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The Role of Socio-Economic Factors and Indigenous Knowledge Practices on the Mycotoxigenic Fungi Contamination of Food

Esiegbuya Daniel Ofeoritse and Ojieabu Amarachi

Abstract

Indigenous methods of food processing in Nigeria are influenced by a wide range of socioeconomic factors and indigenous knowledge practices which support mycotoxigenic fungal contamination of processed food. Some of the socioeconomic factors include level of education, methods of skill acquisition, methods of food vending in market places, methods of food handling and storage, hygienic practices and poor water supply. The uses of indigenous knowledge in food processing are important because its application serve as a source of livelihood improvements, sustainability of indigenous food and eradication of food shortage. The limitation of the application of indigenous knowledge in food processing encourages mycotoxins contamination of foods. This is as a result of the poor hygienic conditions of the processing utensils, processing environments and methods of packaging the processed food. Due to the absence of policies in monitoring the quality of indigenously processed foods in market places and the risk associated with indigenous methods of food processing, there is the need for government agencies to address these issues through policy assessment in the areas of operations, inspection and enforcement and training so as to effectively harness the benefits of indigenous knowledge in food processing for national development.

Keywords: socio-economic, indigenous knowledge, policies, interventions, mycotoxigenic fungi

1. Introduction

Fungi are ubiquitous in nature and produce a wide range of toxins on food substances. The toxins produced by fungi have been documented to be harmful to both man and animals [1, 2]. The pre and postharvest conditions reported to enhance mycotoxins production on food by fungi according to Atanda et al. [1] include climatic conditions, nutrient availability for the fungi, soil types and conditions, time of harvesting, pest infestation, drying condition and duration, storage factors, sanitation, traditional processing methods, substrate types and lack of awareness by a majorly farmers, food handlers and processors.

Exposure to mycotoxins may cause diseases such as primary hepatocellular carcinoma, anemia, immunodeficiency, liver cirrhosis, infertility, stunting and being underweight and nephropathy [2]. The adverse effect of cases of individuals with symptoms similar to these diseases is not well documented especially in developing countries when compared to the incidence and prevalence of mycotoxins in staple foods such as maize, groundnut, rice, peanut etc. In the work of Darwish et al. [2], the author's highlighted the distribution of mycotoxins across different staple foods, feeds and drinks in Africa and the amount and type of mycotoxin present in them. Accordingly, to the authors the percentage distribution of the different types of mycotoxins are aflatoxin 43.75%, ochratoxins 12.5%, fumiginosin 21.87%, zearalenone 9.375%, deoxynivalenol 6.25% and beauvericin 12.5%.

However, there are scarcely documented medical reports linking mycotoxins contamination of food to the cases mentioned above in patients when compared to other causes of diseases. This is due to the following reasons;

1. Lack of adequate facilities and fund for mycotoxins research in teaching hospitals
2. Low technical know-how of laboratory technicians and doctors
3. Inability of patient to pay the require charges.

Atanda et al. [1] also stated that policy enforcement agencies such as the National Agency for Food and Drug Administration and Control (NAFDAC) and the Standards Organization of Nigeria (SON) which are supposed to help detect mycotoxins in foods do not allow staff of the agency to do research. This has further limit staff of these agencies from building capacity in mycotoxins research.

According to Atanda et al. [1] the major factors hindering the documentation of mycotoxin related human health cases in Nigeria, is the legislation on Medical Ethics which prohibits medical practitioners from disclosing the cases of patient. Atanda et al. [1] made several references to outbreaks recorded in literatures to include

1. The death of some children who consumed mouldy Kulikuli (Groundnut cake) in Ibadan was suspected to be due to the presence of aflatoxin in the groundnut.
2. Detection of aflatoxins in the urine of liver disease patients in Zaria, Kaduna State and also in the organs of children who died of kwashiorkor in Southern and Western Nigeria, respectively.
3. Detection of aflatoxins in human semen in Benin City.
4. Detection of aflatoxin M1 in breast milk blood of umbilical cord of babies in the country.

Uriah et al. [3] also reported on the occurrence of aflatoxin in the blood and semen of infertile men which was significantly higher in level when compared than that in fertile men.

Apart from the health challenges associated with mycotoxin contamination of food, it was also stated that Africa loses an estimated US\$670 million in rejected export trade annually due to contamination by aflatoxins [4].

2. The socio-economic and demographic impact on mycotoxin contamination of food

Socioeconomic factors such as level of education, methods of skill acquisition, methods of food display, methods of food handling and storage, vending sites, hygienic practices and poor water supply are reported to be responsible for food contamination. In relation to mycotoxins contamination of food, Kumar and Popat [5] and Mohd Redzwan et al. [6] noted that farmers generally lack knowledge on mycotoxins contamination of food and factors contributing to this include their level of education, farm size, participation in social and extension services, market orientation, economic motivation, level of innovation, ignorant of negative health effects of consuming mycotoxins contaminated food and overall perception. According to the authors, most farmers do not consider control of mycotoxins contamination of food important because the domestic markets do not make additional payment provide for uncontaminated products.

2.1 Level of education and awareness

Education is positively related to awareness, knowledge and perceived benefits [7]. Dosman et al. [8] stated that people with higher educational level are likely to be better informed about the risks of mycotoxins and chemically contaminated food. This might be attributed to their ability to read and understand basic communication skills [9]. Sabran et al [10] noted that individuals with high educational status had high level of knowledge on the occurrence of fungal infections in food when compared to those with low educational status. The authors indicated that education is an important mode to disperse information and knowledge to the public and also that low level of education is likely to promote lack of appreciation for food handling practices and this factors may presents potential risk to food safety.

2.2 Marital status

Studies have showed that marital status may contribute to the level of knowledge about mycotoxins contamination of food. This is because marriage enhances couples to exchange knowledge and this has also helped to enhance diet thus promoting good health and disease prevention [11].

2.3 Gender

Sabran et al [10] reported that women seem to have higher knowledge of aflatoxin contamination of food. This is because women have sound knowledge and practice in regard to food safety than men and also have the strongest reaction to assessing food safety risk [12].

2.4 Methods of food handling and display

In developing countries, food handling and vending sites are a major challenge encouraging fungi contamination of food. Food vendors and buyers serve and select their choice of food products with bare hands which could promote contamination of food especially if the hands are not properly washed and dried. These practices are commonly noticed among fruit sellers were a particular fruit is handled severally before being purchased and eaten by the buyers. Vending sites are also characterized by flies and waste dump which served as sources of cross-contamination [13].

3. Indigenous methods of food processing and preservation on mycotoxins contamination of food

Indigenous knowledge refers to what indigenous people know and do, and have become good at it through series of trial and error processes [14]. According to Sundamari and Ranganathan [15], African indigenous knowledge is an unwritten body of knowledge held in different brains, languages across diverse cultures. Its application cuts across different areas such as traditional medicine, land use and management, family healthcare, breeding of food crop species, preservation of seeds and the domestication and use of wild edible plants. One major aspect that affects mycotoxins contamination of food the respects to indigenous knowledge is some of the methods of food processing and preservation.

Indigenous foods can be regarded as those foods that are obtained from the immediate environment and are made edible or processed through the application of indigenous methods of food processing. Indigenous knowledge on methods of food processing is important because its application

1. can enhance the flavor of the food.
2. removal of toxic substances, for example the conversion of cassava (*Manihot esculenta*, Crantz syn. *Manihot utilissima* Pohl) to garri significantly reduces the cyanide content to a safe level by WHO standards [16].
3. enhance preservation and digestibility of food.
4. helps to reduce anti-nutritional components.

3.1 Sun drying and smoke drying

Indigenous method of sun drying involves spreading the food material on bare grounds, road sides or on roof tops. According to Asogwa *et al.* [17] sun drying is a key traditional and inexpensive method for removing substantial amount of moisture from food, and some of the food items that can be sun dried include tubers, cereals, vegetables, fruits, fish, meat etc. The smoking of meat and fish during drying adds flavor and increases its shelf life [18]. These indigenous practices also help in maintaining food accessibility at all times [19].

During indigenous method of food processing, food quality parameters are mainly assessed through physical inspection and tasting. This is due to the fact that the indigenous food processors lack the technology of monitoring quality and conditions affecting the level of mycotoxins in food. After processing, the food is sometimes exposed to conditions that enhance cross-contamination. This is because indigenous food processors lack the necessary awareness.

In the case of meat, after drying, the product is stored whole or sometimes cut into smaller bits and kept in wire gauze cage for storage or displayed in the market for sale. The essence of the wire gauze cage is also to expose dried meat to air to prevent further moisture buildup. According to meat processors, the meat can be preserved for more than six months as long as it is exposed dry smoking at intervals. This method is not ideally relevant in contemporary situations today because the wire gauze cage exposes to flies and airborne pathogens which might enhance mycotoxin buildup in the stored meat.

Also, in the processing of local delicacies such as 'amala' or 'elubo' from plantain or yam undergo a series of process which begins with the peeling of the skin of

plantain or yam and then slicing it into smaller thin bits before grinding it to form the powder called 'amala' or 'elubo'. Rural food processors developed the local initiative of drying the sliced thin bits of the plantain or yam under the sun for several days will reduce the moisture content and also the mixing of the powdered plantain or yam will results to a local delicacy called 'amala' or 'elubo' which becomes gary white in colour. Scientifically, the drying process under the sun can serve the purpose. But the indigenous imitative of drying on any available floor or slab exposes the raw materials to atmospheric dust, sand and airborne pathogens in which aflatoxigenic fungi are mainly associated [20]. Fungi can thrive within the substrate releasing many toxins into the food substance. Consumers feel that the preparation of the plantain powder into 'amala' which involves mixing with hot water under heat condition will destroy the accumulated toxins. Scientifically, aflatoxins are known to be heat stable and scientific methods have developed techniques for its monitoring its contents along food processing chain. The processing of pistachio nuts, heating at a temperature of 90–150 °C for 30–120 min was found to reduce its aflatoxin content by about 17–63%. While in other food products such as bread and biscuits, temperature did not have any significant effect on the ochratoxin content but significantly reduce its content in biscuits [21, 22]. Some factors affecting the level of mycotoxin content in food includes variety of the food, moisture content, temperature and time of heating [23, 24].

Indigenous food processors also lack the technology of knowing the type of mycotoxins that will be destroyed or not destroyed.

3.2 Leaves wrapping and packaging

Packaging equally refers to the process of design, evaluation and production of packages [25]. Packaging can also be described as a coordinated system of preparing goods for transport, warehousing, logistics and sales [26]. It is important because it serves as a physical protection for the food during transportation, distribution, handling, sales, opening, use and re-use [25]. The type of material used for packaging also serves as a source of attraction to consumers and also helps in defining the quality of the product [27].

In Nigeria and other parts of Africa, the indigenous use of plant leaves for food packaging is important because it is believed that such leaves posses natural pesticides which serves as pest control while others believe that it adds natural aroma and flavor to the packaged food. Examples of some plant leaves for food preservation include *Dorax* sp., *Alchornea laxiflora* (Esin), *Costus lucanusianus* and *Spondia Mombin* (Iyeye) used in the preservation of kolanuts.

The challenges with food packaging in developing countries are that different materials such as leaves, cellophane, paper, used and discarded bottles are used for food packaging without the food handler considering the hygienic status of the packaging material, and as such, this may serve as a possible source of microbial contamination of food [28]. Hicks [29] also highlighted the benefits of food manufacturer and handlers keeping food safe from pathogenic microorganisms [29].

In the use of broad leaves for food packaging, as the leaves deteriorate, it also serves as a source of contamination to the food. Ihejirika et al. [30] stated that pathogen invades *Garcinia kola* seeds especially if the processing methods and packaging materials used have are contaminated with microbes. According to the authors, the mycotoxigenic fungi associated with *G. kola* package with leaves include *Penicillium* spp., *Aspergillus* spp. and *Diplodia* spp. Atanda et al. [31] also detected *A. flavus* and *Rhizopus arrhizus* in kola nuts together with aflatoxin level of 2 µg/kg.

Adejumo and Ola [32] stated that the disadvantages of using local methods to preserve food include

1. Most of the packaging materials used originally held other manufactured products such as beer, soft drinks container that have been discarded and in most cases they are not properly washed etc.
2. Some of the packaging materials used are mainly collected from refuse dump without considering even if they have minor defect such as absent of cover or heavily dirty
3. Attitude of reusing the packaging materials as long as they remain undamaged
4. Food package/displayed in glass slides are handled many times by different customers for inspection before purchase, such practice provide avenues for contamination
5. Leaves used for food packaging are often dirty and are kept in the open with little or no provision for washing before use
6. Paper such as newspapers and magazine used for food packaging is not properly stored and cannot be clean even when dirty
7. Cellophane use for food packaging sometimes contain moisture condensation which enhances mould growth on the food

These disadvantages served as possible sources of mycotoxingenic contamination of the packaged food as against the reversal in scientific approach where these methods are not employed and even if the methods are to be used, the materials used be free from microbes and sources of cross-contamination [13].

3.3 Fermentation

Indigenous methods of food fermentation began more than 7000 years ago [33]. According to the authors fermented foods are important in that they enhances digestion, flavour, aroma, preservation, shelf-life and detoxification of anti-nutrient presents in food. Food fermentation involves mainly the activities of microbes that contribute towards enhancing the quality of the food.

In indigenous food fermentation, local food processor have learnt from experience and continuous practices the number of days to ferment a food and also access the quality of the fermented food formed without applying science. Esiegbuya [34] noted that indigenous method of food processing is not completely irrelevant in modern methods of food processing however it has some disadvantages such as

1. The unhygienic condition of the processing environment, utensils and food processors which can contaminate the fermented food.
2. Use of any available materials for processing and food packaging.
3. Lack of knowledge on the activities and role of the fermenting organisms
4. Inconsistency of the use of processing materials

5. Unhygienic condition of keeping used and unused processing materials
6. Poor method of waste disposal
7. The processed food only satisfies a small segment of the society

The overall effects of some of the poor processing practices by indigenous food processors is the continuous contamination of the processing equipments/utensils, raw materials and finished products by vectors such as insects, rodents and domestic animals. These vectors are known carriers of diseases and other contaminants (urea) from animal droppings. The overall effect of these is possibly mycotoxins contamination of the processed products [34].

In the fermentation of sorghum beer (*bil bil*) from sorghum, Darman [35] highlighted seven points of possible mycotoxin contamination along the processing chain. According to the authors, these points include the stage of soaking, germination, drying, decoction, cooking, mixing of clarified wort and starter culture and fermentation. The reason stated by the author was that some of these stages such as soaking of the sorghum at high temperature reduces the growth of yeast and thus increase the risk of mould growth which can enhance mycotoxins contamination of the fermented product. With the application of modern approach, this process can be monitored when compared in the natural fermentation of maize dough for *doklu* production, it was found that fermentation significantly reduce the amount of aflatoxins. According to Lillehoj et al. [36], aflatoxin was not detected in distilled alcohol but accumulated mainly in spent grains. Toxins such as fumonisins B1 and B2 and ochratoxin A were also found to be stable during beer fermentation [37]. Zearalenone was also found to be stable during the fermentation of corn by *S. uvarum* [38].

Scientific approach also shown that the activities of some microbial enzymes during fermentation process according to Wolf-Hall and Schwarz [39] may transform mycotoxins into non-toxic products but no microbial strain has been recommended so far as a processing aid targeting mycotoxins [40].

4. The policies and actions that enhance the use of indigenous knowledge in food industry

Currently in Nigeria and in some other African countries, there are no known policies or actions for the production of indigenous food and as such the market is free for all without any regulation.

Some of the factors enhancing the application of indigenous knowledge in the food industry include

1. Poor implementation of government policies towards food security
2. Mycotoxins mitigating measures are routinely not applied in Nigeria.
3. Lack of adequate storage system for locally produced food
4. Poor storage facilities as a result of poor power supply have further enhanced the application of indigenous knowledge to preserve food
5. High patronage of products due to availability and low cost
6. Its simplicity

7. Serves as a survival strategy for income generation
8. Lack of awareness on the side of the producers and buyers
9. Lack of set out agenda on the impact of poor food processing practices on food quality

5. Tackling mycotoxins contamination of indigenous food through government policies

In Nigeria, more than 50% of the foods displayed in market places are locally produced using indigenous knowledge and as such are possibly expose to contamination by microorganisms. Udomkun et al. [41] stated that the problem of food insecurity occurs mainly in developing countries and the major factors leading to food insecurity are the methods of food production and postharvest losses.

Presently, emphasis on assessment of imported and exported foods has increased considerably. But not much emphasis has been on the risk assessment of indigenously processed foods which are not exported but consumed locally. This is important because the wellbeing of any population is important for national development. According to a report by Abt associates [42], in collaboration with the Mycotoxicology Society of Nigeria (MYCOTOXSON) and Nigeria's National Agency for Food and Drug Administration and Control (NAFDAC) on the risk assessment of aflatoxin on human health, they found out that despite the rise in the awareness of aflatoxin contamination of foods, unpackaged foods and foods destined for domestic consumption are not regulated. This is so with indigenously processed food consumed locally. The lack of regulation for foods destined for domestic consumption can enhance mycotoxins contamination of indigenously processed food. To address this challenge, there is the need proper regulations which will involved risk analyses (risk assessment, risk management and risk communication) of indigenously processed food.

Food and Agricultural Organization (FAO) stated that up to 25% of the world's food crops are estimated to be contaminated with mycotoxins (Eskola, [43]). The consumption of mycotoxins contaminated food leads to chronic mycotoxicoses and death [44]. Therefore as the global occurrence and importance of mycotoxins cannot be overemphasized, there is the need for improved risk management and communication strategies especially for indigenously processed food in developing countries. This is because there is no stand out policy regulating the activities of indigenous food processors thus any person to get involved in it either for household or commercial purpose.

Omojokun [45] stated that many health problems encountered today arose as a result of consuming unsafe food and that health problems associated with unsafe food are not new as they date far back in history. Indigenous methods of food processing serve as one major source of unsafe food that not much attention has been given to its application. This is not to say that the use of indigenous knowledge of food production be neglected because it has a lot of socio-economic benefits towards national development which includes

1. Serving as a source of livelihood improvements for mostly rural women who are involved in it.
2. Enhancing the sustainability of indigenous food, and
3. Eradication of food waste.

In order to effectively harness these benefits and conserve the use of knowledge indigenous for future generations, there is the need for proper policy assessment to include the following.

1. Government at the federal level should set up a body or assign to any of its agencies to carry out a proper risk assessment and implement management strategies for all food produced indigenously using local knowledge within her country and also profer solutions on how the risk associated with the documented food can be tackled through food safety policies such as establishment of locally acceptable guidelines for mycotoxins control of indigenously processed food.
2. Staff of agencies assigned to monitor the activities of food processors using indigenous knowledge should be those with academic qualifications in such areas and also should be empowered to undergo constant training so as to enhance their capacity on how to coordinate, monitor and audit the activities of food processors. Agencies should be empowered through the provision of laboratory support to vet the quality of products
3. Issuance of license of operation to anyone involved or interested in food processing using indigenous methods especially at commercial level after such individuals must have been made to undergo basic training on area of interest.
4. Routine inspection and enforcement such as routine market surveillance, investigative inspection and compliance investigation and defaulters should be sanctioned with measures such as holding of products, rejecting of products, recalling of products, seal up and prosecution
5. Government agencies should network with academic societies such as the Mycotoxicological Society of Nigeria, Mycological society of Nigeria, Botanical society of Nigeria, Universities and Research institutions who are knowledgeable in the areas of mycotoxins research to help in the training of staff of the monitoring agencies and indigenous food processors on basic Sanitary and Phytosanitary Standards (SPS), Hazard Analysis and Critical Control Points (HACCP) and Good Processing Practices (GPP), risk assessment and management and food packaging techniques and also develop effective risk communication strategy

6. Conclusion

The application of indigenous knowledge for food processing is important for socioeconomic development and empowerment however, methods of application enhance mycotoxigenic fungi contamination of the processed food. In order for **its** benefits to be adequately harnessed for national development, there is the need for government of developing countries to develop a legal framework for monitoring and managing the activities of indigenous food processors so as to enhance food safety.

Conflict of interests

There are no conflicts of interest.

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