Food Control 60 (2016) 117–123

Contents lists available at ScienceDirect

Food Control

journal homepage: www.elsevier.com/locate/foodcont

Aflatoxin contamination of peanuts at harvest in China from 2010 to 2013 and its relationship with climatic conditions

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ARTICLE INFO

Article history:
Received 23 March 2015
Received in revised form
11 June 2015
Accepted 13 June 2015
Available online 20 June 2015

Keywords:
Aflatoxin
Peanut
Agro-environmental
China
Climate

Chemical compounds studied in this article:
Aflaotoxin B_1 (Pubchem CID: 186907)
Aflaotoxin B_2 (Pubchem CID: 2724360)
Aflaotoxin G_1 (Pubchem CID: 14421)
Aflaotoxin G_2 (Pubchem CID: 2724362)

ABSTRACT

Aflatoxins are toxic, mutagenic, and carcinogenic compounds that can contaminate various types of agro-products, among which peanuts are one of the most susceptible foodstuffs. In the current study, a total of 2494 peanut samples collected from four major peanut producing areas in China (Liaoning, Henan, Sichuan, and Guangdong provinces) from 2010 to 2013 were investigated for the occurrence of aflatoxins. A close relationship can be concluded between the result and the weather a month before harvest. According to the relationship, the highest aflatoxin contamination level occurred under the climatic conditions where precipitation was rare and the mean temperature was close to 23 °C, the minimum temperature was approximately 20 °C, and the maximum temperature was about 29 °C. This survey provided valuable information on aflatoxin contamination in pre-harvest peanuts under different agro-environmental conditions in China and laid a foundation for predicting aflatoxin contamination, which would be essential for taking preventive measures to alleviate pre-harvest aflatoxin contamination of peanuts.

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1. Introduction

The total yield, yield per acre, and gross yield of peanuts always take the first place of oil crops in China, and the peanut production in China accounts for about 40% of the world's peanut trade. Peanuts contribute large amounts of vegetable oil, protein, and vitamin E to developed countries (Chen, Liao, Lin, Chiueh, & Shih, 2013; Williams & McDonald, 1983). However, peanuts are one of foodstuffs that are most susceptible to aflatoxin contamination (Schroeder & Hein, 1967; Wogan & Pong, 1970). Aflatoxins are secondary metabolites produced principally by *Aspergillus flavus Link* and *Aspergillus parasiticus Speare* (Liu, Gao, & Yu, 2006; Rachaputi, Wright, & Krosch, 2002) and are toxic, mutagenic, and carcinogenic to humans and all tested animal species including birds and fish (Vaamonde, Patriarca, & FernandezPinto, 2006; Wogan & Pong, 1970). Aflatoxins have been classified by IARC as group 1 carcinogen (IARC, 1993). The most important types of aflatoxins occur naturally on agro-products are aflatoxin B_1(AFB_1), aflatoxin B_2(AFB_2), aflatoxin G_1(AFG_1), and aflatoxin G_2(AFG_2) (Idris, Mariod, Elnour, & Mohamed, 2010; Williams & McDonald, 1983). In view of the highly toxic and carcinogenic properties of aflatoxins, many countries have established regulations on the maximum content of aflatoxins in food and feed (Food & Agriculture, 2004; van Egmond, Schothorst, & Jonker, 2007) (Table 1). Consequently, if the aflatoxin level does not meet the required standard, farmers, processors, and distributors will suffer

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http://dx.doi.org/10.1016/j.foodcont.2015.06.029
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Table 1
The maximum limit standards of aflatoxins in world's leading exporters of peanut (unit, μg/kg).

Country or region	The type of aflatoxin	Maximum limit (μg/kg)
WHO	AFT	15
CAC	AFT	15
European Union	AFB_1/AFT	2/4
America	AFT	15
China	AFB_1	20
Japan	AFT	10
South Africa	AFB_1/AFT	5/10
Australia and New Zealand	AFT	15
Canada	AFT	15
India	AFB_1	30
Singapore	AFT	5

significant economic losses. Although various approaches have been proposed to reduce the aflatoxin content in peanuts (Torres, Barros, Palacios, Chulze, & Battilani, 2014), aflatoxin contamination is still one of the major problems in peanut production worldwide.

Aflatoxigenic fungi survive in a wide range of environments (Horn & Dorner, 1999; Pitt, 2000), and colonization of pre-harvested peanut crops contaminated by aflatoxigenic fungi often results in aflatoxin accumulation in post-harvest peanuts under the conditions that favor contamination (Nesci, Rodriguez, & Etcheverry, 2003). Aflatoxins often occur with the elevated temperature and drought stress in the fields in the final 4–6 weeks of a growing season (Cole, Sanders, Hill, & Blankenship, 1985; Hill, Blankenship, Cole, & Sanders, 1983; Timothy H. Sanders, Cole, Blankenship, & Hill, 1985; T. H. Sanders, Hill, Cole, & Blankenship, 1981). Based on these studies, Australia carried out a study on aflatoxin forecasting and successfully developed a model as part of the Agricultural Production Systems Simulator (APSIM) peanut module to monitor aflatoxin risks in pre-harvest peanuts using climate factors including the temperature, accumulated heat, and soil water (Chauhan et al., 2010). America established a hybrid genetic algorithm/backpropagation neural network (GA/BPN) that could predict aflatoxin contamination levels in peanuts based on environmental data (Henderson, Potter, McClendon, & Hoogenboom, 2000). The DSSAT-CROPGRO-peanut model is a process-oriented mechanistic crop growth simulation model that simulates daily water balance, soil temperatures, and plant water deficits in response to weather inputs, soil characteristics, plant growth characteristics, and crop management practices. The model was particularly suited to predicting the occurrence or risks of aflatoxin contamination in peanuts and was successfully applied in Mali and Niger (Boken et al., 2008; Craufurd, Prasad, Waliyar, & Taheri, 2006). A series of studies have been conducted to verify the aflatoxin contamination level in peanuts of China (Chen et al., 2013; Ding, Li, Bai, & Zhou, 2012; Li et al., 2014). However, previous studies on aflatoxin contamination in China focused only on post-harvest peanut samples and generally demonstrated that the overall contamination level in southern part of China was higher than in the northern region. The relationship between pre-harvest weather data and aflatoxin contents in pre-harvest peanuts has not been studied.

Because of climatic diversity in China whose latitude and longitude span more than 20°, there are four main peanut producing areas in China (Ding et al., 2012). The aim of this research was to investigate the incidence of aflatoxin contamination in peanuts at harvest under different agro-environmental conditions in China and its relationship with climatic conditions. This research would provide technical support to establish an early warning mechanism for large-scale detection and would be important for reducing pre-harvest aflatoxin contamination of peanuts.

2. Materials and methods

2.1. Samples

China spans a wide range of geographic locations from latitude 3°51′ N to 53°33′ N and from longitude 73°33′ E to 135°05′ E. From north to south, it covers temperate and subtropical zones. A total of 2494 peanut samples were collected from farmers' fields in four provinces, which are four main peanut producing areas under different agro-environmental conditions. The samples included 408 peanut samples from Liaoning Province in the northeast under a temperate monsoon climate, 1190 peanut samples from Henan Province in the north under a transitional monsoon climate, 455 peanut samples from Sichuan Province in the Yangzi River Basin under a subtropical temperate monsoon climate, and 441 peanut samples from Guangdong Province in the south under a subtropical-tropical monsoon climate (Fig. 1). The sowing areas in these four provinces were the largest for each main producing area and were among the top 8 sowing areas of China in 2010–2013. The samples of at least 3.0 kg were collected yearly from 9 counties of 5 cities in Liaoning, 26 counties of 16 cities in Henan, 33 counties of 13 cities in Sichuan, and 29 counties of 15 cities in Guangdong. In each county, each of 10–20 samples was independently harvested from different villages. All samples were delivered to the laboratory in sealed bags and stored under ventilated and dry conditions. Then, impurities and dusts of each sample were removed, the remaining was unshelled, and the seeds were cut into 0.5 cm thick slices, ground, and thoroughly mixed in a sample grinder until they could pass through a 0.9 mm sieve. The ground samples were put in glass containers and stored at 4 °C, and then analyzed by HPLC. All of this work was completed within 4 weeks.

2.2. Climate data

The precipitation and temperature data in different counties of China in different years came from China Meteorological Data Sharing Service System.

2.3. Aflatoxin data analysis

The statistical analysis of aflatoxin contents in different regions and years, were implemented by Analysis Descriptive in Excel.

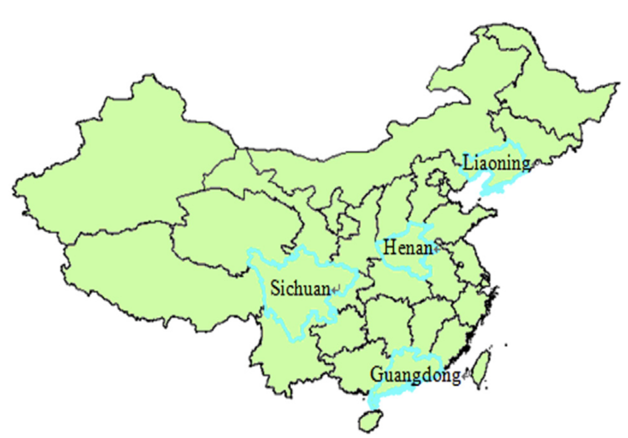

Fig. 1. Four peanut sampling provinces of China.

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