Acta Scientific Biotechnology

Volume 1 Issue 2 February 2020

Mini Review

Food Safety Concerns Due to Presence of Aflatoxins of Common Maize Based Food Consumed in Ghana and the Need to Implement Hazard Analysis and Critical Control Point (HACCP) Systems

Dery Bede[1,2]*, Lou Zaixiang[1,2] and Guo Yahui[1,3]

[1]*State Key Laboratory of Food Science and Technology, School of Food Science and Technology, Jiangnan University, China*

[2]*National Engineering Research Center for Functional Food, Jiangnan University, China*

[3]*Synergetic Innovation Center for Food Safety and Nutrition, Jiangnan University, China*

***Corresponding Author:** Dery Bede, State Key Laboratory of Food Science and Technology, School of Food Science and Technology, Jiangnan University, China.

Received: January 17, 2020

Published: January 28, 2020

© All rights are reserved by **Dery Bede., *et al.***

Abstract

An effective pregnancy journey requires an adequate energy deposit for both maternal and fetal tissue for success. In this regard, most women both in the pregnancy or lactating state in Ghana depend heavily on maize products for energy. Unfortunately, most of these maize meal preparations methods end up with aflatoxins accretion which has been detected in maternal blood and breast milk in current research in Ghana. In this regard, there is a dependence on maize foods such as Banku, Fante and Ga Kenkey, Corn porridge, and Tuo Zaafi. All these foods begin with soaking a maize kernel in water for about 3 to 5 days, milling, doughing and allowing for fermentation at normal room temperature. Unfortunately, HACCP principle is usually ignored due to ignorance on the part of the large population in Ghana thereby some process of the meal preparation leading to accretion of aflatoxins accretion and other enterotoxins from the water used from rivers and streams which has the faecal remains of livestock which also drink from these water bodies.

Keywords: Pregnancy; Livestock; HACCP

Introduction

Any substance that can be eating either raw or cooked to provide nourishment to the body or for pleasure is termed as food. It can be of plant or animal origin which has in its abundance of carbohydrates, protein, lipids, vitamins and minerals [1]. Since we need these nutrients to stimulate growth, it is therefore imperative that we pay much attention to the safety of the food.

Due to heavy migration these days, food ingredients and processed foods cross borders from farms, companies to reach the retail market and finally to consumers and therefore food safety risks at every step of the food supply chain can affect people at the other end of the globe [2].

Processing foods with food safety consciousness at home or at the industrial level ensure copious and safe food which is accessible to the world but food safety assurance in today's global village present hash task and burden for governments, companies, manufacturers and the consumers [3].

During pregnancy and lactation, the energy requirement of women increases and hence the need to increase the frequency of feeding and focus on high energy-dense foods. According to World Health Organization and Food and Agricultural Organization, they define the energy requirement of pregnant and lactating women as the level of energy intake from food that will balance their energy expenditure when the woman has a baby size, composition and level of physical activity consistent with good health that will allow for the maintenance of economically necessary and socially desirable physical activity [4]. For an effective pregnancy journey, the woman needs to have enough energy deposit both in the maternal and fetus tissues for success and must also have enough energy reserves to be able to feed the baby after birth [5].

On the other hand, researches have proven the increased energy needs of children as their age progresses due to a corresponding increase in their total energy expenditure which encompasses their basal metabolism, thermoregulation, increased physical activity as well as the synthetic cost of growth [5]. Ghana being a developing country, not all family are able to afford the purchasing of food formulae for their children once they wean them from bread milk on the sixth month and so to catch up with the extra energy demand of the child, mothers also feeding their children with the same staple that explained below.

In order to meet this energy requirement, there is a preference to eat foods that are high in energy for breakfast, lunch and dinner in order to meet their energy requirement for their personal health and that of their babies. In their quest to meet the energy requirement, the frequent staple they depend on are foods made of

maize. Unlike rice which is mostly consumed in China, maize in the most frequently consumed staple in Ghana and Africa at large [6]. Common foods made from the staple are Ga Kenkey, Fante Kenkey, Banku, Tuo Zaafi, and Hausa Koko all made from fermented corn dough [7].

Ga Kenkey, Fante Kenkey, and Banku are a kind of fermented maize dumplings usually produced as a ready to eat food in Greater Accra, Central Region, Ashanti Region and Bono Ahafo Region of Ghana respectively. Hausa Koko and Tuo Zaafi also originated from the Northern part of Ghana but the Hausa Koko is in a form of porridge whiles Tuo Zaafi is also in a form of dumplings made from milled corn but not fermented [8].

In the preparation of corn dough for Kenkey, koko, and banku, washed and clean whole maize grains are soaked in water for 2 to 3 days, milled and mixed with water into dough and left to undergo fermentation for 2 to 3 days but depending on the quantity of the dough, it could be left for a week or more until the dough is entirely utilized [9].

In Kenkey preparation, one portion of the fermented dough is boiled and mixed with the other portion of the uncooked dough. The mixture is molded into balls and wrapped in maize husk and then boiled for about 3 hours. Whereas Kenkey is prepared by mixing only fermented corn doughs. Banku is prepared by mixing fermented corn dough and fresh cassava dough and stir continuously on fire till it becomes very tick [10]. Even though Hausa koko is made of millet and other spices added to form porridge, most people including pregnant and lactating mothers produce their own home porridge from fermented corn.

Recently, there have been reports on the contamination of these foods which are mostly consumed by these women and their children. This is because the dough prepared are not stored properly in conditions that will reduce or inhibit the growth of these fungi. Fungi strive very well in ambient conditions such as high water activity and suitable temperature and good nutrition [11]. The dough is prepared by mixing milled corn with a large amount of water and then stored for some time but water activity significantly influences fungi growth with their corresponding mycotoxins production. Fungi require about 13% moisture and relative humidity of 65% to strive well and the dough itself provides these suitable conditions for the swift growth and multiplicity of these fungi [12]. Temperature is another factor that promotes fungi growth in the above-stated foods. A report shows that Aspergillus species strives very well at a temperature between 25^{0}C to 37^{0}C in the presence of moisture activity and luckily the temperature range is the annual ambient temperature of Ghana and also the dough when left to undergo fermentation is left in a room temperature and over a long time hence enhancing the growth of fungi [13].

A study was done in Sudan, Ghana, Kenya and Nigeria first confirmed the presence of aflatoxins in human breast milk which was suggested that aflatoxins could cross the human placenta and induce biological effects on the fetus [14].

In recent times, there have been reports on the detection of Aflatoxins in maternal blood serum which causes biochemical, immunological, and metabolic instability in the fetus which can possibly result in intrauterine growth retardation, low birth weight and neonatal jaundice [15]. A substance such as drugs, alcohol and infection are known to affect pregnancy but environmental toxins also play a role in the outcome of pregnancy. Such environmental toxins may find its way to affect the fetus through food and water and one of the most prevailing toxins in Ghana is Aflatoxins because of high dependence on maize products as well as other cereals during pregnancy and lactation [16].

A study was done in Ghana specifically Kumasi which is the capital of the Ashanti Region of Ghana. The study was to investigate the association between birth outcomes and Aflatoxin B_1 biomarker's blood levels in pregnant women. A total of 785 pregnant women visiting the antenatal clinic was used for the study where blood samples were taken after delivery and investigation for Aflatoxin B_1 lysine adduct level was done using High-Performance Liquid Chromatography and statistically adjusting to the socio-demographic information of the pregnant women, they found out that mothers with high levels of the Aflatoxin B_1 lysine, thus >11.34pg/mg were more likely to produce low birth weight babies [17]. Several studies have been done where they studied the influence of storage locations on levels of Aflatoxin contamination and distribution in maize in some parts of Ghana. In a particular study, they recorded aflatoxins levels of 153.20ppb, 120.50ppb, 134.17ppb, 10.50ppb and 9.50ppb in different cities of the country [15]. Fifteen maize samples from a different market in the Greater Accra Region of Ghana were also analyzed for fumonisins and all the samples were affected with the levels ranging from 70 to 4222ug/kg. One sample of visible mouldy kernels exhibited a whooping total fumonisins level of 52,670 ug/kg [18].

Aflatoxins are a type of fungi metabolites that are toxic in nature and are produced by the fungi Aspergillus flavus, Aspergillus parasiticus and Aspergillus nominus [17]. These fungi can grow on many commodities because they find them as a good substrate full of enzyme and their rate of growth escalates when there are a suitable temperature, moisture and atmospheric humidity [18]. The four major types of aflatoxins are B_1, B_2, G_1 and G_2. The hydroxylated metabolite of Aflatoxins B_1 and B_2 in animals produces Aflatoxins M_1 and M_2 [19].

The figure below illustrates the different chemical structure of Aflatoxins, thus, the four main toxin structures which are B_1, B_2, G_1, G_2 and the hydroxylated metabolite M_1 and M_2. (See figure 1).

Aflatoxins and recorded implication on pregnant women and children

Aflatoxins have been attributed to a strong cancer-causing, immunosuppressant, growth retardation effect on long-duration consumption of an aflatoxin-contaminated diet. Aflatoxins toxicity can be categorized as both acute and chronic. Acute aflatoxicosis is when the AFB1-epoxide binds with the various cellular macromol-

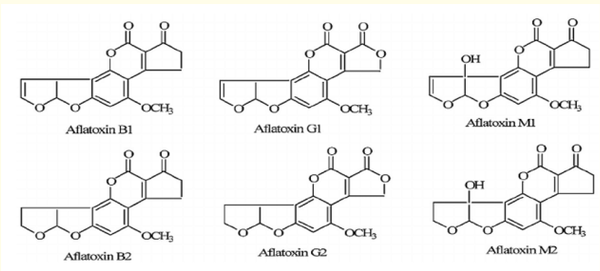

Figure 1: Chemical structure of Aflatoxins B_1, B_2, M_1, M_2, G_1 and G_2.

ecules leading to hepatocellular injury and death [19]. A patient infected with acute aflatoxicosis manifest symptoms such as acute liver damage, jaundice, high fever, lymphedema, severe and frequent abdominal pain [20]. A case-control study was conducted in Ghana to determine the association between aflatoxin contamination and liver disease. Their urine samples were collected for analysis of aflatoxins metabolite (AFM1) and a significantly high amount of AFM1 was detected with the mean value of 68.5±679.8pg/mg creatinine [19]. Another study was to also determine the association between birth outcomes and Aflatoxin B1 biomarker's blood levels in a pregnant woman in Ghana. The average AFB1 lysine adduct level in the maternal serum was 10.9 ± 19 pg/mg albumin but upon adjusting the socio-demographics to other potential confounding parameters, volunteers in the highest AFB1 lysine adduct level (>11.34pg/mg) were likely to have low birth weight babies compared to women who recorded low AFB1 lysine adduct levels in their blood serum [21]. Another research was also able to establish the association between anemia and AFB1 biomarkers in blood serum of pregnant women in Ghana [34]. Shockingly, another study conducted in Ghana also identity aflatoxins in 100% of blood samples taking from HIV infected pregnant women 96% of HIV uninfected pregnant women [22].

In children, depending on the aflatoxin level of exposure, it contributes to low birth weight, growth impairment, immunosuppression as well as mental retardation in children by inducing changes in insulin-like growth protein factor and inhibiting mineral bioavailability [23]. Lombard observed that infants who were affected by the toxin through maternal exposure had low height-for-age and low weight-for-age scores. It was disclosed in this study that infants and young children who had the toxin's exposure greater than the provisional maximum tolerable daily limit were noticeably shorter and lighter. It also causes various kinds of cancer and resultant deaths depending on the type, period and amount of exposure [24].

Hazard analysis and critical control point employed in cornmeal preparation

In order to ensure the consumption of healthy maize products in Ghana, the concept of HACCP has to be implemented to ensure the safety and prevention of diseases caused by aflatoxins. HACCP is a globally accepted protocol for the identification of hazards, critical control points (CCPs), and preventive measures for the enactment of monitoring systems. To prevent contamination of our products during processing or production, seven basic principles of HACCP was enacted and first published by Codec Alimentarius Commission in 1993 and also the National Advisory Committee on Microbiological Criteria of food [25].

Principle 1: Hazard analysis

The corn is subjected to critical analysis to determine all possible hazards such as physical hazard, chemical hazard and microbiological hazard, after which potential hazards are removed [26].

Principle 2: Critical control point

This is the point reached where control can be applied and a food safety hazard can be prevented or eradicated or reduced to the acceptable level. To facilitate the identification of a critical control point and determine corrective actions, Mortimore and Wallace developed the HACCP decision tree to serve as a guide to the producer. The first question directs the producers to whether there is the existence of any of the three kinds of hazards. If the answer is No, then it means there is no CCP and if the answer is yes, there is a CCP and then they move on to the next question which is seeking to find whether there can be a solution to the hazard identified. If there is a solution then the third question seeks to find out whether the solution is solely intended to eliminate or reduce the likely occurrence of the hazard to an acceptable level and if yes then it is also a critical control point [26].

Figure 2 below demonstrates how systematically we can implement the HACCP decision tree for the identification of Critical Control Point in any food setting (See figure 2).

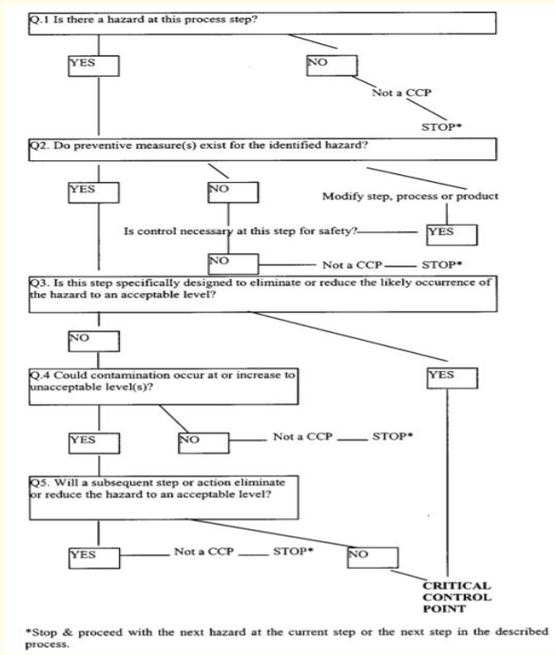

Figure 2: HACCP decision tree for the identification of Critical Control Point.

Principle 3: Critical limit establishment

Critical limit is the lowest or highest value to which a physical, chemical or microbiological hazard must be prevented or eliminated or removed to an acceptable level [26].

Principle 4: System establishments to monitor critical control point

It is prudent to engage in product monitoring to ensure that the production process is under control at each identified Critical Control Point. This process is important for regulatory and auditing bodies to ensure that the individual or company is following the HACCP plan [26].

Principle 5: Corrective action establishment

This is the action that is to be taken when monitoring procedures indicate a deviation from an established critical limit. To proper establish a correction action, the Process Analytical Technology Initiative (PAT system) plays a significant role. The PAT system is innovative technologies that help to design, analyze and control manufacturing through timely measurement [27]. There have been several pieces of research that have used numerous technologies to detect various hazards that serve as an aid for rapid corrective action.

The table below shows the various technologies that have been implemented or used to identify the various hazards in food industries and research institutions (see table 1 below).

PAT System	Physical hazard	Chemical hazard	Biological hazard	Reference
X-ray	✓			[27]
Electronic tongue and nose		✓	✓	[27]
Laser-induced breakdown spectroscopy		✓	✓	[27]
Raman Spectroscopy	✓	✓	✓	[27]
Hyperspectral imaging	✓	✓	✓	[27]
Magnetic resonance imaging	✓	✓		[27]

Table 1: PAT System for identification of Hazards in food Industries.

Principle 6

Verification of the monitoring plan along with demonstrating that the implementation process meets the validation criteria [28].

Principle 7

The last principle of HACCP requires that all procedures starting right from hazard identification to verification is documented for proper record keeping [29].

HACCP decision tree for analysis of hazards in Ghanaian maize staple foods preparation

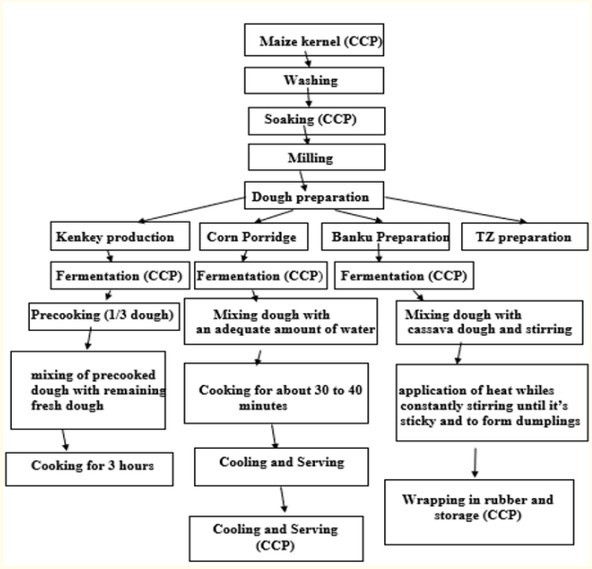

Figure 3

Analysis of Hazard in maize food production in using Codex Alimentarius logic sequence for determination of CCP

In the table below, we used the Codex Alimentarius logic sequence for the determination of CCP to critically analyze and identify the CCP in the process of food preparation. Most of the people that get infected with aflatoxins are mostly the ones residing in the rural areas of Ghana where there is no access to clean potable water. Most depend on wells and other rivers that are contaminated with the fecal remains of other animals that also drink and walk through it [28].

The table below is comprehensively designed to guide us in the implementation of HACCP in the preparation of maize food staples (see table 2).

Feasible means to prevent or reduce aflatoxins infection of maize during storage in Ghana

Moisture content could accumulate in maize and other cereal products as a result of the cumulative activities of bacteria which further enhances fungal growth and mycotoxins accretion. In other to reduce this phenomenon, it is imperative to note the points below.

Antioxidants use

Butylated hydroxyanisole (BHA), Butylated hydroxytoluene (BHT) and Propylparaben (PP) are few of the antioxidants that have been proven to have fungicidal and fungistatic activities on maize controlling the growth and aflatoxins synthesis by Aspergillus flavus and Aspergillus parasiticus [29].

Process step	Identified hazards	Q1. Do control preventive measures exist?	Q2. It the step specifically designed to eliminate the hazard	Q3. Could contamination with identified hazards reoccurs	Q4. Will a subsequent step eliminate identified hazards	CCP
Maize Kernels	Aflatoxins	Yes	Yes			CCP
Cleaning	No hazard					
Steeping/water	Fecal pathogens	Yes	No	Yes	Yes	CCP
	Enterotoxins	Yes	No	Yes	No	
Milling	No hazard					
Doughing/water	Fecal pathogens	Yes	No	No		
Fermentation	Fecal pathogens	Yes	Yes	Yes	Yes	
	Enterotoxins	Yes	No		No (heat stable)	CCP
Pre-Cooking	No hazard					
Molding	No hazard					
Packaging/ Maize husk	Aflatoxins	Yes	Yes			CCP
Cooking	Faecal pathogens	Yes	Yes			CCP
	Enterotoxins	Yes	No			

Table 2: Analysis of Hazard in maize food production in using Codex Alimentarius logic sequence for determination of CCP.

Passone., *et al.* tested the efficacy of BHA, BHT, and PP at a dose between 10 and 20 mmolg-1 to inhibit the activity of AFB1 accumulation by Aspergillus parasiticus and Aspergillus flavus on irradiated grains. They also tested the efficacy of these antioxidants in different water conditions at 11 and 35 days at a temperature of 28 degrees and no fungal growth was observed even at the highest stress water condition of 0.937aw. Adding individual antioxidants also confers inhibitory activity at a high dose but the combination of these three antioxidants is synergistically active at a low dose to control aflatoxins activities by increasing lag phase and reducing growth rate [30]. In addition, cysteamine and BHA have also been proven to inhibit aflatoxin production induced by carbon tetrachloride [31].

The use of synthetic weak acid

Weak acids are used in food and feed to avert fungal spoilage. The common weak acid preservatives used are sorbic acid, benzoic acid, and propionic acid. These compounds are fungistats and show antimicrobial activity only when they are present as undissociated acids. It has been found that propionic acid only can inhibit fungal growth at a concentration of 0.05%, sorbic acid at a concentration of 0.1%, benzoic acid at a concentration of 0.05% whiles acetic and butyric acid at a concentration of 0.5%. These acids inhibit fungal growth by inhibiting the expression of gene related to aflatoxin biosynthesis and inhibiting the expression of gene transcription [32].

Pests insect control

The severe attack of insects and other pests on grains during storage accounts for a major loss of our grains and also their activities lead to an accumulation of moisture which subsequently leads to fungi growth. Usually, insect control has to do with the use of chemicals which in the end leaves chemical residue on our food and possibly the environment.

Phosphine is one of the effective fumigants that has been used to disinfect maize during the storage of maize and other commodities in most developing countries [33]. Essential oils offer a substitute to phosphine to control insect pests. Contact and fumigant insecticidal actions have been demonstrated for a range of essential oil constituents [34].

The search for new advanced methods to replace chemicals in these few years has led to the development of the Ozone technology which can be generated electrically on demand. 50ppm of ozone was used to treat 8.9 tons of maize for 3 days and it resulted in the killing of 92% or 100% of adult red flour beetles and adult maize beetles [35].

Conclusion

Any substance that can be eating either raw or cooked to nourish the body is termed as food. Due to heavy migration these days, food ingredients and processed foods cross borders from farms, companies to reach the retail market and therefore the need for food safety analysis is inevitable. In Ghana, pregnant and lactating women depend heavily on maize food products to meet their educational requirements. In this regard, there is a dependence on maize foods such as Banku, Fante and Ga Kenkey, Corn porridge, and Tuo Zaafi. All these foods begin with soaking a maize kernel in water for about 3 to 5 days, milling, doughing and allowing for fermentation at normal room temperature. Unfortunately, HACCP principle is usually ignored due to ignorance on the part of the large population in Ghana thereby some process of the meal preparation leading to accretion of aflatoxins accretion and other enterotoxins from the water used from rivers and streams which has the fecal remains of livestock which also drink from these water bodies.

In Ghana, records of aflatoxins in mothers have been recorded in the blood and urine through HPLC detection. Most of our grains get infested with pest and insects and their activities lead to moisture accumulation which subsequently leads to fungi growth and aflatoxins buildup.

Bibliography

1. Ababouch, L. "The role of government agencies in assessing HACCP". *Food Control* 11.2 (2000): 137-142.

2. Abdulai A. "Spatial price transmission and asymmetry in the Ghanaian maize market". *Journal of Development Economics* 63.2 (2000): 327-349.

3. Abdulmumeen HA., *et al*. "Food: Its preservatives, additives and applications". *International Journal of Chemical and Biochemical Sciences* 1 (2012): 36-47.

4. Abdulrazzaq YM., *et al*. "Fetal exposure to aflatoxins in the United Arab Emirates". *Annals of Tropical Paediatrics* 22.1 (2002): 3-9.

5. Achaglinkame MA., *et al*. "Aflatoxin contamination in cereals and legumes to reconsider usage as complementary food ingredients for Ghanaian infants: A review". *Journal of Nutrition and Intermediary Metabolism* 10 (2017): 1-7.

6. Afum, C., *et al*. "Association between aflatoxin M1 and liver disease in HBV/HCV infected persons in Ghana". *International Journal of Environmental Research and Public Health* 13.4 (2016): 377.

7. Agag BI. "Mycotoxins in foods and feeds: 1-aflatoxins". *Assiut University Bulletin for Environmental Researches* 7.1 (2004): 173-205.

8. Akrobortu DE. "Aflatoxin contamination of maize from different storage locations in Ghana". (2008).

9. Amoa-Awua WK., *et al*. "The effect of applying GMP and HACCP to traditional food processing at a semi-commercial kenkey production plant in Ghana". *Food Control* 18.11 (2007): 1449-1457.

10. Atter A., *et al*. "Safety of a street vended traditional maize beverage, *ice-kenkey*, in Ghana". *Food Control* 55 (2015): 200-205.

11. Bakan B., *et al*. "Fungal growth and Fusarium mycotoxin content in isogenic traditional maize and genetically modified maize grown in France and Spain". *Journal of Agricultural and Food Chemistry* 50.4 (2002): 728-731.

12. Bankole SA and Adebanjo A. "Mycotoxins in food in West Africa: current situation and possibilities of controlling it". *African Journal of Biotechnology* 2.9 (2003): 254-263.

13. Beuchat LR. "Indigenous fermented foods". *Biotechnology Set* (2001): 505-559.

14. Bumbudsanpharoke N and Ko S. "Nano-food packaging: an overview of market, migration research, and safety regulations". *Journal of Food Science* 80.5 (2015): R910-R923.

15. Butte NF. "Energy requirements of infants". *Public Health Nutrition* 87a (2005): 953-967.

16. Butte NF and King JC. "Energy requirements during pregnancy and lactation". *Public Health Nutrition* 8.7a (2005): 1010-1027.

17. Carlson D and Poulsen HD. "Phytate degradation in soaked and fermented liquid feed—effect of diet, time of soaking, heat treatment, phytase activity, pH and temperature". *Animal Feed Science and Technology* 103.1-4 (2003): 141-154.

18. Carpitella S., *et al*. "Combined HACCP and TOPSIS-based approach to prioritize risks in the salmon manufacturing process: A case study. 22nd Summer School" Francesco Turco". *Industrial Systems Engineering* 2017 (2017): 150-156.

19. Eli-Cophie D., *et al*. "Glycemic index of some local staples in Ghana". *Food Science and Nutrition* 5.1 (2017): 131-138.

20. Fung F and Clark RF. "Health effects of mycotoxins: a toxicological overview". *Journal of Toxicology: Clinical Toxicology* 42.2 (2004): 217-234.

21. Gowen AA., *et al*. "Hyperspectral imaging-an emerging process analytical tool for food quality and safety control". *Trends in Food Science and Technology* 18.12 (2007): 590-598.

22. Halm M., *et al*. "Kenkey: an African fermented maize product". *In Handbook of food and beverage fermentation technology* (2004): 940-959.

23. Han Z., *et al*. "An ultra-high-performance liquid chromatography-tandem mass spectrometry method for simultaneous determination of aflatoxins B1, B2, G1, G2, M1 and M2 in traditional Chinese medicines". *Analytica Chimica Acta* 664.2 (2010): 165-171.

24. Hulebak KL and Schlosser W. "Hazard analysis and critical control point (HACCP) history and conceptual overview". *Risk Analysis* 22.3 (2002): 547-552.

25. Jain PK and Joshi H. "Coumarin: chemical and pharmacological profile". *Journal of Applied Pharmaceutical Science* 2.6 (2012): 236-240.

26. Kells SA., *et al*. "Efficacy and fumigation characteristics of ozone in stored maize". *Journal of Stored Products Research* 37.4 (2001): 371-382.

27. Khlangwiset P., *et al*. "Aflatoxins and growth impairment: a review". *Critical Reviews in Toxicology* 41.9 (2011): 740-755.

28. Kpodo K., *et al*. "Fusaria and fumonisins in maize from Ghana and their co-occurrence with aflatoxins". *International Journal of Food Microbiology* 61.2-3 (2000): 147-157.

29. Liao W and Lu X. "Determination of chemical hazards in foods using surface-enhanced Raman spectroscopy coupled with advanced separation techniques". *Trends in Food Science and Technology* 54 (2016): 103-113.

30. Luzi A., *et al*. "Acute effects of aflatoxins on guinea pig isolated ileum". *Toxicology in Vitro* 16.5 (2002): 525-529.

31. Markiewicz-Keszycka M., *et al*. "Laser-induced breakdown spectroscopy (LIBS) for food analysis: A review". *Trends in Food Science and Technology* 65 (2017): 80-93.

32. Maxwell SM., *et al*. "Aflatoxins in breast milk, neonatal cord blood and sera of pregnant women". *Journal of Toxicology Toxin Reviews* 8.1-2 (1989): 19-29.

33. Mellon JE., *et al*. "*Aspergillus flavus* hydrolases: their roles in pathogenesis and substrate utilization". *Applied Microbiology and Biotechnology* 77.3 (2007): 497-504.

34. Moon Y-S., *et al*. "Organic acids suppress aflatoxin production via lowering expression of aflatoxin biosynthesis-related genes in Aspergillus flavus". *Food Control* 88 (2018): 207-216.

35. Moran F., *et al*. "Facilitating smart HACCP strategies with Process Analytical Technology". *Current Opinion in Food Science* 17 (2017): 94.

Assets from publication with us

- Prompt Acknowledgement after receiving the article
- Thorough Double blinded peer review
- Rapid Publication
- Issue of Publication Certificate
- High visibility of your Published work

Website: https://www.actascientific.com/
Submit Article: https://www.actascientific.com/submission.php
Email us: editor@actascientific.com
Contact us: +91 9182824667