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Assessment of aflatoxin awareness in The Gambia

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Aflatoxins belong to a category of mycotoxins that have impacted mankind since the beginning of organized cultivation. This toxin is produced by certain molds in food and feeds and results to adverse health effects to both humans and animals, as well as economic barriers to farmers and countries. Therefore, this study aimed to investigate the current level of aflatoxin awareness and knowledge of its contamination, preventive measures, and health implications among the population. Questionnaires were administered to capture data on socio-economic features, perceptions, and knowledge revolving around aflatoxin using a multi-stage sampling technique. Among the sample, respondents aged above 50 years with higher educational status and farmers were more informed about aflatoxin awareness. Among the regions, Central River Region showed the highest level of aflatoxin awareness. Family/friends are the most frequent source of information as compared to traditional media (radio and television), formal workshops and internet. The results suggest a need for an introduction of educative intervention programs and establishing initiatives through avenues that can promote aflatoxin awareness in the country.

Key words: Aflatoxin, awareness, demographic, The Gambia.

INTRODUCTION

Mycotoxins have impacted mankind since the beginning of organized crop cultivation. However, scientific study of the toxins began in the 1960s following the severe death of turkey birds due to consumption of contaminated ration of groundnut meal (Blount, 1961). Since then, over 400 'mycotoxins' have been discovered and are categorized based on structural similarities and their major toxic effects (Hussein and Brasel 2001; Bennett and Klich 2003). The toxin that stands out in scientific literature is aflatoxin due to its highly deleterious toxic effects, and its impact on global trade (O'Riordan and Wilkinson, 2008).

Aflatoxins (AFs) are secondary metabolites of fungi belonging to several *Aspergillus species*. Among the known species within the genus *Aspergillus, Aspergillus flavus*is the most economically important. These fungi are saprobe mold that is capable of surviving on many substrates (organic nutrient sources) like plant debris, tree leaves, decaying wood, animal fodder, cotton, compost piles, dead insects and animal carcasses, stored grains, and even immuno-compromised humans and animals (Klich, 1998). Crops or produce may be infected with the toxigenic fungi at convenient

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environment conditions such as at a temperature of 25–32°C, moisture content of 12–16% and relative humidity of 85% (Ledda et al., 2017), mechanical damage of pods also induce insect infestation leading to infection.

The adverse health effects and economic barriers caused by these toxins demand a well-tailored aflatoxin management strategy (Bandyopadhyay et al., 2016). This should involve technologies inhibiting aflatoxin contamination along the entire value chain (Ayalew et al., 2017; Njoroge, 2018) in conjunction with awareness programs. The significant decline of exportation on aflatoxin-susceptible crops like groundnut from The Gambia (Jallow et al., 2019) and Africa or all developing countries (Bhat and Vashanti, 1999; Otsuki et al., 2001a) is a result of the excessive stringent measures ranging from 0 to 10 ppb by the importing countries. The difference between the EU (4ppb for maximum tolerance limits) and the Codex limits (15 ppb) would only save two lives for every one billion people (Otsuki et al., 2001b). In most cases, fungal infestation on produces or foodstuffs indicates a high possibility of contamination of at least one kind of the toxin. Such infestation causes low nutritional value and poor organoleptic properties, which affect feed intake by animals (Akande et al., 2006) subsequently reduces livestock productivity and increases mortality (Zain, 2011).

Aflatoxin enormous health effects include carcinogenicity, mutagenicity, teratogenicity, oestrogenicy, neurotoxicity, or death based on the type, dose, sex, health, age, and nutritional status of the exposed being (Peraica et al., 1999; Hussein and Brasel 2001; Fung and Clark 2004; Lewis et al.,2005; Reddy et al., 2010). Available scientific evidence indicates aflatoxin can increase the rate of progression from HIV infection to AIDS (Jolly et al., 2013; Jolly, 2014). Studies conducted in Asia and Africa also revealed a high incidence of hepatitis B infection in populations with a significant or prevalent dietary exposure to aflatoxins (Bommakanti and Waliyar, 2007).

Good Agricultural Practices are among the best strategies to mitigate aflatoxin poisoning. The use of pest and disease-resistant plants, crop rotation, insect control and post-harvest control like proper drying, sorting, and removal of moldy foodstuff (Bruns 2003; Chulze 2010; Matumba et al., 2015).

A recent paper on a decade-long analysis showed the contamination trend of aflatoxin in groundnuts is within the acceptable limits of Codex Alimentarius (Jallow et al., 2019). However, there is limited data on the level of awareness amongst farmers and the general population about causes, preventive measures, and health implications of aflatoxin nationwide. This study was designed to measure the level of aflatoxin awareness among the population and generate evidence-based data to drive policy decisions that can help establish the right strategies for crop production, storage, exportation, and safe consumable farm produce. Furthermore, this research was also used to educate those ignorant about the consequences of aflatoxin and correct any misinformation amongst the less informed.

MATERIALS AND METHODS

The demographic of The Gambia comprises about 2.1 million people (Mackenzie et al., 2019) of about eight ethnolinguistic with a more acculturated people of traditions and cultures. A nationwide survey of structured questionnaires was designed and an in-person interview conducted involving 325 respondents to capture the socio-economic features, perceptions, and knowledge of aflatoxin among the populace. The questionnaire data was collected by trained professionals after obtaining consent from participants. The word aflatoxin being technical was translated and explained to the interviewee in their respective local languages. Some of the demographic information collected included age, sex, marital status, household size, education level, and occupation as shown in Table 1. Respondents were also asked aflatoxin related questions such as the causes, aflatoxin associated diseases, preventive measures, and the source/media (radio, TV, workshop, family/friend and internet) of their information were recorded. All respondents were randomly selected using multi-stage sampling technique that is sequencing from the region, district to the community as demarcated in Figure 1 by Jallow et al. (2021).

Statistical data analysis

Data obtained from the questionnaires were manually recorded, doubled checked for validation and transformed into a Microsoft Excel file. The Excel file was exported into Statistical Package for Social Sciences SPSS 17.0 (2009) for further analysis. Descriptive statistics, such as frequencies and percentages, were calculated using cross-tabulation in Excel. All statistical tests with Alpha or p-values less than 0.05 were considered statistically significant. Factors associated with aflatoxin awareness were investigated using multivariate logistics regression analysis models.

RESULTS AND DISCUSSION

Of the overall 325 respondents, 159 (49%) had some knowledge or heard of aflatoxin, whereas 166 (51%) did not. Figure 1 illustrates the level of aflatoxin awareness amongst the various regions in The Gambia. Central River Region (CRR) has the highest level of awareness 34 (68%), Lower River Region (LRR) 36 (72%) has the second highest level, followed by Upper River Region (URR) 26(52%) and NBR (40%), while the lowest values were recorded in West Coast Region (WCR) 19(38%) and Greater Banjul Area (GBA) 24 (32%). Surprisingly NBR scored low even though being the main hub for the cultivation of most aflatoxin prone crops like groundnuts and maize.

The demographics strata of all survey respondents that answered “yes” to the question “Have you heard/know about aflatoxin” is depicted in Table 1. It was observed that the trend of aflatoxin awareness declines from elderly people down to younger ones. People older than age fifty (≥50) have a better awareness 54 (64%),

Table 1. Socio-demographics of respondents to aflatoxin awareness.

Variable	Group	n	Yes	%
Age	<20	14	6	43
	20-29	66	24	36
	30-39	93	40	43
	40-49	67	35	52
	≥50	85	54	64
Sex	Male	176	95	54
	Female	149	64	43
Married	Married	258	136	53
	Single	67	23	34
Household size	≤ 5	155	35	23
	>5	170	124	73
Education level	None	173	90	52
	Primary	58	29	50
	Secondary	67	29	43
	Tertiary	21	6	29
	University	6	5	83
Occupation	Civil service	21	11	52
	Business	126	49	39
	Farmer	111	74	67
	other	67	25	37

n= total persons within groups.

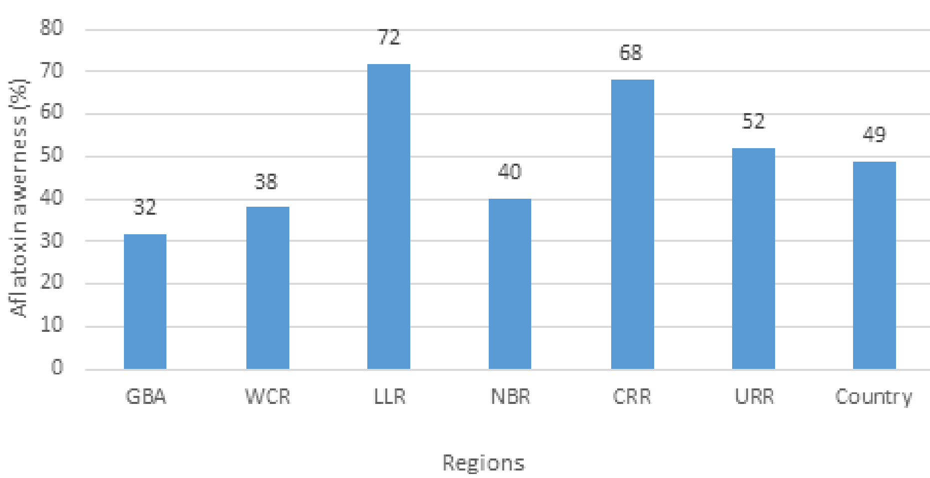

Figure 1. National demographics of aflatoxin awareness based on regional distribution.

followed by the age range (40 - 49) with (52%). The least uninformed age group about aflatoxin was 20-29 with (36%). It was also discovered that male respondents 95(54%) are more aware than their counterpart females 64 (43%). Likewise married people seem to know of aflatoxin 136 (53%) than singles 23 (34%). Similarly, larger families or households 124 (73%) also had more knowledge of the toxin than small household sizes of 35 (23%). As would be expected, people with higher educational status, thus up to university level 5 (83%), are the most informed of what aflatoxin is as compared to the rest in the educational cadre. Overall, a large number

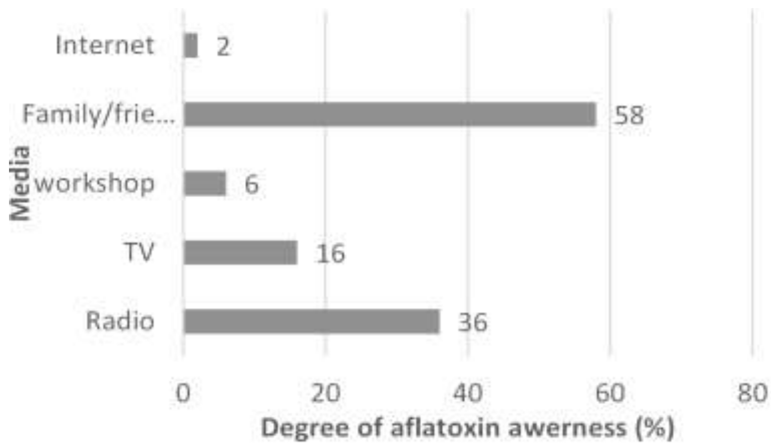

Figure 2. Source of aflatoxin awareness.

of our research respondents had no formal education. However, it was amazing to notice a reverse correlation between the level of education and aflatoxin awareness. Ninety participants (90), thus 52% of people with little or no education were more informed about aflatoxin as compared to people of primary education (50%), secondary education (43%), and Tertiary education (29%). Table 1 shows that farmers (67%) are the most knowledgeable about aflatoxin in comparison to other working classes such as Civil servants (52%) and business owners (39%). Others which include artists, mechanics, tailors, drivers etc. combined were the least informed (37%).

An insight into the extent of knowledge of the interviewees who had some information about aflatoxin were further investigated in terms of causes, preventive measures, and health consequences of aflatoxin contamination. Of the causes of aflatoxin investigated includes, unexpected rains recorded (49%), relative humidity (19%), and moisture content (22%). Moisture Content (MC) refers to the amount of water in a grain/ seed; while water activity (aW) refers to the availability of water to microorganisms to enable interaction within the grain/seed. Research revealed microbial or fungal growth can be enhanced with a minimum a_w level of 65% (Giorni et al., 2012). To decrease and control the MC of grain/seed, various control measures such as the use of super absorbent polymers (SAPs) are used to mix with grain/seed to lower the MC of the grain/seed (Mbuge et al., 2016). Desiccants like silica gel, quick lime, calcium chloride and zeolite seed drying beads have also been used in drying grains/seeds for storage (Kiburi et al., 2014). Other significant causes of aflatoxins that were considered also includes, Poor agronomic practice 39 (25%) like delay in sowing, weeding, fertilizer application, tinning etc. It was revealed in this research that significant respondents (20) were ignorant about fungi infestations and poor post-harvest practices (8%) could be the real cause of aflatoxin. The knowledge on temperature and mechanical damage was 3 (2%) and 11 (7%) respectively, while poor land preparation, which includes improper clearing, burning, ploughing etc., was completely unknown (0) to be a cause of aflatoxin contamination. Our investigation to inquire about the awareness of participants about the preventive measures to mitigate aflatoxin revealed, GPHA marks little above the average percentage of 86 (54%), GAP 20 (13%), while pest and disease control 16 (10%). Pest and disease control was not well known as a precautionary measure. Similarly, knowledge about proper land preparation and the farming system was less than 10%. Data gathered concerning awareness about health implications of aflatoxin disclosed many participants wrongly assumed liver cancer 54 (34%) to be heart disease. The same wrong organ identity or misinterpretations was also observed by Xu et al. (2007). In addition, Stunted growth scores 1 (1%), and others (vomiting, heartburns etc.) 35 (36%), Immune suppression and death were unheard of to be consequences of afflation.

Enquiry into the sources of information about aflatoxin in this study showed family/friends to be the highest (58%) ranked source of aflatoxin awareness followed by traditional media, radio and TV (36%) and (16%), respectively. Workshops (6%) and the internet (2%) were the least sources of information (Figure 2). This can be explained by the fact that, Workshops are organized on rare occasions with a few trainees who are mostly academics, technicians, or professionals. Furthermore, Internet access is available only in the urban areas with high tariff rates and poor internet connectivity issues. The trend is similar to James et al. (2007) findings, which sequenced radio, TV and family as the respective awareness source.

Majority of the farmers in The Gambia practice subsistent farming that applies traditional and cultural farming systems. The priority for most of these farmers is increasing crop productivity as opposed to increasing quality. However, due to Aflatoxin being colorless, odorless, and invisible, contaminated foods may be perceived as safe and edible. Unfortunately, Farmers and consumers have virtually no access to aflatoxin testing methods or facilities, therefore the concept of consuming aflatoxin free food or feeds cannot be assured. Also farmers do not see the need to adopt aflatoxin control measures or employ strict post-harvest practices since it might be time consuming and increase the cost of productivity. Furthermore, local trade fairs or markets do not provide premium prices for aflatoxin free produces.

Various studies have shown that the level of education positively influences informed behaviors of consumers toward their food safety and risk factors awareness (Ezekiel et al*.,* 2013; Alimi et al*.,* 2015; Matumba et al*.,* 2015). Also, Kumar and Popat (2010) noted that awareness of AFs was affected by socio-economic factors such as education level, farm size, membership in agricultural innovation platforms, market structures, financial incentives, were all contributory factors to the overall perception of aflatoxin. Otherwise, knowledge of aflatoxin is predominant only in countries that experienced outbreaks of aflatoxin poisoning (aflatoxicosis) in the past. For example, 2016 in Tanzania, 2015 in Ethiopia and in most African and developing countries Stepman (2018).

This research echoes the views and knowledge about aflatoxins in The Gambia. The outcome of this survey revealed a low national awareness of 49% amongst the investigated populace, which indicts a decline from the 88% awareness found in 2007 in a study by Xu et al. (2007) in The Gambia. However, it's worthy to indicate Xu et al. (2007) had a very small sample size of only 25 respondents. Overall, married males, highly educated people and farmers had more knowledge about aflatoxins. This could be because produce that are mainly susceptible to aflatoxin (groundnut, maize etc.) are mainly grown by men in the country. Women continue to face challenges like poverty, access to farmlands, implements, owning media sources like radio, TV and limited time for recreation (continuous chores) might be the reasons for the low awareness. This is corroborated by Schuler et al. *(*2006). This observation is different from the studies of Sabran et al. (2012; Saulo and Moskowits (2011) who indicated that women had a greater knowledge of fungal and aflatoxin awareness. The awareness of large family sizes could mean couples (polygamous) discuss and exchange knowledge on farming practices and aflatoxin among them as is locally accustomed to. The same reason explains why larger household sizes score higher awareness than smaller family sizes (Table 1). This contradicts Udomkun et al. (2018) study that large households were observed to be less knowledgeable and less aware about aflatoxin contamination compared to small households. To correlate the effects of occupation to the knowledge of aflatoxin, this study reveals a significantly high awareness of farmers (67%) than the findings of James et al. (2007) which recorded 53.2% AFs awareness. Makau et al. (2016) reported about 38.5%, while similar studies by Issah et al. (2015) reveals that 78% of 240 respondents were aware of aflatoxin. Another research by Marechera and Ndwiga (2014) also reported a much higher percentage (92.5%) of aflatoxin awareness of farmers in Kenya. The level of farmer awareness was relatively high given that most respondents from rural communities happen to be farmers. Other non-farming careers had respective low knowledge of aflatoxin. The elderly (≥50) being more aware than younger ages (<30) could be caused by rural-urban exodus in search of better opportunity and higher and quality education. The irregular migration (backway) especially to Europe has also eroded the younger potential farmers. The lack of ready market with premium prices has caused a shift in the cultivation of aflatoxin susceptible crops.

This paper reveals a low awareness (<50%) of causes, preventive measures, and health implications of aflatoxin Table 2. Due to the ubiquitous nature of aflatoxigenic fungi in the environment, aflatoxin contamination could occur during pre- or post-harvest by various factors (Kajuna et al*.,* 2013); although correspondents were less acquainted with poor postharvest practice as a cause of aflatoxin 8(5%). Interestingly, good post-harvest practices rated the highest in the prevention of aflatoxin 86 (54%). A similar study revealed low levels of knowledge about mycotoxins in poultry feed by both feed processors and farmers where a majority (> 50%) were not aware of these toxins, their occurrence, predisposing factors, and dangers to both animals (Nakavuma et al*.,* 2020), and the possible entry of these toxins into the human food chain (Nemati et al*.,* 2014; Ráduly et al*.,* 2020).

Exposure to AFs is through ingestion of contaminated food and feeds (IARC (2004). Inhalation and direct contact through the skin or the mucous membrane is another path to exposure (Kemppainen et al*.,* 1998; Boonen et al., 2012). A short-term exposure to high levels of AFs poisoning through diet may cause severe acute aflatoxicosis that could lead to fulminant high fever, rapid jaundice, edema of limbs liver failure and death. Chronic exposure is a long-term insidious interaction to low minutes of AFs poisoning usually resulting to subclinical diagnosis and hence difficult to recognize thus the low awareness. However, it's also linked to adverse health outcomes (FDA, 2012).

Media is a great tool to create awareness. Yet, if awareness programs or publications are not harness by scientific facts it could generate unforeseen negative consequences. Sensational magazine headlines "Kenkey causes cancer" (James et al., 2007) could cause public fear, distrust in science leading to refusal and rejection of credible scientific information and recommendations thus creating barriers to behavioral change.

Conclusion

The outcomes of this research provided an insight into

Table 2. The causes, prevention and health consequences of aflatoxin.

Variable	Number of respondents	Percent
Cause of aflatoxin		
Rain during harvest/drying	78	49
Relative Humidity (RH)	30	19
Moisture content (MC)	35	22
High temperature	3	2
Drought	6	4
Insects/rodents infestation	18	11
Fungi infestation	20	13
Land preparation (clearing, ploughing etc.)	0	0
Poor agronomic practice (late sowing, weeding, tinning, etc.)	39	25
Poor post-harvest practice (late harvest, drying, storage etc.)	8	5
Mechanical damage	11	7
Prevention of aflatoxin		
Land preparation (proper clearing, ploughing etc.)	10	6
Farming system	5	3
Pest and disease control	16	10
Good agronomic practice (GAP) (timely sowing, weeding etc.)	20	13
Good post-harvest practice (GPHA) (timely harvest, drying, storage etc.)	86	54
Health implication of aflatoxin		
Liver cancer	54	34
Immune suppression	0	0
Stunted growth	1	1
Death	0	0
Others (vomiting, heartburns etc.)	35	36

the general knowledge, practice, and perception, regarding aflatoxin in The Gambia. The paper therefore suggest a multi-dimensional approach from a policy designed that entail training, radio and TV broadcast in local languages about aflatoxin and with drama groups to demonstrate and build awareness on the causes, preventives and health risks associated with aflatoxins. This will ensure food security and food safety that safeguard the health and wealth of the general public.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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