Continental Climate Changes on the Occurrence of Aflatoxin Producing Aspergillus Species: Review

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Abstract:- Most countries that are found to lie in the middle latitudes (40˚ - 55˚ N) experience continental climates that are described to have a large annual disparity in temperatures. These regions are known to have warm summers that often change to very hot and are often humid. On the other hand, the winters are cold or sometimes severely cold. Green House Gases (GHG) emission which mainly includes the CO_2 as a result of increased human activities has contributed to global warming with high temperatures being recorded in continental regions in Europe. As the climate changes, increased aflatoxin contamination of plants and farm produce in parts of Europe has been recorded from the main aflatoxin producing fungi belonging to the aspergilli genus that include: mainly Aspergillus parasiticus together with *A* .flavus belonging to section *Flavi*. From these two aspergilli species, *A flavus* is widely known and it occurs in large amounts where temperatures for their growth are within the range of 28˚C optimum and for the production of mycotoxins mainly the aflatoxins the temperatures are between 28˚C - 30˚C. Exposure to and consumption of aflatoxins has many detrimental effects to plants, animals and human life where humans suffer from increased nutritional deficiencies, immune suppression and hepatocellular carcinoma.

Among the Aflatoxins groups, the most poisonous and toxic is the Aflatoxin B1 that is abundantly produced by A. flavus and A. parasiticus which are the most toxigenic strains in fungi. To control the spread of these mycotoxin fungal strains due to the climate changes in the continental zones, proper mitigation purposes to curb the harsh climatic conditions has to be effectively implemented and adhered to ensure that safe agriculture is practiced to produce mycotoxin free farm produce required to feed the increasing human population globally.

***Keywords**:- Continental climate; Climate changes; Aflatoxin; aspergilli; toxigenic; mitigation.*

- *Abbreviations*

IPCC: Intergovernmental Panel on Climate Change; HPLC: High Performance Layer Chromatography; CO_2: Carbon (IV) Oxide; EFSA: European Food Safety Authority; ˚C: Degrees Celsius; TLC: Thin Layer Chromatography; EU: European Union; ELISA: Enzyme linked Immunosorbent Assay; GHG: Green House Gas; GC: Gas Chromatography.

I. INTRODUCTION

Continental climates refers to the climates that are often described to experience notable changes in temperatures annually and these regions are known to have summers that are relatively hot and their winters are cold. These climates lie in the middle latitudes (40˚ - 55˚ N) where there are prevailing winds that mainly blow overland. These regions lack water bodies like the oceans and seas that can moderate the temperatures. These continental climates are known to be experienced in many countries found in the Northern Hemisphere, where there are large land masses and suitable conditions that support this climate. Many regions of northern and northeastern China, eastern and south-eastern Europe, south-eastern and central Canada and lastly the central and upper regions of the eastern United States shows the characteristics of this climate. Mainly, continental climates experience continuous rainfall in the warmer months and it tends to be moderate in amount. The annual downfall may occur either as snow during cold winters, where the snow remains on the earth surface for more than thirty days. Furthermore, the summers experience violent storms and frequent warmth but in these climates the summer weather is observed to be more stable than winter weather. However, according to Tirado et al. (2010) it has been found out that conditions adverse to the growth of many plants like (drought stress, temperature stress, stress induced by pest attack, poor nutrient status, etc.) encourages the fungal partner to develop more than under conditions that are favorable to the plant with the expectation of greater production of mycotoxins.

II. CHANGES IN CONTINENTAL CLIMATES

Continental climates are experiencing changes and there have been cases of significant evidences that highlight this phenomenon of current climate change that is being experienced globally. The high emission and considerable increase of the greenhouse gases present in the atmosphere as a result of the increased human activities mainly through atmospheric pollution are causing global warming. In Europe, the effects of changes in the climate are being observed due to the high variations in the temperatures during summers and the extreme cold winters. During the 20th century, Europe experienced an increase in the average surface temperature annually recorded to be about 0.8℃, which was accompanied with high rates of warming over a long period of time. It was found out that the 1990s were the warmest on record (IPCC: Climate Change, 2007). The warming experienced has been stronger in most of the continental climatic regions during the winters than in the summers. There have been observations of an increase in warm extremes rather than a decrease in the cold extremes (IPCC: Climate Change, 2013).

The IPCC (Stocker et al. 2013)(Eds) reports that the world's land ecosystems play a major roles as carbon sinks in the contemporary global carbon cycle therefore it alleviates the increase of atmospheric CO_2 concentrations as a result of the global CO_2 emissions which then causes an overall effect on climate change.

Europe is also on the verge of increasingly being faced by the inevitable effects of the prolonged effects of climate change. Researchers depicts that climate change will occur gradually as a result of increases in average temperatures and changes in precipitation levels. However, in the shorter term; extreme weather changes will be felt which will be considered as a major short-term challenge but the main impacts of these changes will occur in the long term partly due to presence of elaborate factors that influence the balance of carbon in the terrestrial ecosystems including climate change, land-usage and land-cover changes (forest regrowth, fire suppression etc.) and nitrogen deposition, and CO_2 increase in the atmosphere (EFSA, 2007).

In their report, European Food Safety Authority (2007) highlighted the emerging problem of continuous contamination by the potential aflatoxin of several plants that include corn, almonds and pistachios that were grown in areas of Southern Europe, as a result of the changes in the subtropical climate occurring in some recent years.

Mostly, the aflatoxin producing fungi that is found in the farm crops and in the soils varies with different climates. These fungi show a poor competition when the conditions for growth are cool and the growth of *Aspergillus flavus* when the minimum temperature are below 20 °C is usually low as compared to the warmer regions when maxima temperature is N25 °C where aflatoxin-producers are always commonly found mostly in soils, air, and on crop surfaces (Manabe et al , 1978; Shearer et al, 1992).The crops that are cultivated in warm areas have greater chance of being contaminated by the aflatoxin producers and in some regions, infection only occurs when temperatures increase favoring the development of drought conditions (Sanders et al ,1984; Schmitt & Harburgh, 1989)

III. ASPERGILLUS FLAVUS AS AN AFLATOXIN PRODUCER

According to Goldman & Osmani, (2008) and Hina et al, (2013) The Aspergillus genus is a well-recognized metabolites producer and it can produce a variety of secondary biologically active chemical compounds that include antibiotics, mycotoxins, immune-suppressants, and cholesterol lowering agents. Under mycotoxins, the Aflatoxins are the most widely studied and researched on and they are predominantly synthesized from main toxigenic causative agent Aspergillus flavus (Fig. 1). According to Maren (2007), A. flavus has a broad host range as an opportunistic and a very common pathogen of soil, plants, animals and insects and it causes storage rots in numerous crops and it produces the highly regulated mycotoxin, aflatoxin B_1. In agriculture, A. flavus together with A. parasiticus produces highly carcinogenic aflatoxins which are a health hazard to animals and man.

Human beings are prone to high aflatoxins exposure due to the periodic handling and consumption of aflatoxin contaminated foods which later leads to the development of numerous nutritional deficiencies, hepatocellular carcinoma and suppression of the immunity levels (Wagacha & Muthomi, 2008)

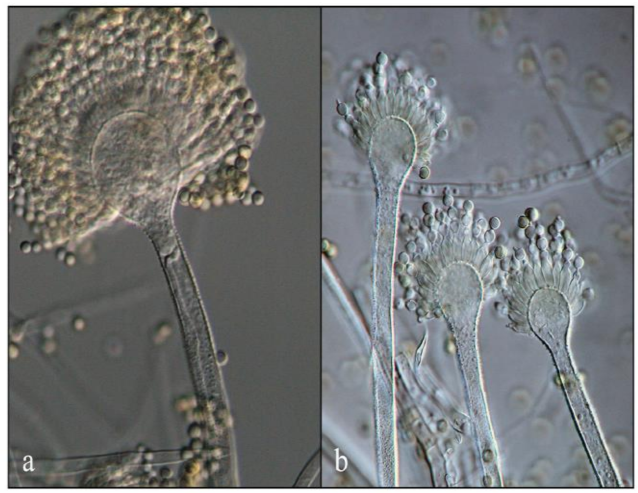


Fig 1:- (a) Bi-seriate and (b) mono-seriate heads of *A. flavus*.

Aspergillus flavus is classified under the section Flavi**.** This section is well studied and known to contain the major economically important aflatoxin-producing fungi that include the A. flavus and A. parasiticus. The other species in this section that include A. nomius, A. bombysis, A. pseudotamarii, and A. parvisclerotigenus are infrequent aflatoxin producers. Four species not in section Flavi which are classified as potential aflatoxins producers are A. ochraceoroseus, A. rambellii, Emericella venezuelensis and E. astellata (Frisvad, 2005).

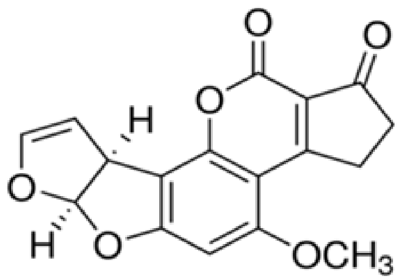
IV. AFLATOXINS AS A SECONDARY FUNGAL METABOLITE

Aflatoxins were first identified from peanut samples in 1961 when it was discovered that greater than 100,000 turkeys died from acute liver necrosis referred to as the Turkey-X disease due to the toxicity that came from the animal feeds containing aflatoxin-contaminated peanut meal (Blout, 1961; Van der Zijden, 1962).

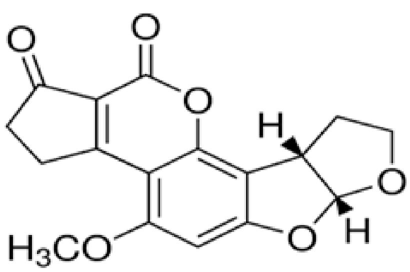
It was identified that according to Bennett & Klich (2003) Exposure to aflatoxins results to the development of two general forms of diseases -aflatoxicosis. First, Acute aflatoxicosis mainly leads to death while chronic aflatoxicosis often results to cancer with the liver being the primary target organ, immune suppression, teratogenicity and other symptoms.

Aflatoxins produced by Aspergillus flavus, A. parasiticus, A. nomius and A. wentii, are genotoxic carcinogens and very potent toxins that are highly distributed and mainly associated with some common types of plants that include maize, groundnuts, tree nuts, figs, dates and certain oil seeds such as cotton seeds.

Baranyi et al, (2015) describes Aflatoxins as a group of structurally related difuranocoumarins that were named as aflatoxins B_1, B_2, G_1, and G_2 (Fig 2) based on their differences in fluorescence under UV light (blue or green) and the numbers next to the letters indicate their relative migration distance on a thin-layer chromatographic plate.



(i)



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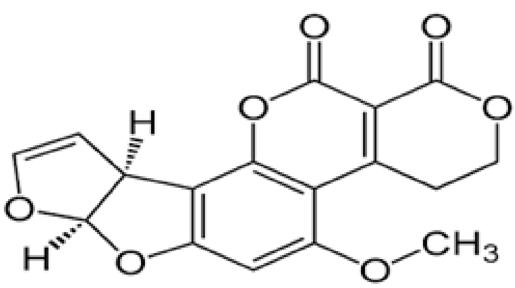

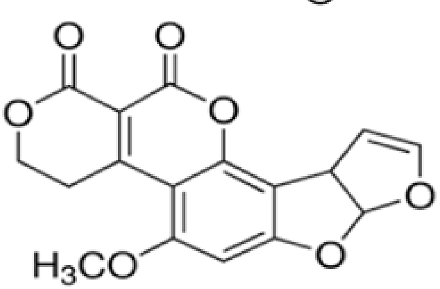

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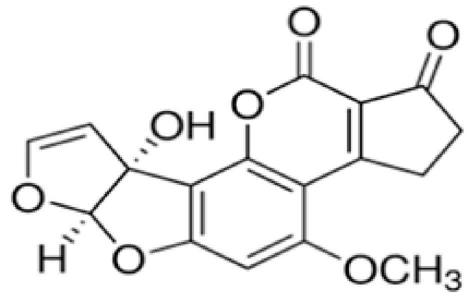

(v)

Fig 2:- Chemical Structures showing major aflatoxins types. (i) Aflatoxin B_1, (ii) Aflatoxin B_2, (iii) Aflatoxin G_1, (iv) Aflatoxin G_2, (v) Aflatoxin M_1

Aflatoxin B_1 [Figure 2(i)] is regarded as the most poisonous and toxic natural carcinogen known (Squire, 1981) mainly produced by the aspergilli toxigenic strains. Apart from major aflatoxin types named above, over a dozen of other structural analogues described include the aflatoxins P_1, Q_1, B2a, and G2a (Russell, 2015, eds). Baranyi et al, (2015) further describes that aflatoxin D_1 was detected in ammoniated corn and aflatoxin B_3 as a metabolite of *A. flavus* (CAST, 2003) and lastly, Aflatoxin M_1, a hydroxylated metabolite, is found primarily in animal tissues and fluids (milk and urine) as a metabolic product of aflatoxin B_1 (Gilbert & Vargas, 2005).

According to Klich (2007) the TLC technique became the standard for analysis as well as screening of aflatoxins, and is still used because it is simple to use and inexpensive. Other methods including high-performance liquid chromatography (HPLC), gas chromatography (GC) and immunological methods such as enzyme-linked immunosorbent assay (ELISA) are also used (European Commission, 2006; Van Egmond, 2007).

A legislative law concerning the limits for mycotoxin contamination of consumer raw products and derived products in the European Union has been put in place to protect people from consuming mycotoxins contaminated farm produce *Aspergillus flavus* total aflatoxins are potent to humans and are carcinogenic, affecting the liver while severe detrimental effects of *A. parasiticus* Aflatoxin B_1 are observed in some animals, mostly chickens and in *A. nomius* the aflatoxin M_1 is present in (milk) (IPCC, 2007).

These mycotoxins that are highly carcinogenic like aflatoxins, they have been found to be very heat-stable and thus difficult to destroy during food processing. In turn, this has led to the development of laws in many parts of the world about the reduction of aflatoxins contaminations in food products and other consumer products (Sanchis, & Magan, 2004) as compared to the developing countries where the laws are not extensive, especially for the consumption of staple food products (Council of European Union, 2007).

According to the IPCC (2007) report, the presence of mycotoxins in food is influenced by the current Climatic changes that favor the growth of fungi producing these mycotoxins. In 2003–4 there were very hot and dry episodes in parts of northern Italy where maize is a key animal feed for cattle that in turn provide the milk for the important cheese production regions. However, because of the very dry conditions in those years, *Aspergillus flavus* became a significant problem. *A. flavus* generally can tolerate wide ranges of temperature from 19 ˚C – 35˚C with about 28 ˚C being the optimum temperature for growth and 28 ˚C– 30 ˚C for aflatoxin production (European Parliament, 2003).

V. MITIGATION PLANS FOR THE CURRENT CLIMATE CHANGES

Numerous meetings and summits focusing on mitigation plans have been held by the European Union member countries so that they can try respond to the challenges of the observed continental changes in the climate. The EU's main objective has been to limit global average temperature increase to 2 ℃ as compared to the pre-industrial levels.

Green House Gases emissions still remains to be a major challenge that is contributing to the continental climate changes and the European Council (2003) concluded by deciding that the EU should unilaterally reduce Green House Gases (GHG) emissions by 20 % by the year 2020 as compared to 1990, afterwards the emission reduction figure would be raised to 30 % if other developed countries take up the initiative of reducing these gases. To achieve these targets, the most developed countries with comparable reduction ambitions have to support the developing countries in mitigating the problem of climate change. For the developed countries to achieve medium to long term emission reductions, they have to collectively reduce their emissions by 60-80 % by year 2050.According to the European parliament (2003) the presence of a trading scheme which was set from 2005, has been focusing on ensuring a reduction of the emission of GHG into the atmosphere from large machinery set-ups that consume a lot of energy and emit these gases and it will assist in reducing the high rising global temperatures especially in the continental regions.

VI. CONCLUSION

The continental zone is experiencing high rise in temperatures and it has been attributed to the increased human activities that are resulting to atmospheric pollution and the emission of GHG that contribute to higher average environmental temperatures that mainly favors the growth of mycotoxin producing fungi that could contaminate the farm produce with the toxic aflatoxins that are very detrimental to plants, animal and human life.

Countries within the continental regions that are experiencing climatic changes with very hot summers and cold winter up have to follow the mitigation plans set by the European Union that will in the long run play a role in curbing the extreme climatic changes in the continental zones for safer Agriculture that will be free from mycotoxigenic fungi contamination.

VII. CONFLICT OF INTEREST

Author of this review article has no conflict of Interest

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