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Assessment of awareness level and attitudes of farmers inthemanagement and mitigation of health risk associated with the occurrence of mycotoxins along the cocoa value chain

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Abstract: *Background: This study was aimed at assessing the level of knowledge and perceptions of 100 cocoa farmers on issues of mycotoxin contamination and their management along the cocoa value chain in South-West Nigeria.*
Materials and methods: Quantitative data were collected from 100 cocoa farming families through the use of questionnaires which were subjected to statistical analysis using the SPSS software programme.
Result: The result showed that the majority of the participants (59%) were between the ages 35 and40 years. The data revealed that 13% of the farmers had no formal education. Ninety-five percent (95%) of farmers dry cocoa beans on concrete floors through sun drying. Over 70% of the respondents had never heard about mycotoxins. Educational level, length of fermentation and drying of cocoa had a significant influence on mycotoxin contamination.
Conclusion: Mycotoxin awareness was particularly low among farmers with low education. Sensitization is recommended to raise farmers' awareness about mycotoxin contamination of cocoa and incorporating mycotoxin knowledge as food safety training.
Keywords*: Cocoa, mycotoxin awareness, food safety, sensitization*

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I. Introduction

Mycotoxins are toxic secondary metabolites produced by aerobic, mycelia, microscopic fungi, especially from the genera *Aspergillus Fusarium*, and *Penicillium* [1] which may cause adverse health effects (e.g., hepatotoxicity, nephrotoxicity, neurotoxicity, and immunotoxicity) in humans and animals [1]. Toxic effects in plants related to mycotoxins and mechanisms governing endophytic plant colonization and disease have also been described [2]. Among multiple mycotoxin congeners characterized, aflatoxins (AFs), citrinin (CIT), patulin (PAT), penicillic acid (PA), tenuazonic acid (TEA), ochratoxin A (OTA), cytochalasins, deoxynivalenol (DON), fumonisins (FBs), fusarin C (FC), fusaric acid (FA), and zearalenone (ZEA) are considered the most common fungal contaminants in plant tissue [2]. For humans, the majority of mycotoxicoses result from eating contaminated foods, and the symptoms depend on the type of mycotoxin, the amount and duration of the exposure, and certain inherent factors related to the patient such as age, sex, health, and dietary status. Traditionally, toxigenic fungi contaminating agricultural grains have been conventionally divided into two groups: those that invade seed crops have been described as "field" fungi (e.g., *Cladosporium*, *Fusarium*, *Alternaria* spp.), which reputedly gain access to seeds during plant development, and "storage" fungi, (e.g., *Aspergillus*; *Penicillium* spp.), which proliferate during storage [3]. Under appropriate conditions (e.g., available genes in a strain, nature of the crop, moisture, and temperature), harvest and postharvest fungi colonization and mycotoxin production are feasible; this is particularly crucial for beverages made from tropical products such as different varieties of tea, coffee, cocoa, and fruits [4].Mycotoxin accumulation in tropical crops may be relevant as these commodities are generally grown under relatively warm temperatures and high-humid conditions [4] Even though chemical (including bio detoxification) biological and physical (e.g., roasting, and

shelling) detoxification or toxin reduction operations are possible, toxins can still reach the final consumer as they are relatively resistant to harsh processing conditions and are seldom spread homogenously across products [4]. Most tactics aimed at mycotoxin prevention are essentially disease management practices whose goal is to reduce infection of the plants or grain by toxigenic fungi[5].

Cocoa is the leading non-oil foreign exchange earner in Nigeria, however, growth in the sector has been slow since the abolition of the Nigerian Cocoa Board in 1986 [9]. The dominance of smallholders in the cocoa production sector and the lack of farm labour due to an increased rate of urbanization held back production. Nigeria has the potential to produce over 300,000 tons of cocoa beans per year, but production only amounted to 145,000 tons in 1999[10]. Despite the decline in the sector's contribution, cocoa still stands tall for its significance in foreign exchange earnings coming second after petroleum. Cocoa is an important generator of income for most rural farmers in Nigeria especially in the South West and serves as a backbone for their livelihood. Therefore the aim of the research was to look into the level of awareness, management, and mitigation of health risk associated with the occurrence of mycotoxins along the cocoa value chain in Nigeria

Crop contamination by mycotoxins is a threat to the health and wellness of individual which can often lead to economic losses. The traditional division of farm work exists by sex and is subject to socioeconomic and agro-ecological variations [6]. Most of the government effort in reducing the dangers posed by foodborne pathogens has focused on the application of more effective food safety management systems, such as hazard analysis [7]. Most conservative described the incidence of illness related to aflatoxins at 1%, in low and middle-income countries, which translate to 2 billion USD in health expenditures[8].

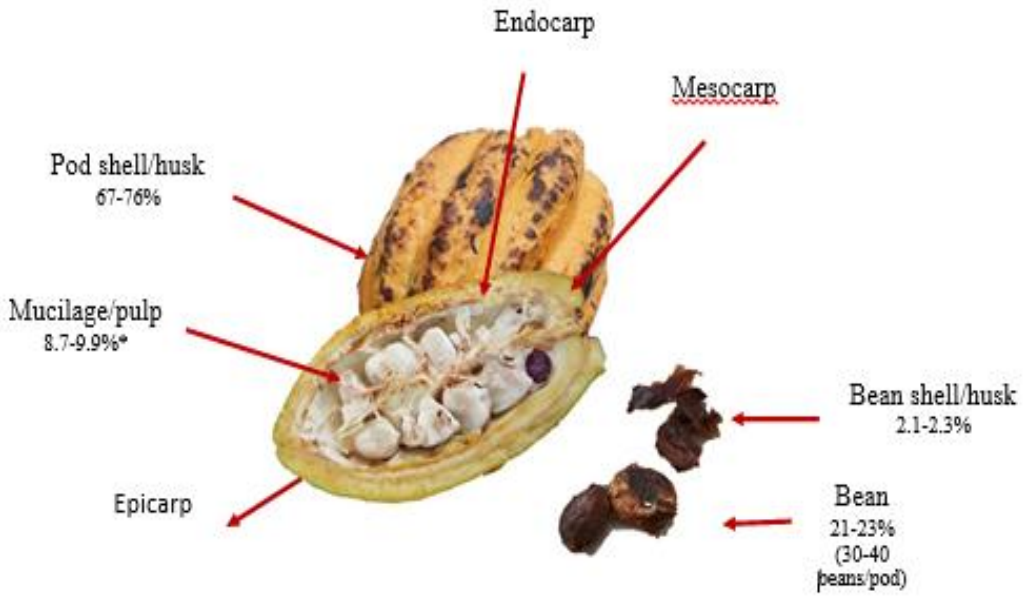

Fig. 1: The Cocoa Fruit Structures and Waste (Source:[13]

II. Materials And Methods

Study Area

The study location for the research is Ondo State which is one of the highest cocoa producing state in Nigeria.

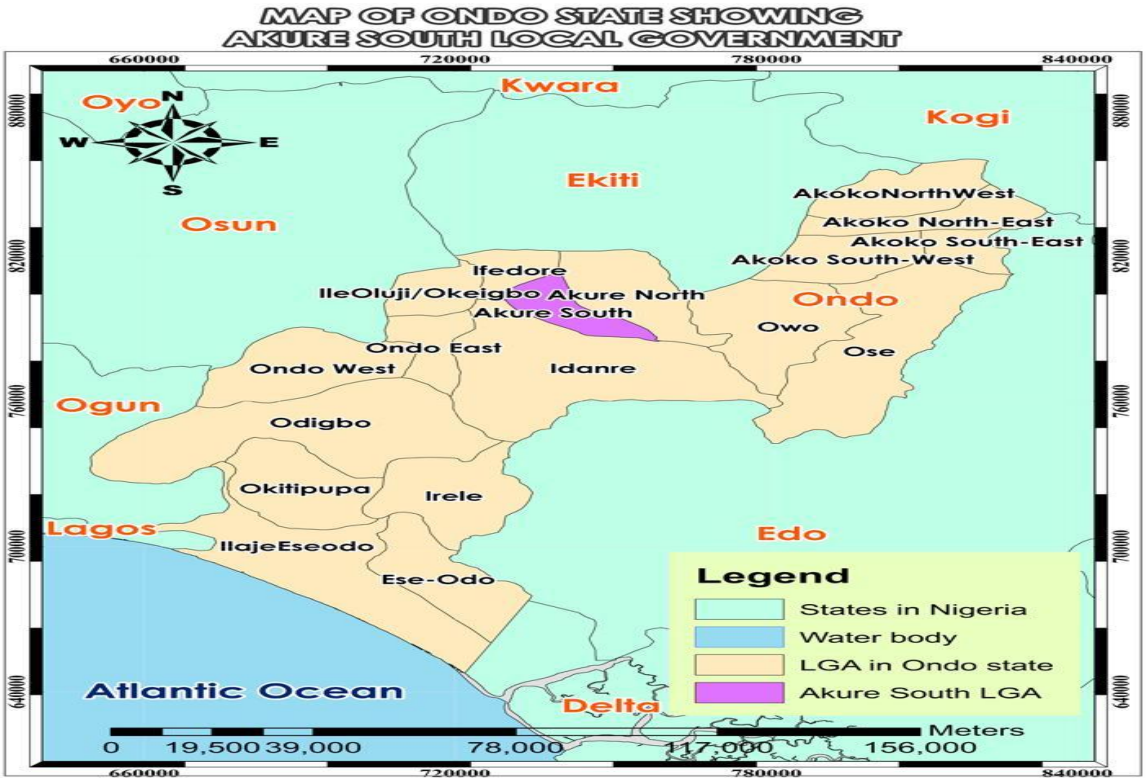

Fig.2: Map of Ondo State showing the Local Governments

Research Design

A self-administered semi-structured interviewer questionnaire was used to collect data from the study location. Study variables include socio-demographic characteristics, knowledge, and perception about mycotoxin and attitudes towards mitigation measures to control mycotoxins in cocoa was used to collect data. Participants who could not read the questionnaire were guided by the researcher. Responses from the cocoa farmers were used as the primary data for the study which employed the cross-sectional design with a quantitative method of data collection to assess management and mitigation of health risk associated with the occurrence of mycotoxins along the cocoa value chain in Ondo State.

Target Population and Sample Size

The sample size for this cross-sectional study includes 100 respondents across all cocoa value chain in Ondo State.

Data Management

The data collected from the field survey was entered, processed and analyzed using the SPSS (version 23) software programme. Consistency of data entered was ensured through the double entry and looking for outlier values. Frequency tables were generated. Scores were computed for knowledge, attitude, and practices by aggregating together all relevant questions; and scoring correct answers. The P values were considered significant at $P<0.05$.

The data was further generated into frequency tables which aided in the analysis. The study employed both descriptive and inferential statistical tools in the
software (SPSS). The descriptive tool categorized the farmer's knowledge of mycotoxins.
Different questions were asked in the questioner which were, age, sex, information about the level of education, involvement in cocoa planting, harvesting, processing, packaging and storing, length of fermentation, method of drying, level of awareness about mycotoxin contamination in cocoa and prevention.

III. Results

The socio-demographic characteristics of the population were presented in Table 1 and Fig 3. Statistically, 59% of respondents' age fell within age 35-45 while 25% of respondents were within the age bracket of45-55 years and 16 % were the least age group of respondents (18-25 years). The frequencies of the

sex of the respondents show that the highest percentage of the respondents were female (54%) over the male (46%). Therefore, this finding shows that females are dominant in the production of cocoa

Table 1: Frequency Distribution of Age of the Respondents

Age group (years)	Frequency (N)	Percentage (%)
18-25	16	16
35-45	59	59
45-55	25	25
Total	100	100

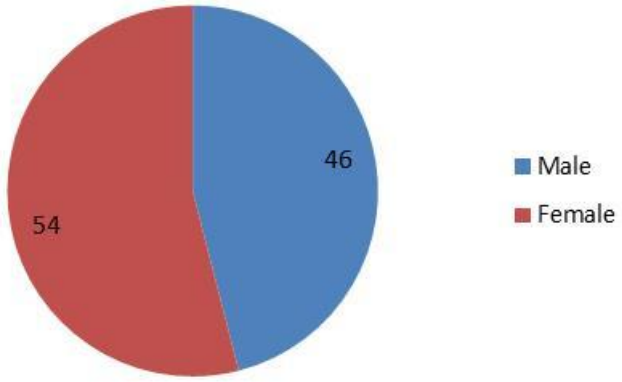

Fig 3: Frequency Distribution of Sex of the Respondents

Level of Education of Respondents

Figure 4 shows the level of education attained by the respondent. It was observed that 13% of the respondent had no formal education, while 7, 41, 32 and 7% of the respondents had primary, secondary, tertiary and post graduate education respectively.

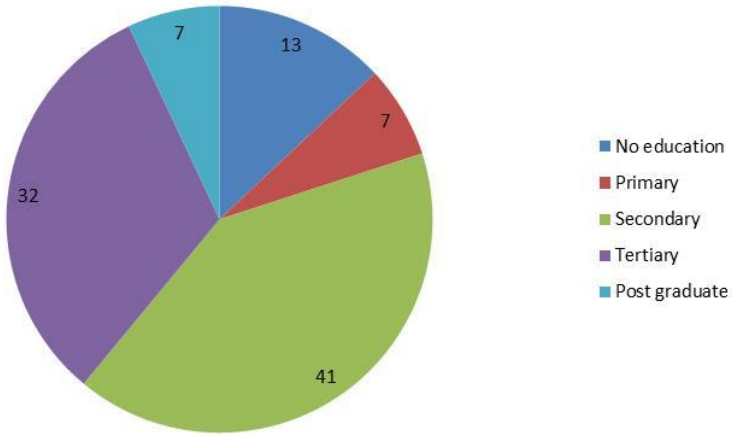

Fig 4: Level of Education of Respondents

Methods of Harvesting of Cocoa pods

The methods used by respondent for harvesting of Cocoapods shows that majority of the respondent uses anchor in harvesting their Cocoa (44%), 31% of the respondents harvest cocoa by plucking,24% use go-to-hell, while only 1% uses Cutlass for harvesting as shown in Fig 5. Anchor, is dominantly used by farmer in harvesting their Cocoa because of its benefit. For instance, it covers a long distance with its long stick and it is easy to use.

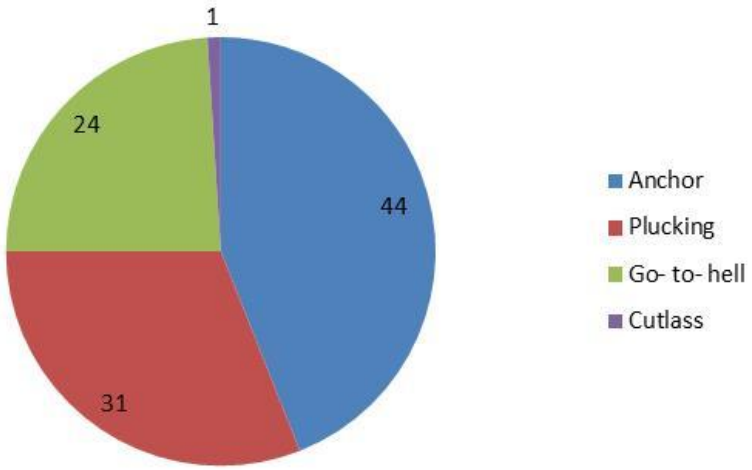

Fig 5: Methods of harvesting of Cocoa pods

Methods of Fermentation of Cocoa pods

Information provided by the respondents on the method used during fermentation of cocoa podsis as shown in Table 2. It was observed that 62% of respondents use jute sack bags in fermenting their Cocoa, 27% ferment cocoa on the floor and 11% use toppling methods for fermentation.

Table 2: Method used in fermentation of Cocoa

Method of fermentation	Frequency	Percentage(%)
Sack bag	62	62
Toppling cover	11	11
Floor	27	27
Total	100	100

Duration of Fermentation of Cocoa pods

Figure 6shows the duration used by respondents in fermentation of cocoa pods. It was observed that 60% of the respondents ferment cocoa pods for 7-9 days, 29% of the respondents ferment cocoa podsfor 4-6 days and 11% of the respondents ferment cocoa podsfor 1-3days .

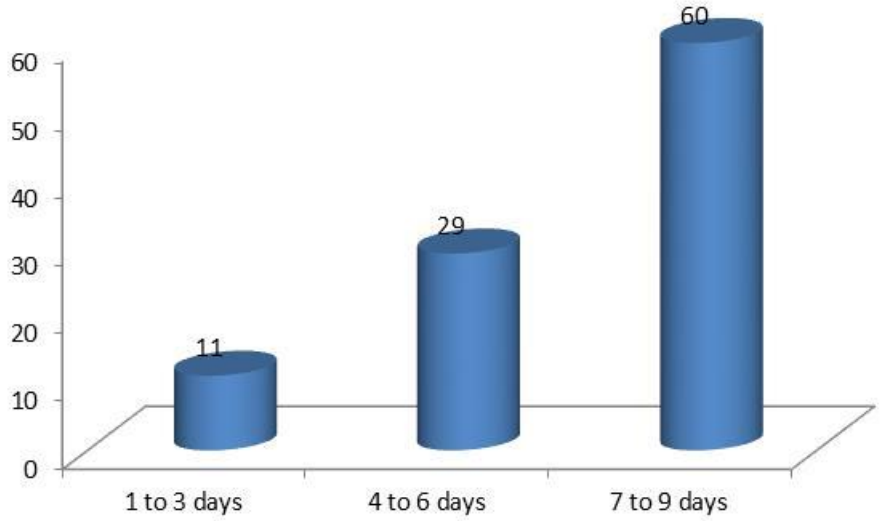

Fig. 6: Duration of Fermentation of Cocoa pods

Methods of Drying Cocoa beans

It was observed that 95% of the respondents dry their cocoa beans by sun drying on the ground while 5% of the respondents use oven to dry the cocoa beans as shown in figure 7.

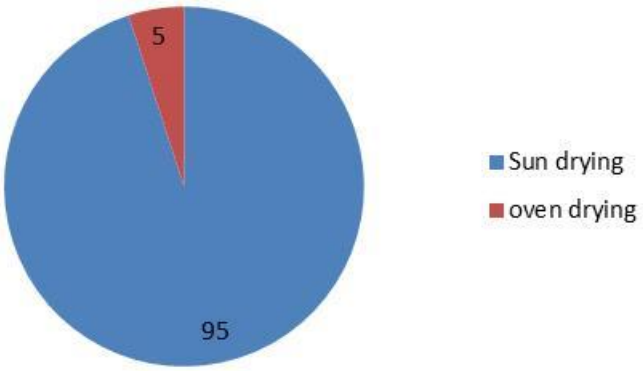

Fig. 7: Methods of Drying Cocoa beans

Methods of storing of Cocoa beans

The percentage of respondents that stores dried cocoa beansinside sack bag was 64% while 35% who can afford to build a hall store dried cocoa beans inside the store halls and only 1% store their cocoa on the floor of their passage in residential homes.

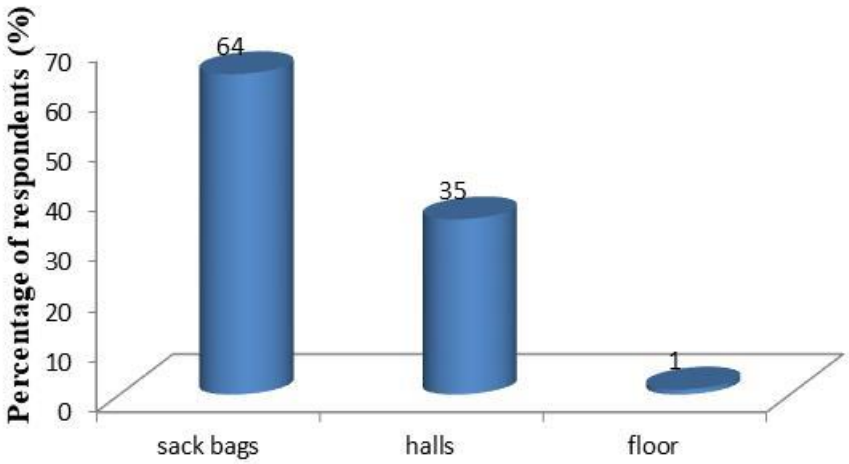

Fig. 8: Method of storing dried cocoa beans

Knowledge of mycotoxin contamination of cocoa

The awareness level and knowledge of mycotoxin contamination of cocoa by the farmers were as shown in table 3. It was observed that 63% of the respondents were not previously aware of mycotoxin contamination of cocoa while 37% had previous knowledge about mycotoxin contamination of cocoa. About 70% of the respondents had no knowledge about the health implications of consuming mycotoxin infected crops while 30% had previous knowledge of the health implications. About 90% of the respondents admitted that they have been visited by the Agricultural extension workers while 10% of them have not been visited. The categories of those that have attended training or seminars related to harvesting, handling, drying and storing methods of cocoa were 57% while 43%of the respondent did not attend any form of training.

Table 3: Knowledge of mycotoxin contamination of cocoa

Knowledge/ level of awareness	Percentage of respondents	
	Yes	No
Mycotoxin contamination in cocoa	37	63
Health implications from mycotoxin contamination	30	70
Visited by Agric extension workers	90	10
Participation in training related to handling and storage of Crops like cocoa	57	43

IV. Discussion

The socioeconomic characteristics data generated in this study indicated that cocoa farming is an economic activity by different categories of gender groups. More female participated in the interview, a phenomenon related to the tendency that majority of the household heads are men which is in contrary to the findings of Osarenren et al., [14] who observed that the gender distribution in his report indicated that the majority of the respondents where predominantly males accounting to 88.9% of the respondents while the females only accounted for 11.1% in farming actives. The findings in this study portray the role of women in farm management, decision making, as they often play a minimal part in making economic decisions which affect them directing or indirectly but they are involved in major farming roles [15]. The data generated in this report had more farmers with high education than those of low education, probably due to the socioeconomic set-up in the area, such as resource scarcity, mainly land, that forces the majority to attain higher education as a coping strategy and farming activities as a replacement for employment.

The report on the level of awareness of mycotoxin contaminations of cocoa which shows that only very few respondents have a pre-knowledge about mycotoxin. This level of awareness is very low as compared to the level of awareness by Kamala et al[16]

Cocoa is a crop that needs to be fermented[3] and dried before export. The processing of cocoa beans consists of two major steps namely fermentation and drying [11]. Fermentation and drying are both essential steps for the quality of final product it was discovered that 60% of the farmers ferment their cocoa for the duration of 7 to 9 days Fresh cocoa beans are fermented for 5–7 days and dried immediately after fermentation to a safe moisture level of 7.5%, while 62% ferment cocoa inside a sack bag. The importance of bean fermentation in contributing to chocolate quality has been recognized for over 100 years, and numerous studies have been conducted in different countries to determine the microbial species associated with this process. These fermentations are generally conducted as traditional, indigenous processes, as reviewed [17,18]

Drying is usually carried out using natural sun and artificial hot air techniques[18]. Ninety-five 95% of the respondents administered the use of sun-drying while 5% of them prefer the oven for drying of cocoa, this is because most of the respondents were cocoa smallholders' producers. Cocoa smallholders produce in small quantity would prefer sun drying, while for the bigger plantation they use an oven (artificial) method. Natural or artificial drying methods may be chosen, depending on characteristics of each species, the amount of harvested seeds, and on weather conditions prevailing after seeds were harvested. Natural cocoa bean drying is directly dependent on weather conditions. Sun-dried beans and beans air blown for 7 days and subsequently dried in an oven at 60˚C were of better quality than beans oven-dried at 60˚C. So the sun drying method of cocoa beans is best for optimal quality. Majority of respondents in the study location clustered around the lower and middle wealth class with low or no income with the age ranging from 35-40years of age with (59%) which make most of them to go for the use of a very cheap tool, anchor (44%) and sack as the only means of harvesting and storing (64%) which finally showed that some of the producers lack training or are not well oriented on mycotoxins in cocoa which lead to some of them not knowing that food poisoning is a serious issue.

V. Conclusion and Recommendation

Based on the findings of this study, it can be concluded that cocoa females farmers are dominant in the production of cocoa within the study area with low educational level and considering the level of awareness about mycotoxin contamination of cocoa bean indicated that 63% of the respondents were not previously aware of mycotoxin contamination of cocoa. Therefore, the following recommendation will be useful to policy makers in improving production of cocoa in Ondo State. Cocoa farmers should be enlightened on the health risk associated with mycotoxin contamination of cocoa

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