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EXPOSURE OF SCHOOL CHILDREN TO AFLATOXINS AND FUMONISINS THROUGH MAIZE-BASED DIETS IN SCHOOL MEALS PROGRAMME IN SALIMA DISTRICT, MALAWI

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ABSTRACT

Exposure to aflatoxins and fumonisins contaminated food poses threats to human health, including causation of cancer, immunosuppression, impaired growth, respiratory problems, diarrhea, among others. This study was carried out to evaluate the levels of aflatoxins and fumonisins in maize-based porridge and the estimated intake levels of the contaminants among school going children in selected primary schools in Salima District, Malawi. A total of 496 children and 124 food handlers from 31 primary schools within three Extension Planning Areas (EPAs) under the School Meals Programmes were involved. Consumption and meal preparation data were collected from the respondents using pre-tested questionnaires. Reveal Q+ Kits were used to quantify aflatoxins and fumonisins in sampled meals. Monte Carlo risk simulation using @RiskPalisade software (UK) was used to generate exposure data. All porridge samples had varying detectable levels of mycotoxins. However, there were no significant ($P < 0.05$) differences in the aflatoxins and fumonisins levels for samples from different EPAs indicating the endemic presence of mycotoxins within the district. Over 95% of the schools used maize as the main ingredient in preparing the porridge with relatively high quantities consumed 610 grams/child/day equivalent to 0.019 kg/kg bodyweight/day regardless of the gender ($\chi^2 = 5.624$, $P = 0.286$) or the age ($r = 0.033$, $P = 0.459$) of the respondents. The levels of aflatoxins and fumonisins in the samples ranged from 2.13 to 33.37 µg/kg and < 0.3 to 1.0 ng/kg, respectively. The mean and the 95th percentile intake levels for aflatoxins ranged from 0.2 - 0.60 ng/kg bodyweight/day and 6 – 9.2 µg/kg bodyweight/day for fumonisins, which exceeded the recommended safety levels for children according to standards of European Food Safety Authority (2007) and Joint Food and Agriculture Organization/World Health Organization Committee on Food Additives (2008), respectively. The consumption of maize-based porridge was found to expose school-going children to unacceptable levels of mycotoxins whose effects on their health, education and well-being remain unknown. There is a need to educate food handlers on mycotoxins intoxication and proper postharvest handling practices of maize-based foods to prevent exposure. Furthermore, diversification to reduce overreliance on maize-based diets should be promoted.

Key words: Aflatoxins, Fumonisins, Exposure, School children, School Meals, Maize-based-porridge

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INTRODUCTION

Approximately 368 million children in developed and developing countries are fed through school meals every day [1]. The School Meals Programme (SMP) was introduced in developing countries to address chronic hunger, increase children enrollment, and improve learning ability among children. The program is implemented in many countries as a social protection intervention and a productive safety net for children through provision of foods [2]. Several benefits have been reported from the School Meals Program, including increased enrolment and improved nutrition [3]. However, the program if not properly effected may be a source of foodborne illnesses which may negatively impact the health, education, growth, and development of schoolgoing children [4].

The implementation of the School Meals Programme varies from country to country where some provide either breakfast or lunch only, whereas others offer both meals which are often prepared at school. The School Meals Programme in Malawi includes the provision of porridge of Corn-Soya Blend (CSB), Take Home Rations (THRs) of maize for orphans, and Home-Grown School Meals Programme (HGSMP) which prepare a variety of foods sourced locally [5]. According to the World Food Programme [5], maize is a major staple ingredient in Home-Grown School Meals Programme in Malawi.

Consumption of maize and maize-based foods has been reported to have food safety concerns due to the presence of mycotoxins [6]. The toxicants are a global safety concern as they cause foodborne illnesses [7]. Children are most at risk of dietary mycotoxins exposure compared to older people, due to low immune system, increased food demand, and uncontrolled diet [8]. The most commonly occurring mycotoxins found in maize and maize based-foods are aflatoxins and fumonisins, which are caused by *Aspergillus* and *Fusarium* species, respectively. The most common types of aflatoxins in foodstuff include aflatoxin B1, aflatoxin B2, aflatoxin G1 and aflatoxins G2, while fumonisins include fumonisins B1 and fumonisins B2. Aflatoxins B1 and fumonisins B1 are the most toxic and carcinogenic to humans [9]

Mycotoxins occur along the food chains including harvesting, transportation, marketing, storage, processing, food preparation and end up in the final meal [10]. Mycotoxins proliferation are exacerbated by poor postharvest handling practices mainly poor storage conditions, insects and pest attack [11]. The risk of exposure to aflatoxins and fumonisins contaminated foods includes acute and chronic toxicity [12]. Findings have reported high aflatoxins and fumonisins levels in maize-based foods from southern Africa, including Malawi where the levels of mycotoxins exceed the maximum limits sets by regulatory bodies [13]. Therefore. the risk to mycotoxins exposure among consumers from the region may be relatively high and, therefore, the need for research on their mitigations.

The most common mycotoxin exposure occurs through dietary intake by consumption of contaminated foods [14]. According to Kimanya [14], mycotoxins are potential disease causing toxicants and are as well precursors for cancer diseases,

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immunosuppression, impaired growth, respiratory problems, diarrhea, abdominal pains, and progression of HIV to AIDS. Among children, high exposure to mycotoxins has been widely associated with impaired growth, poor development, and increased occurrence of opportunistic infections [15]. Although several studies have reported that toxicants are significantly high in countries that largely consume maize-based foods [16], there is limited information in Malawi on dietary exposure to mycotoxins especially for school going children under the School Meals Programme whose main meals are maize-based.

The objective of this study was to determine the extent of exposure to aflatoxins and fumonisins for school going children by estimating the intake levels of the mycotoxins through consumption of porridge made using maize-based ingredients, commonly consumed by children in primary schools under the Home-Grown School Meals Programme in Salima district, Malawi.

MATERIALS AND METHODS

Study Area

The study was carried out between August and November 2019 in Salima district, central Malawi. Salima is one of the districts implementing the School Meals Programme in the country. The program covers three Extension Planning Areas (EPAs), namely: Katelera, Chipoka, and Tembwe. These EPAs were demarcated based on agro-ecological zones. The district covers approximately 2,196 km^2 with a population of about 478,346, of which 53 % are below 18 years [17]. Salima district is located along the lake shores of Malawi in the central region (Figure 1).

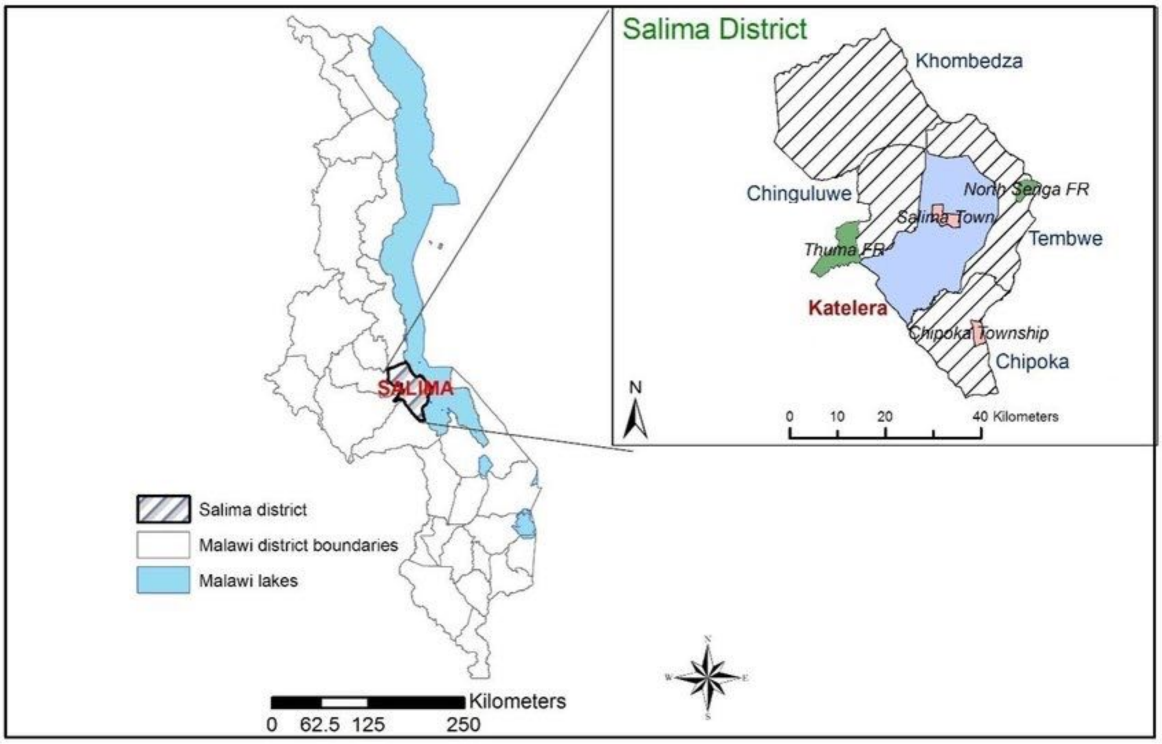

Figure 1: The Study area, Salima District, Central Malawi [18]

Study Design

This was a cross-sectional study with an analytical component. Consumption of maize-based porridge data were collected through administration of pre-tested semi- structured questionnaires to purposively select food handlers (n=124, Yamane's formula [19]). Food handlers included school meals cooks, farmer groups members and suppliers as well as the schools' stores keepers. Fisher's formula [20] was used to randomly select school children who were drawn from randomly selected primary schools within the district (n=31). The survey for school children was designed to capture data on social demographic characteristics, body weights (bw), quantities of porridge consumed, and regularly experienced health problems. The quantities of meals and body weights (bw) were collected by weighing served meal portions and the children's respective body weights (bw) using certified digital weighing scales in Malawi. The questionnaire for food handlers collected information on the type of meals and ingredients for preparing school meals as well as the postharvest handling practices. The objectives of the study were explained to the respondents and consent to participate in the study was sought before commencement of the interviews. The questions were administered by trained enumerators who translated the questions into local dialects for ease of communication.

Maize-based porridge sample collection

A total of 30 maize-based porridge samples (Fisher's formula [20]) were purposively collected in triplicates from different cooking pots per school. The collected samples were packed in airtight plastic bottles (400 mls) and transported in cooler boxes to the Aflatoxins Research and Training Laboratory at Chitedze Agricultural Research Station in Lilongwe, Malawi. The prevalence of the toxins exceeding the recommended levels was determined after quantification as described by Monyo *et al.* [21].

Quantification of aflatoxins and fumonisins

The levels of aflatoxins and fumonisins in the porridge samples were detrmined using Reveal ®Q+ immunoassay Kits (©Neogen Corporation, 2018). Approximately 20 grams of each sample was weighed on Scout Pro digital balance (Ohaus, USA) and mixed with 100 ml of 65 % ethanol. The mixture was thoroughly blended for 60 seconds using a waring blender (Model 8120,USA). The mixture was filtered using Whatman filter paper 185 mm (Cat no. 1001 185, Sigma-aldrich) into 250 ml Conical flask. A 100 µl of sample filtrate was then mixed with 500 ml of aflatoxin sample diluent and homogenized in a sample dilution cup. For fumonisins determination, a 100 µl of sample filtrate was mixed with 200 ml of fumonisins sample diluent and homogenized in sample solution cup. Each sample extract of 100 µl was transferred into a clear sample cup. The Reveal ®Q+ Kits test strips for aflatoxins and fumonisns were respectively placed into sample extracts for 6 minutes to develop. These were then instantly inserted into Reveal AccuScan® Gold reader system for analysis. The Reveal ®Q+ Kits for aflatoxin and fumonisins had detection and quantification limits of 2-150 ppb and 0.3-6 ppm for total the aflatoxins and fumonisins, respectively. The results obtained from aflatoxins and fumonisins analysis were recorded in mg/kg and µg/kg, respectively.

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Aflatoxin and fumonisin intake levels

Intake levels of aflatoxins and fumonisins through maize-based porridge consumption

Exposure to aflatoxins and fumonisins by children due to the consumption of maize-based porridge was assessed probabilistically using @Risk TopRank Palisade (UK) software for excel (Palisade, UK) V.8.0, where data for aflatoxins, fumonisins and consumption levels were fitted to obtain the best fit distributions as shown in Table 1. The data on maize-based prorridge consumption levels were combined with quantified aflatoxins and fumonisins in the porridge samples in order to calculate the exposure to myctoxins. The mean and the 95th percentile (P95) intake levels for the estimated Margins of exposure (MoE) were calculated using Monte Carlo simulation after a 1,000,000 iteration runs for variability. The Tolerable Daily Intake (TDI) of aflatoxins was estimated based on Margins of Exposure (MoE) of 10,000 as safety levels of public health [22], which is is equivalent to 0.017 ng/kg bw/day for children [23] or approximately 0.62 ng/child/day. Therefore, any exposure value of above 0.017 ng/kg bw/day was regarded as unsafe for school-going children. Exposure to fumonisins was calculated based on provisional maximum total daily intake (PMTDI) of 2 µg/kg bw/day [24], which is approximately equivalent to 0.073 µg/child/day. The estimated exposure rates of fumonisins above 0.002 µg/kg bw/day and 0.073 µg/child/day were considered unsafe for school children's health.

Quantitative risk assessment for aflatoxin and fumonisins exposure

The consumption data obtained based on daily consumption of maize-based porridge was estimated by dividing the weekly intake of maize-based porridge (kg/ person) by respondents' body weights (bw) and dividing again by 7 days according to JECFA [25] to obtain the amount consumed per kg bw/day. The distribution of aflatoxins and fumonisins in the porridge was gotten by dividing the levels of the mycotoxins per kilogram of maize-based porridge. The intake levels were obtained through multiplying the corresponding amount of aflatoxins and fumonisins in the samples and the consumption levels of maize-based porridge to obtain the estimated intake levels per kg bw/day for the respondents.

Data analysis

Data were subjected to Statistical Package for Social Scientists (version 20.0) for windows®. Descriptive statistics were used to obtain percentages, means, and standard deviations. Pearson's correlations and Chi-square analysis were used to analyze the association between categorical variables. Independent t-test was also applied to compare the mean differences between continous variables. One way analysis of variance (ANOVA) was used to obtain the least significant differences between variables with the Tukey's HSD test set at $p \leq 0.05$. The intake and consumption levels were analyzed using Microsoft Excel @Risk TopRank Palisade(UK) V8.0.0 AddIn software.

RESULTS AND DISCUSSION

Consumption of maize-based porridge by children in the School Meals Programme

Demographic characteristics of the school children

Four in every respondent (43 %) were males while the rest (57 %) were females. The age of the school children ranged from 5 to 19 years, with an average age of 11.7 ± 2.8 years. A proportion (15.9 %) of children were from grades 6 and 7, and 8.1 % from class one. There was a significant association between gender and age of school children (χ^2 = 8.592, P = 0.032), where males were significantly older than females. A strong correlation was also observed between the age and grade level (r = 0.631, P = 0.043), where older children were significantly in higher grade level, while younger children were in lower grade levels. The grade levels for both male and female children were not influenced by their gender (χ^2 = 3.499, P = 0.835), indicating that transition to the next grades was equal for both.

The findings indicate the probability that the children in lower grade levels might be more susceptible to mycotoxins exposure compared to those in the higher grades, since the portions of the serving were relatively the same. Studies have shown that younger children are more susceptible to pathogenic microorganisms and environmental toxicants [26] compared to older people due to their low developed immune system, increased food demand, and uncontrolled diet [8]. Increased age and level of education had a significant positive correlation with the awareness of foodborne infections, food safety, and hygiene practice [27].

Meals prepared for children's consumption in schools

Porridge was consumed in all schools under this study with the primary ingredient used for preparing being maize as reported by more than 9 in every ten food handlers (96%) (Table 2). Alternatively, 85 % of the respondents used groundnuts with significantly minimal use of other major ingredients (Table 2). Furthermore, all respondents indicated that porridge was mainly made from maize-soybean-groundnuts flour blends and in some instances, mixed with mashed vegetables. The respondents also reported that ingredients were combined with the aim of increasing nutrient density for the school meals. All respondents indicated that the porridge was served once daily in the morning before commencement of the class sessions during the school days- usually Monday to Friday. The combination of maize and legumes has been widely used to improve child nutrition in developing countries [28]. However, maize-legume based foods in sub-Saharan African countries have also been found to contain varying levels of mycotoxins [14]. None of the schools reported consumption of animal-based foods, which may be as a result of the cost of these foods. Educating and empowering the children's families to practice livestock production and consumption of small animals and animal products such as chickens, goats and rabbits at home should also be promoted in order to complement the school meals diet.

Consumption levels of maize-based porridge in schools

Consumption levels of maize-based porridge in schools ranged from 450 to 800 grams per child per day with an averaged of 609.7 ± 62.1 grams. The consumption levels of

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maize-based porridge were significantly (P = 0.021) different among the children. The distribution fit for the consumption of the porridge by general Beta had ranged from 0.008 to 0.082 kg/kg bw/day with a mean value of 0.019 kg/kg bw/day (Figure 2). However, there was no correlation between meal consumption levels and the age (r = 0.033, P = 0.459), and grade levels (r= -0.004, P = 0.937) of the respondents. There were also no significant associations between the quantities of meals consumed and the gender of the school children ($\chi^2 = 5.624$, P = 0.286).

The findings from this study on the average consumption of maize-based porridge (610 grams/day) by school children was quite high compared to the average consumption level of 150 to 500 grams/day estimated in other African countries [29]. A study in South Africa reported an average of 400 to 500 grams/person/per day with relatively high mycotoxins exposure [30]. The average consumption of maize-based porridge reported in the present study might have exposed the school children to mycotoxins exceeding the regulatory safety levels.

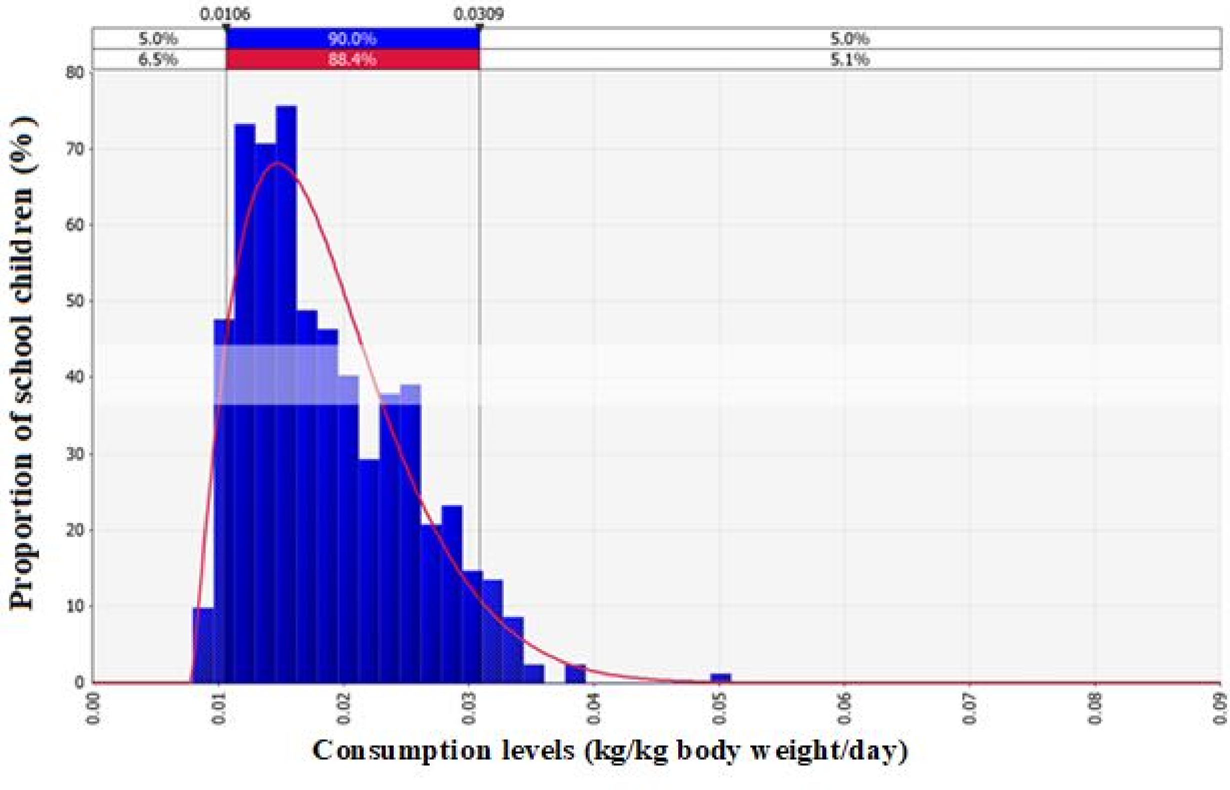

Figure 2: Model distribution for consumption (kg/kg bw/day) of maize-based porridge by school children under SMP in Salima district, Malawi

Body weights of school children

The body weights of school children varied significantly (P = 0.016) and had ranged from 12 to 66 kilograms, with an average weight of 34.6 ± 1.2 kgs. It was also observed that there were significant positive correlation between body weights and age (r = 0.835, P = 0.001), and the grade level of school children (r = 0.725, P = 0.001) as the older children in the higher grades weighed more. The children's body weights were, however,

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not influenced by their gender (χ^2 = 2.859, P = 0.391) or the quantities of porridge consumed (r = 0.076, P = 0.089).

The present study found that there were no significant associations between body weight, age, and meal consumption levels of the school children as schools served porridge using uniform serving spoons or cups regardless of their age and body weight. Given that the intake levels of mycotoxins are estimated based on levels of food consumed and the respective body weights [31], the uniform serving of maize-based porridge potentially puts at risk school children with lower body weights by consuming maize-based foods. Moreover, children suffer most from mycotoxins exposure due to their low ability to detoxify toxins and increased food intake per kg body weight [32]. The results of the present study agree with Kang'ethe *et al.* [33] who equally reported no significant differences in meal consumption levels among specific age groups and exposure to mycotoxins.

Health problems experienced by school children

About a fifth (19 %) of the school children reported experiencing frequent headaches while others stated occasional stomach discomforts (16 %), irregular diarrheal diseases (14 %), frequent coughs (11 %), fevers (11%) and nausea and/or vomiting(7%). On the other hand, 29 % of school children reported that they rarely experienced any manifested healh problems. There were no significant associations of health problems and gender (χ^2 = 12.507, P = 0.130), age (χ^2 = 1.213, P = 0. 258), and meal consumption levels (χ^2 = 49.25, P = 0.423) of school children. A significant association was observed between health problems and school grade level (χ^2 = 56.698, P = 0.029), where children in the lower grades reported experiencing more health problems compared to children in the higher grades. Similarly, no association was observed between the health problems and bodyweight of school children (χ^2 = 66.934, P = 0.64).

The health issues reported in the current study might have been due to consumption of unsafe foods and or poor hygienic practices, which was observed in schools during the study visits including sitting and placing plates on bare-ground during eating, overcrowding of school children at the serving points (kitchen) and dining areas contaminated with lots of dust. Besides poor hygiene, the schools where samples were obtained, had no properly designated dining structures, forcing the children to eat on the open space. Some of the school cooks did not wear the recommended protective clothing such as aprons and headcovers during meal preparation and serving. The results in the present study are similar to those reported in Ghana where school children experienced abdominal cramps, vomiting and nausea after consuming mycotoxins contaminated school lunch [4]. Studies have shown that molds contaminate foods at any stage along the value chain including during processing and preparation [34] and, therefore, the current diseases experienced may be as a result of the presence of mycotoxins in the meals served. However, more investigations need to be carried out to determine the causes of the frequent and occasional illnesses expereineced by the school children.

Levels of aflatoxins and fumonisins in maize-based porridge

All the samples analyzed had detectable levels of aflatoxins and fumonisins and were described by exponential distributions. The levels of aflatoxins ranged from 2.13 to 33.37

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µg/kg with a mean value of 11.62 µg/kg. There was significant difference in the levels of aflatoxins among samples obtained from schools (P = 0.014). Forty per cent (40 %) of the contaminated samples had levels of aflatoxins exceeding the regulatory limits of 10 µg/kg according to unpublished revised standards by Malawi Bureau of Standards (MBS). Moreover, 17 % exceeded the recommended levels of 20 µg/kg set by the United State of America [35]**.** On the other hand, 90% of the samples exceeded the 4 µg/kg limit set by the European Union for processed maize-based products [36]. It was further observed that all the samples had aflatoxins above the acceptable levels of 0.1 µg/kg according to the European Union for cereal-based products meant for consumption by young children.

Slightly more than half (56%) of the maize-based samples from different schools had significantly (p=0.020) different levels of fumonisins ranging from non-detectable levels <0.3 to 1.1 mg/kg with a mean of 0.30 mg/kg. Furthermore, 6% of the analyzed samples had fumonisins concentration levels exceeding the recommended safety levels set by the European Union (0.1 mg/kg) for all processed maize-based products meant for consumption by young children. Currently, there are no standards in Malawi that specify the recommended limits for fumonisins in foods meant for human consumption and, therefore, need for developing standards to guide citizenry.

The results from the Extension Planning Areas where the study took place showed that all areas had an occurrence of aflatoxins and fumonisins (Table 3). However, the levels for both mycotoxins were not significantly (P>0.05) different. These findings indicate the endemic presence of the mycotoxins in all the study areas. The aflatoxin levels were highest (13.21 µg/kg) in samples obtained from Chipoka Extension Planning Area with the least (9.97 µg/kg) found in Tembwe area. On the other hand, fumonisins ranged from non-detectable levels of <0.3 to 0.417 mg/kg between the areas. Similarly, the levels of fumonisins were also high (0.7 mg/kg) in Chipoka Extension Planning Area and lowest (0.12 mg/kg) in Tembwe Extension Planning Area.

This study established high levels of aflatoxins and fumonisins through consumption of maize-based porridge consumed in the School Meals Programme. The high levels of aflatoxins and fumonisins might presumably be attributed to poor postharvest handling practices of maize, which were observed during the collection of samples in schools; transportation of uncovered foodstuffs on open trucks/lorries, offloading of bags on bare ground, storage of maize bags in contact with floor and wall, dirty storerooms with lots of dust, birds' droppings and spider-nets. In some cases, food handlers reported that they rarely sorted the maize used to prepare the meals, therefore, the inclusion of rotten and moldy grains was common. These were attributed to the bulkiness of grains and limited time for meal preparations. Previous studies have reported that foodstuffs are contaminated with mycotoxins due to poor postharvest handling practices such as poor transportation and storage [37]. Besides, the study did not extend to the postharvest handling practices by the farmers to assess whether they practiced good agricultural practices aimed at mitigating against the occurrence of mycotoxins.

The high levels of aflatoxins and fumonisins in the maize-based porridge samples might be attributed to the combination of the ingredients, which included maize, groundnuts, and soybean. Previous studies have reported that maize, groundnuts and their derived products from Southern Africa, including are highly contaminated with aflatoxins and fumonisins [11,13]. The results of the current study agree with other researchers who reported high aflatoxins and fumonisins levels in maize-based foods intended for children consumption in developing countries [38].

Exposure of school children to aflatoxins and fumonisins from the consumption of maize-based porridge in schools

Exposure of school children to aflatoxins through consumption of maize-based porridge in schools ranged from 0.034 ng/kg bw/day to as much as the levels may have been in the sample (+∞) (Data not shown). The mean and 95th percentile (P95) for exposure to aflatoxins through consumption of maize-based porridge were 0.2 and 0.6 ng/kg bw/day, respectively. The children under the current study had averaged weight of 36.4 kg. They, therefore, experienced aflatoxin exposure ranging from 1.24 ng/kg bw/day to 7.28 ng/kg bw/day at the 95th percentile through consumption of maize-based porridge (Table 4). The results showed that school children were exposed to aflatoxins above the acceptable limits of 0.017 ng/kg bw/day as recommended by European Food Safety Authority [23] through the consumption of maize-based porridge in schools which might eventually negatively affect their health.

Exposure of school children to fumonisins due to consumption of maize-based porridge in schools ranged from 2.0 to 3.0 µg/kg bw/day, with the mean and the 95th percentile at 6.0 and 9.2 µg/kg bw/day, respectively. The intake levels for fumonisins through consumption, therefore, ranged from 73.0 µg/kg bw/day to 334.9 µg/kg bw/day at the 95th percentile. Similarly, exposure to fumonisins was beyond the acceptable limits of 2.0 µg/kg bw/day set by Joint Food and Agriculture Organisation/World Health Organization Committee on Food Additives [24], and the chances are that the children may be experiencing varying levels of intoxication from the mycotoxins in the meals. Exposure of children to aflatoxins might be attributed to high consumption levels of aflatoxins contaminated maize-based porridge in schools with the health risks remaining unkown. The results of the current study agree with previous studies which reported high exposure of children to aflatoxins from regular consumption of maize-based foods and products in countries like Tanzania whose levels ranged from 0.14 to 120 ng/kg bw/day [39] and Nigeria, which reported an average of 641 ng/kg bw/day) [38].

Furthermore, the study established high fumonisins exposure for children from consumption of maize-based porridge in the surveyed schools. High fumonisins exposure might equally result from consumption of fumonisins contaminated maize-based in the porridge. Children consuming large quantities of maize-based porridge in schools might be at risk of mycotoxicosis. The results from the present study are comparable to other authors who reported high exposure of children to fumonisins through large intake of processed maize-based complementary foods in countries like Tanzania with an average range of 0.005 - 0.88 µg/kg bw/day) [40] and Nigeria whose median values ranged from 6 - 18 µg/kg bw/day [38] and other developing countries having levels ranging 0.013 - 0.82 µg/kg bw/day [37]. These findings indicate relatively high exposure to aflatoxins and fumonisins for school going children through consumption of maize-based porridge under the School Meals Programme, which may affect their health, education and the future well-being.

CONCLUSION

This study found that children under the School Meals Programme in Salima, may be exposed to unacceptable levels of aflatoxins and fumonisins through the consumption of maize-based porridge in schools. The high consumption of mycotoxin contaminated maize-based diets in the schools may be contributing to relatively high mycotoxins intake. Given that the school children have fairly low body weights, there is a risk of mycotoxin intoxication and therefore raising food safety concerns for these children. Moreover, poor hygienic practices in the schools could contribute to unknown health complications among the school children. Regularly consuming maize-based porridge in the School Meal Programme without proper regard to hygiene may, over the long term, detrimentallu affect the health, education and future well-being of school children.

The study recommends regular monitoring of food commodities and working on policies aimed at mitigating against increased mycotoxin accumulation. There is need for diversification of maize with other cereal-based foods that are less prone to mycotoxins contamination. Substitution of maize-legume blend with roots and tubers can be recommended to reduce consumption levels of maize foods in schools. We also recommend the promotion of good hygienic practices in schools to prevent children from recurring health problems. Furthermore, it is necessary to create awareness on ensuring proper postharvest handling practices and processing of maize based-foods offered in schools. Similar studies should also be replicated across the country to determine the extent to which the country's school going children are exposed to mycotoxins with investigations on whether there are disease incidences attributed to the mycotoxins intake.

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Table 1: Distribution functions used in quantitative risk assessment simulation for aflatoxins and fumonisins exposure

Parameter	Function	Monte Carlo Function
Aflatoxin		
Maize based porridge consumption (kg/kg bw/day)	Extent	RiskBetaGeneral(2.2546,13.245,0.0077801,0.08229,RiskName("Maize based porridge consumption (kg/Kg bw/day)"))
Aflatoxins levels in maize based porridge (ng/kg)	Levels	RiskExpon(0.0094927,RiskShift(0.0018136),RiskName("Aflatoxin distribution in maize based porridge (ng/kg)"))
Aflatoxins intake levels in maize based porridge (ng/kg bw/day)	Intake	Aflatoxin distribution in porridge* Maize based porridge consumpt
Fumonisins		
Maize based porridge consumption (kg/kg bw/day)	Extent	RiskBetaGeneral(2.2546,13.245,0.0077801,0.08229,RiskName("Maize based porridge consumption (kg/Kg bw/day)"))
Fuminisins levels in maize based porridge (µg/kg)	Levels	RiskExpon(0.29778,RiskShift(-0.0099259), RiskName("Fumonisin distribution in maize based porridge samples (µg/kg)"))
Fumonisins intake in maize based porridge (µg/kg bw/day)	Intake	Fumonisin distribution in porridge* Maize based porridge consumption

Bw – Body weight

Table 2: Ingredients and meals prepared for school children in primary schools under the Schol Meals Programme

Factor	Frequency (n=124)	Percentage (%)
Ingredients		
Maize	119	96
Groundnuts flour	105	85
Soy bean	71	57
Fruits	59	48
Vegetables	72	58
Rice	61	49
Others	2	3
Animal source foods	0	0
Type of meal prepared		
Porridge	124	100
Nsima (Ugali)	5	4
Others	2	2

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Table 3: Aflatoxins and fumonisins levels in maize-based porridge samples collected in 3 Extension Planning Areas under the Schol Meals Programme

		Aflatoxins		Fumonisins	
EPAs	**Frequency (n)**	**Mean ± SD (µg/Kg)**	**Range (µg/Kg)**	**Mean ± SD (mg/Kg)**	**Range (mg/Kg)**
Tembwe	10	9.97 ± 4.9 [a]	3-17.6	<0.3 ±0.338 [a]	<0.3-1.1
Katelera	10	11.61 ± 11.86 [a]	2-63.9	0.3 ± 0.384 [a]	<0.3-1.3
Chipoka	10	13.21 ± 14.35 [a]	3-74.7	0.4167 ± 0.471 [a]	<0.3-1.4

EPA – Extension Planning Areas (demarcated based on agro-ecological zone)

Means with the same superscripts along column are not significantly different, Tukey Test (P < 0.05)

Table 4: Estimated margins of dietary exposure of children to aflatoxins and fumonisin due to consumption of maize-based porridge in SMP in Salima District, Malawi

Parameter	**Aflatoxins Intake (ng/kg bw/day)**			**Fumonisins Intake (µg/kg bw/day)**		
	Min	**Mean**	**P95**	**Min**	**Mean**	**P95**
Dietary Exposure	0.03	0.20	0.60	2.00	6.00	9.20
MOE (Min bw =12 Kg child	0.41	2.40	7.20	24.00	72.00	110.40
MOE (Mean bw =36.4 Kg child)	1.24	7.28	21.84	72.80	218.40	334.88
MOE (Mean bw = 66 Kg child)	2.24	13.20	39.60	132.00	396.00	607.20

P95 = 95th percentile, MOE=Margin of Exposure, Min = Minimum, Max = Maximum,

Bw = Body weight

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REFERENCES

1. **FAO and WFP.** United Nations Food and Agriculture Organization and World Food Programme. Home-Grown School Feeding Resource Framework, 2018.

2. **Drake L, Woolnough A and C Burbano** Global School Feeding Sourcebook, 2016.

3. **WFP.** United Nations World Food Programme. The State of School Feeding Worldwide, WFP, Rome, 2013.

4. **Ababio P F, Taylor K D A, Swainson M and B A Daramola** Impact of food hazards in school meals on students' health, academic work and finance - Senior High School students' report from Ashanti Region of Ghana. *Food Control*. 2016; **62**:56-62.

5. **WFP.** United Nation World Food Programme. School Meals Programme (SMP) in Malawi. 2018.

6. **Misihairabgwi J M, Ezekiel C N, Sulyok M, Shephard G S and R Krska** Mycotoxin contamination of foods in Southern Africa: A 10-year review (2007–2016). *Crit Rev Food Sci Nutr*. 2017;**59(1)**:43-58.

7. **WHO.** World Health Organisation. Estimates of the global burden of foodborne diseases. Foodborne diseases burden epidemiology reference group 2007–2015.

8. **Gong Y Y, Watson S and M N Routledge** Aflatoxin Exposure and Associated Human Health Effects, a Review of Epidemiological Studies. *Food Saf.* 2016;**4(1)**:14-27.

9. **IARC.** International Agency for Research on Cancer (IARC). IARC monographs on the evaluation of carcinogenic risks to humans. *Chem agents Relat Occup*. 2012;**56(100)**:1–599.

10. **Marin S, Ramos A J and G S V Cano-Sancho** Review Mycotoxins: occurrence, toxicology, and exposure assessment. *Food Chem Toxicol*. 2013;**60:**218-237.

11. **Misihairabgwi J M, Ezekiel C N, Sulyok M, Shephard G S and R Krska** Mycotoxin contamination of foods in Southern Africa: A 10-year review (2007–2016). *Crit Rev Food Sci Nutr*. 2019;**59(1):**43-58.

12. **Alshannaq A and J Yu** Occurrence , Toxicity , and Analysis of Major Mycotoxins in Food. 2017.

13. **Mwalwayo D S and B Thole** Prevalence of aflatoxin and fumonisins (B 1 + B 2) in maize consumed in rural Malawi, 2016;**3**:173-179.

14. **Kimanya M E** The health impacts of mycotoxins in the eastern Africa region. *Curr Opin Food Sci*. 2015;**6**:7–11.

15. **IARC.** International Agency for Research on Cancer. Mycotoxin Control in Low and Middle Income Countries. **In** C. P. Wild, J. D. Miller, & J. D. Groopman (Eds.). IARC Working Group Report No. 9, Lyon. 2015.

16. **Kimanya M, Demeulenaer B and B Tiisekwa** Co-occurrence of aflatoxin and fumonisins in home stored maize for human consumption in rural villages of Tanzania. Food Addit. Contam. Part A—Chem. Anal. *Control Expo Risk Assess*. 2008;**25(11)**:1353–1364.

17. **NSO.** National Statistics Office. Malawi Population and Housing Census.; 2018.

18. **Musa F, Kamoto J, Jumbe C and L Zulu** Adoption and the Role of Fertilizer Trees and Shrubs as a Climate Smart Agriculture Practice: The Case of Salima District in Malawi. *Environments*. 2018;**5(11)**:122.

19. **Yamane T** Statistics, An Introductory Analysis, 2nd Ed., New York: Harper and Row.; 1967.

20. **Fisher L** Self-designing clinical trials. *Stat Med*. 1998;**17**:1551-1562.

21. **Monyo E S, Njoroge S M C, Coe R, Osiru M, Madinda F, Waliyar F, Thakur R P, Chilunjika T and S Anitha** Occurrence and distribution of aflatoxin contamination in groundnuts and population density of aflatoxigenic Aspergilli in Malawi. *Crop Prot*. **2012;(42)**:149–155.

22. **Benford D, Bolger P M and P Carthew** Application of the margin of exposure (MOE) approach to substances in food that are genotoxic and carcinogenic. *Food Chem Toxicol*. 2010;**48**:S2-S24.

23. **EFSA.** European Food Safety Authority. Opinion of the Scientific Panel on Contaminants in the Food Chain on a request from the Commission related to the potential increase of consumer health risk by a possible increase of the existing maximum levels for aflatoxins in almonds, hazelnuts and pis. *EFSA J*. 2007;**446**:1−127.

24. **JECFA.** Joint Food and Agriculture Organization of the United Nations and WHO Evaluation of Certain Food and Contaminants. Sixty-Eighth Report of the Joint FAO/WHO Expert Committee on Food Additives, 2008.

25. **WHO.** World Health Organisation. Food additives series 65. Safety evaluation of certain food additives and contaminant. Prepared by 74th Meeting of Joint FAO/WHO Expert Committee on Food Additives (JECFA): Geneva. 2012.

26. **CDC.** Centers for Disease Control and Prevention. Outbreak of Aflatoxin Poisoning: Eastern and Central Provinces, Kenya, January–July 2004. September 3. *Morb Mortal Wkly Rep*. 2004;**53(34)**:790–793.

27. **George M, Kiran P R and G A Joseph** Knowledge and practices regarding food hygiene and health profile of food handlers in eateries in a town in Southern Karnataka. *Int J Community Med Public Heal*. 2018;**5(5)**:2123.

28. **Soro-Yao A A, Brou K, Amani G, Thonart P and K M Djè** The use of lactic acid bacteria starter cultures during the processing of fermented cereal-based foods in West Africa: a review. *Trop Life Sci Res*. 2014;**25**:81–100.

29. **Gong Y Y, Routledge M, KimanyM E, Musoke G, Nelson F, Manyong V and S Sonoiya** Aflatoxin standards for food. Knowledge Platform 2015 Situational Analysis East Africa Region. *East African Community*. 2015.

30. **Shephard G S, Marasas W F O and H M Burger** Exposure assessment for 374 fumonisins in theformer Transkei region of South Africa. *Food Addit Contam*. 2007;**24(375)**:375 621-629.

31. **Liu Y and F Wu** Global burden of aflatoxin-induced hepatocellular carcinoma: a risk assessment. *Environ Health Perspect*. 2010;**118(6)**:818–824.

32. **WHO.** Food Safety Digest. *Manuf Comput Solut*. 2018;**6(8)**:20-23.

33. **Kang 'ethe E K, Gatwiri M and A J Sirma** Exposure of Kenyan population to aflatoxins in foods with special reference to Nandi and Makueni counties. Ministry of Agriculture Livestock and Fisheries, Veterinary Laboratories, Kabete, Private Bag Kabete. *Food Qual Saf*. 2017;**1(2)**:131-137.

34. **Eshiett M E, Oluwabamiwo B F, Mulunda M and L Ngoma** Mycotoxin and food safety in developing countries Edited by Hussaini Anthony Makun, 2013.

35. **USA.** United State of America. Mycotoxin Regulations for Food and Feed in the USA, 2016;(September):2016.

36. **EU.** European Union. Mycotoxin Regulations for Food and Feed in the EU, **2016;(1137)**:2016.

37. **WHO.** World Health Organisation. Co-Exposure of Fumonisins with Aflatoxins. REF. No.: WHO/NHM/FOS/RAM/18.3 February, 2018.

38. **Ojuri O T, Ezekiel C N and M K Eskola** Mycotoxin co-exposures in infants and young children consuming household- and industrially-processed complementary foods in Nigeria and risk management advice. *Food Control*. 2019;98(November 2018):312-322.

39. **Magoha H, Kimanya M, De Meulenae B, Roberfroid D, Lachat C and P Kolsteren** Risk of dietary exposure to aflatoxins and fumonisins in infants less than 6 months of age in Rombo, Northern Tanzania. *Matern Child Nutr*. 2016:516−527.

40. **Kamala A, Kimanya M and C Lachat** Risk of Exposure to Multiple Mycotoxins from Maize-Based Complementary Foods in Tanzania. *J Agric Food Chem*. 2017;**65(33)**:7106-7114.