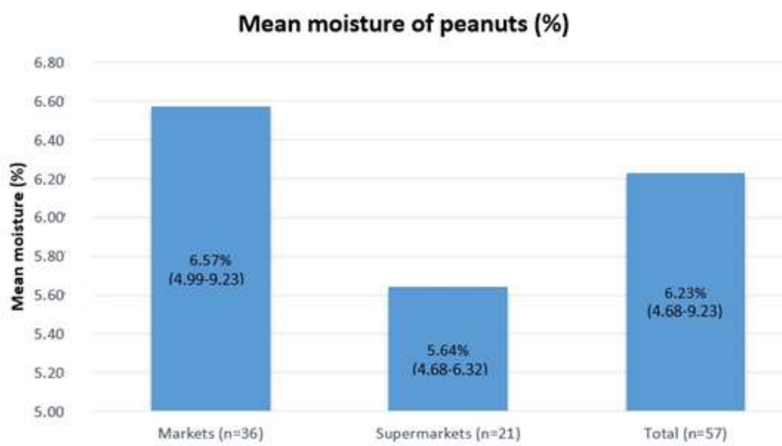

Figure 4. Mean moisture (%) of peanuts from markets and supermarkets.

Moisture

The peanut samples had a mean moisture content of 6.23% (4.68-9.23%) (Figure 4), which was satisfactory because it was below the limit of 9% established by Codex alimentarius. Peanut marketed in supermarkets had lower moisture compared to the markets. Only one sample (1.75%) had moisture above the Codex alimentarius limit (> 9%) (CODEX, 1995b), which was from a municipal market. This parameter was not associated with high levels of AFB1 ($\chi^2 = 0.04$, $p = 0.85$) (Table 1). Adama (2009) explained that the production of aflatoxins by aflatoxigenic fungi depends on several factors, including the moisture content. The fact that this parameter was not associated with high levels of aflatoxins (χ^2=0.04, p= 0.85) is in disagreement with the results reported by other authors, who state that AF contamination increases when grains are stored at high moisture (Hell and Mutegi, 2011; Kamika, 2012; Mutegi et al., 2013b).

CONCLUSION AND RECOMMENDATIONS

The average AFB1 concentration in raw peanut (*A. hypogaea*) seeds marketed on the municipal markets and supermarkets in Maputo city was 2.71 μg/kg. The percentage of these compounds above the EU level was 3.5%, which shows that it was a low percentage and methods for reducing this prevalence can be established. Municipal markets had poor conditions for a correct storage of peanuts, compared to supermarkets, which increases the probability of contamination by AFs. It is recommended to:

(1) Implement a phytosanitary legislation in Mozambique that includes limits for AFs and other mycotoxins in peanuts and other cereals, as well as standards for the production, transport and safe marketing of peanuts, which prevents fungal growth and production of mycotoxins.
(2) Study the entire peanut production chain in the country in order to identify the point at which the peanut is contaminated by AFs.
(3) Train the stakeholders on the peanut production chain in ways to minimize the probability of occurrence of these toxins in the crop and
(4) Study the prevalence of total AFs and particularly AFB1 in peanuts in other provinces, with emphasis on Nampula province, which is the main producer of this crop in Mozambique.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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