Food Chemistry 146 (2014) 284–288

Contents lists available at ScienceDirect

Food Chemistry

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

Effect of ozone on aflatoxins detoxification and nutritional quality of peanuts

Ran Chen [a,b,d,1], Fei Ma [a,c,d,1], Pei-Wu Li [a,b,c,d,e,*], Wen Zhang [a,b,e,*], Xiao-Xia Ding [a,d,e], Qi Zhang [a,c,d], Min Li [a,b,d], Yan-Ru Wang [a,b,d], Bao-Cheng Xu [a,b,d]

[a] Oil Crops Research Institute of Chinese Academy of Agriculture Science, Wuhan, People's Republic of China
[b] Key Laboratory of Oil Crop Biology of Ministry of Agriculture, Wuhan, People's Republic of China
[c] Key Laboratory of Detection for Mycotoxins of Ministry of Agriculture, Wuhan, People's Republic of China
[d] Laboratory of Risk Assessment for Oilseeds Products of Ministry of Agriculture, Wuhan, People's Republic of China
[e] Quality Inspection and Test Center for Oilseeds Products of the Ministry of Agriculture, Wuhan, People's Republic of China

ARTICLE INFO

Article history:
Received 28 March 2013
Received in revised form 23 June 2013
Accepted 10 September 2013
Available online 19 September 2013

Keywords:
Aflatoxin
Detoxification
Ozonation
Peanut
Nutritional quality

ABSTRACT

Aflatoxins are a group of secondary metabolites produced by *Aspergillus flavus* and *Aspergillus parasiticus* with carcinogenicity, teratogenicity, and mutagenicity. Aflatoxins may be found in a wide range of agri-products, especially in grains, oilseeds, corns, and peanuts. In this study, the conditions for detoxifying peanuts by ozonation were optimised. Aflatoxins in peanuts at moisture content of 5% (w/w) were sensitive to ozone and easily degraded when reacted with 6.0 mg/l of ozone for 30 min at room temperature. The detoxification rates of the total aflatoxins and aflatoxin B_1 (AFB_1) were 65.8% and 65.9%, respectively. The quality of peanut samples was also evaluated in this research. No significant differences ($P > 0.05$) were found in the polyphenols, resveratrol, acid value (AV), and peroxide value (PV) between treated and untreated samples. The results suggested that ozonation was a promising method for aflatoxin detoxification in peanuts.

1. Introduction

Aflatoxins are a group of natural compounds mainly produced by *Aspergillus flavus* and *Aspergillus parasiticus*. They have been found to be carcinogenic, teratogenic, and mutagenic to humans and animals (Hell & Mutegi, 2011; Li et al., 2010). Aflatoxin B_1 (AFB_1) is the most common and toxic among the aflatoxin group. In 1993, the International Agency for Research on Cancer (IARC) classified AFB_1 as a group I carcinogen (Alencar, Faroni, Soares, Silva, & Carvalho, 2012; Ding, Li, Bai, & Zhou, 2012; IARC, 2002). Aflatoxins are easily found in peanuts, corns, rice, and other agri-products, and they are considered inevitable in pre- and post-harvest crops. Biotoxins pose a serious threat to human health and greatly impact the food and feed industry. It is essential to bring aflatoxin contents of food and feedstuff to a safe level by developing detoxification technologies (Suzuki et al., 2002; Tripathi & Mishra, 2011; Velazhahan et al., 2010). Most of the reports on detoxification involve physical, chemical, and biological methods (Banu & Muthumary, 2010; Chen, Liu, Xing, Liang, & Liu, 2010; Kabak, Dobson, & Var, 2006; Zhang, Xiong, Tatsumi, Li, & Liu, 2012). However, most of the current methods are not practical, due to time consumption, nutrition losses, or low detoxification efficiency.

Ozone is one of the most powerful sanitisers. It was affirmed as Generally Recognised As Safe (GRAS) in the United States and approved by the Food and Drug Administration (FDA) as an antimicrobial agent that can be directly applied in the food industry (Alencar, Faroni, Martins, Costa, & Cecon, 2011; Li et al., 2012; Tiwari et al., 2010). Previous studies have demonstrated that ozone is an effective agent to detoxify aflatoxins because the ozone-treated products exhibited much less toxicity than the untreated samples and showed no mutagenic activities or deleterious effects (Hideo, Yuji, Minoru, & Toshiyuki, 1988). Reports also show that detoxification efficiency increases with time and ozone concentration (Akbas & Ozdemir, 2006; Inan, Pala, & Doymaz, 2007). However, it is important to note that, as a chemical detoxification method, ozonation with low ozone concentration and short treatment time is required to mitigate the damage to peanut nutrition. In the present study, the effects of exposure time, ozone concentration, and moisture content on aflatoxin detoxification were investigated. Considering the importance of quality and nutrition components, we also evaluated the nutritional quality changes of

* Corresponding authors at: Oil Crops Research Institute of Chinese Academy of Agriculture Science, Wuhan, People's Republic of China. Tel.: +86 27 86812943; fax: +86 27 86812862.
E-mail addresses: peiwuli@oilcrops.cn (P.-W. Li), zhangwen@oilcrops.com (W. Zhang).
[1] Ran Chen and Fei Ma ranked the first authors.

0308-8146/$ - see front matter © 2013 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.foodchem.2013.09.059

peanuts by determining the polyphenols, resveratrol, AV, and PV. Polyphenols and resveratrol are considered as oxidised indicators for the first time in this research.

It is an urgent requirement that a commercially acceptable method for detoxifying aflatoxins be developed for application in the food industry. The purposes of the present study were to: (1) optimise the conditions for detoxifying aflatoxins in peanuts by gaseous ozonation and offer a practical method for ozonation detoxification, and (2) assess the peanut quality and nutrition changes caused by ozonation.

2. Materials and methods

2.1. Sample preparation

Peanuts were supplied by a peanut products company (Rizhao, Shandong, China) with an average aflatoxin content of 200 μg/kg detected by HPLC. The original moisture content of peanuts was 7.8%, and it was regulated by air-drying the peanuts or blending the peanuts with a calculated quantity of pure water. The moisture content was determined according to the Association of Official Agricultural Chemists (AOAC) method 934.06 (AOAC, 1996).

2.2. Detoxification treatments

Ozone gas was generated by an ozone generator (SOZ-YB-10G, Guangzhou Ozone Technology Co., Ltd., China). One kilogramme of peanuts was placed in a 30 l box, which was divided into two by a metal mesh (Fig. 1). The lower part is a 10 l gas chamber room, and the upper part is a 20 l reactor room. Peanuts were evenly spread over the metal mesh. Ozone gas from the generator was introduced into the chamber room, filtered through the peanuts in the reactor room, and finally passed through the vent hole on one side. The diameter of the outlet was greater than that of the inlet, ensuring that the exhausted ozone could be released successfully. The concentration of the injected ozone was regulated by controlling the proportion of the ozone output from the generator and determined by a ST04 portable many gas detection instrument (Zhengzhou Best Electronic Technology Co., Ltd., China). All experiments were performed at room temperature with relative humidity of 65–75%.

2.3. Effects of different factors on detoxification

Experiments were performed on the peanut samples to discover the detoxification effects of factors such as the treatment time (10, 20, 30, 60, and 120 min), ozone concentrations (3.0, 4.5, 6.0, and 7.5 mg/l), and moisture contents of the peanuts (2, 5, and 8%). AFB_1, AFB_2, AFG_1, AFG_2, and the total aflatoxins were studied under various treatments.

2.4. Aflatoxin analysis

Aflatoxins in peanuts were extracted and cleaned up using the AOAC method 991.31 (AOAC, 2002). Aflatoxin immunoaffinity columns (IACs), with column capacity of 100 ng, were made, utilising the antibody-amino silica gel microparticle (Ma et al., 2013; Xiao et al., 2006). Quantitative analysis of aflatoxins was performed by Agilent 1220 HPLC, equipped with a fluorescence detector (FLD). A C18 analytical column (15 cm × 4.6 mm × 5 μm) and Romer Derivatisation Unit were used in the system.

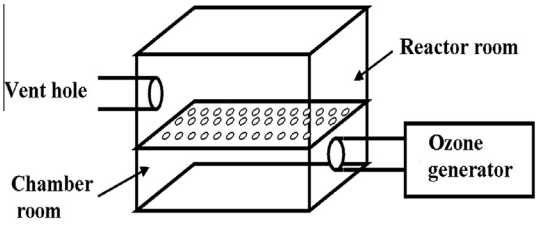

Fig. 1. Ozonation device for aflatoxin detoxification of peanut samples.

2.5. Quality analysis

To study the ozone effect on the peanut quality, peanut samples from different purchase batches were treated under optimal ozonation conditions. Then, polyphenols, resveratrol, AV, and PV of samples were analysed. All the parameters were determined 48 h after ozone treatment; so was the untreated group.

Polyphenols were determined, using the Folin–Ciocalteu assay (ISO 14502-1, 2005; Stratil, Klejdus, & Kubáň, 2006). A Unicam UV 500 (Thermo, USA) was used to collect absorption spectra at 765 nm. A linear calibration graph was constructed with gallic acid concentrations of 5, 10, 20, 30, 40 μg/ml.

Resveratrol was analysed using an Agilent 1100 HPLC equipped with a diode array detector (DAD) with the target compound detected at 306 nm according to the method reported by Pereira, Câmara, Cacho, and Marques (2010).

The AV and PV were obtained from the crude oil of the peanut samples, which was prepared using a laboratory presser. The AV was determined using the titration method (AOCS Cd 3d-63, 1997). The PV was determined by the Acetic Acid-Chloroform method (AOAC 965.33, 2000; AOCS Cd 8-53, 2003) and calculated using formula (1):

$$\mathrm{PV} = \frac{(V1 - V2) \times C \times 0.1269}{m} \times 100 \quad (1)$$

where V_1 is the volume (ml) of the $Na_2S_2O_3$ standard solution for the sample, V_2 is the volume (ml) of the $Na_2S_2O_3$ standard solution for the control check, C is the concentration (M) of the $Na_2S_2O_3$ standard solution, 0.1269 is grammes of iodine equivalent to 1 mmol of $Na_2S_2O_3$, and m is the mass (g) of the oil sample.

2.6. Statistical analysis

All experiments were replicated three times and one-way analysis of variance was used with a 5% probability. The significance analysis was carried out using the Statistical Analysis System (SAS) version 6.0 (2001).

3. Results and discussion

3.1. Effect of treatment time on detoxification

The effect of time on the detoxification is presented in Fig. 2. Ozone concentration of 7.5 mg/l and peanut moisture content of 5% were applied in treatments. The detoxification rate of the total aflatoxins increased with time if the treatment time was not more than 30 min. When the reaction time was 30 min, the highest detoxification rates of the total aflatoxins and AFB_1 were obtained, these being 66.9% and 65.0%, respectively. However, no distinct trend ($P > 0.05$) was observed if the reaction time was more than 30 min. According to Alencar's research (Alencar, Faroni, Martins, et al., 2011), the saturation time and residual concentration of gaseous ozone demonstrated that gaseous ozone reached a constant concentration after a certain period of time. Hence, the reaction between ozone and aflatoxins would reach a balance after a period of time. We chose 30 min as the best exposure time in this research.