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# Aflatoxin – Publication analysis of a global health threat

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ABSTRACT

*Background:* As a metabolite of *Aspergillus flavus* and *Aspergillus parasiticus*, Aflatoxin is a carcinogenic and mutagenic mycotoxin that is confirmed as a class-1 agent. It contaminates the most of our staple foods, affecting 25% of global crops. It is a global threat to human health by causing liver cancer in conjunction with Hepatitis B. Developing countries are particularly at risk not only because of the climatic but also of the agricultural production conditions. Climatic change and the intensification of global trading are also enhancing the risk of the global contamination. The overall health effects are dramatic.
*Methods:* Therefore, we choose this mycotoxin for an in-depth analysis of its global scientific publication output. The focus is on the geographical and chronological facts and trends, the international networks and the development of research fields. For this purpose, the bibliometric data was collected in the Web of Science database and interpreted according to a variety of scientometric parameters.
*Results:* The results show a superiority of the USA regarding the absolute publication numbers that was taken over by China in 2016. Not only the dramatic incidence and prevalence rates of liver cancer and the high Aflatoxin contamination rate in China, but also the immense increase of the expenditure for research and development play a role.
In relation to the integration of socio-economic features other countries emerge, i.e. Tunesia, Nigeria or Egypt. Other severely affected countries of Africa, Asia and South-America show a relatively low publication output. India, as an emerging country, achieves a considerably high output. Here, the health hazards are threatening and resulted in an outbreak of Aflatoxicosis induced Hepatitis in 1974. Although an outbreak of Aflatoxicosis in Kenya caused the deaths of 120 people, Kenyan research output is relatively low. The analyses of the distribution over time in 5-year intervals showed the relative decrease of the research area *Oncology*, whereas *Food Science & Technology* gained proportionally importance.
*Conclusions:* For future Aflatoxin studies, it is extremely important to carry out projects with the participation of the most affected countries and to support and enhance the knowledge growth of the individual farmers to establish more adapted production practices.


## 1. Introduction

Foodborne diseases remain a tremendous global challenge. Hence, promoting food safety is an important key to protect human life and health. According to the World Health Organization (WHO), an estimated 600 million people are affected by foodborne illnesses each year leading to the necessity to improve global food safety by multidisciplinary actions on local, national and international levels. Globalization and the intensified trade of agricultural commodities (Schaffartzik et al., 2014) in conjunction with a changing climate cause unique challenges and health hazards that have to be addressed immediately, not only in the developing countries but also in the industrial world (Frazzoli, Gherardi, Saxena, Belluzzi, & Mantovani, 2016).

The FAO (Food and Agriculture Organization of the United Nations) estimates that approximately 25% of the crops are infested by mycotoxins (FAO, 2017). Moldy contamination plus warm and humid conditions facilitated by global warming are prerequisites for the production of Aflatoxins – the toxic metabolites of *Aspergillus*

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*flavus* and *Aspergillus parasiticus* (Medina, Rodriguez, & Magan, 2014). These fungi are natural contaminants of food such as cereals, nuts, vegetables, fruits, spices and meat. Aflatoxins are invisible, odor- and tasteless. They affect foods at every stage of their production. The infestation before harvest is relatively difficult to eliminate, whereas contamination after harvest can be controlled by rapid drying and clean storage practices (Medina et al., 2014). In farm animals, Aflatoxin ingestion impacts growth and the immune system, which strains local meat production, national economy and the global food supply (Wild & Gong, 2010).

Aflatoxins affect human health in numerous ways. The IARC (International Agency for Research on Cancer) classified the fungal metabolites as class-1 agents. Aflatoxins are cancerogenic, particularly in conjunction with a chronic Hepatitis B virus (HBV) infection. The causal relationship with Hepatitis C virus seems probable but is not strongly proved (Wild & Montesano, 2009). Aflatoxins are linked to a statistically significant risk for Hepatocellular Carcinoma (HCC) (Qian et al., 1994; Ross et al., 1992). The WHO reported 788,000 global deaths due to HCC in 2015 and ranked the condition as the second common cause of cancer death – following lung cancer – worldwide (WHO, 2017). In the developing world, the two risk factors for HCC – HBV and Aflatoxin – are highly prevalent (Liu & Wu, 2010). This finding might explain why HCC occurs mainly in less developed countries; here, 83% of new cases have been registered in 2012 (WHO, 2012). Furthermore, Aflatoxicosis (Wild & Gong, 2010) due to acute Aflatoxin poisoning can be life threatening; common symptoms include digestion problems, severe edema, haemorrhage, and acute liver damage. Chronic exposition is accompanied with dysfunctional digestion and growth retardation as well as fetal congenital malformations in pregnant women (Sarma, Bhetaria, Devi, & Varma, 2017). Many countries reacted with strict legal Aflatoxin limits regarding a variety of foods. In 2006, the European Commission set the maximum Aflatoxin B1 level (AFB1) at 2.0 μg/kg in grain or grain products and at 0.1 μg/kg for processed cereal based baby foods (European Commission, 2006). In the United States of America (USA), higher levels of AFB1 (20 μg/kg) are tolerated by the Food and Drug Administration (FDA). The agency decided on 0.5 μg/kg as a maximum level of Aflatoxin M1 (AFM1) in milk (FDA, 2000).

Strict regulations on trading practices, food monitoring and storage methods have been implemented in the industrialized world and led to successfully reduce the Aflatoxin related health risks (Brown, Chen, Cleveland, & Russin, 1999). Inhabitants of developing or underdeveloped countries remain particularly vulnerable for malnutrition from food borne diseases and suffer from the lack of resources, knowledge and technology. In 2006, a survey showed that more than 5 billion people were exposed to the intake of contaminated food in developing countries (Sarma et al., 2017; Strosnider et al., 2006). Rural populations are mainly at risk due to the persisting subsistence production (Plymoth, Viviani, & Hainaut, 2009; Strosnider et al., 2006). Also, an occupational hazard exists for various employees such as farm workers who experience an airborne ingestion due to contaminated stables or animal feed (IARC, 2017) amongst other injuries (Bhattarai et al., 2016) (Moen, Kayumba, Sakwari, Mamuya, & Bratveit, 2016; Schneberger, Aulakh, Channabasappa, & Singh, 2016). Next to occupational exposure, Aflatoxin in food or the feed chain is the most hazardous threat to human health. Here, the mycotoxin exposure varies considerably due to the source, the type of food, the kind of storage and the climatic conditions (Sanders, Blankenship, Cole, & Hill, 1984). Especially the consumption of maize, cereals, peanuts and milk – via the feed-food carry over has to be seen critically. Whereas these commodities are staples of the modern and globalized world, they are responsible for the human exposure to high Aflatoxin levels (Wild & Gong, 2010).

Aflatoxins and the related foodborne diseases constitute a global problem and a major Public health challenge. This translates into a necessity to increase awareness among food producers, handlers and consumers as well as authorities to minimize Aflatoxin exposure – particularly in the developing countries. On national and international level, regulatory policies need to be customized to ensure a safe consumer environment. To address these needs, further research and the implementation of related public health measures are important future steps. To plan scientific endeavors and the distribution of financial support, the scientific output on „Aflatoxin“ needs to be evaluated. Therefore, this particular topic was selected for the *New Quality and Quantity Indices in Science* (NewQIS) project (Groneberg-Kloft, Quarcoo & Scutaru, 2009) presented here. We performed a scientometric analysis to quantify related research output and to evaluate the scientific productivity of single countries within the framework of the international research landscape.

## 2. Methods

### 2.1. Methodological platform

The multidisciplinary NewQIS platform was founded in 2009 by specialist in the fields of engineering, computer sciences and medicine (Groneberg-Kloft et al., 2009). The authors published a standardized and validated methodology, which was used to conduct studies on numerous relevant topics (Groneberg, Braun, Klingelhoefer, Bundschuh, & Gerber, 2016; Groneberg, Geier, et al., 2016; Quarcoo, Bruggmann, Klingelhofer, & Groneberg, 2015; Schreiber, Klingelhofer, Groneberg, & Bruggmann, 2016). Aims of NewQIS include the (1) objective, precise and reliable scientometric analysis of the global research publication output, which is evaluated chronologically and geographically, (2) the depiction of the results in global maps based on density equalizing map projections (DEMP), and (3) the investigation of national and international scientific collaborations. These transparent data allow researchers, decision makers and funding institutions to evaluate the present global research landscape related to "Aflatoxin", to plan research endeavors and to allocate research funds according to identified shortcomings.

### 2.2. Data source

The online database "Web of Science Core Collection (WoS)" from Thomson Reuters (by now *Clarivate Analytics*) was used to identify and retrieve the articles on Aflatoxin. WoS is one of the most comprehensive and renowned sources for scientific publications. The platform provides numerous relevant bibliometric data and facilitates the quantification of citations via its unique *Citation Report* function. The data for the socio-economic analyses has been extracted from the World-Factbook (CIA, 2015).

### 2.3. Search procedure and data integration

The term (*aflatoxin*) was used to search in the title, the author's key words and the abstract. The evaluation period was set from January 1st, 1900 until December 31st, 2016. All document types were involved. The biomedical context was ensured by filtering the subject categories. Afterwards, the bibliometric data was stored as plain text files, and processed as a data base file in order to serve as information source for the envisaged analyses.

### 2.4. Data analyses

The bibliometric data was evaluated regarding the publication