ELSEVIER

Trends in Food Science & Technology xx (2014) 1–6

TRENDS IN FOOD SCIENCE & TECHNOLOGY

Review

Ultraviolet irradiation detoxification of aflatoxins: A review

Enjie Diao, Xiangyang Li*,[1], Zheng Zhang, Wenwen Ma, Ning Ji and Haizhou Dong*,[1]

College of Food Science & Engineering, Shandong Agricultural University, Taian 271018, PR China (Tel.: +86 538 8242850; e-mails: xiangyang_l@163.com, haizhoudong@126.com)

Ultraviolet (UV) irradiation as a non-thermal technology is widely applied in the food industry for disinfection. It also can be used to degrade aflatoxins in foods dues to its low cost, without residues, and minimizing the loss of quality in terms of flavor, color and nutritional value. This article reviews the UV detoxification efficiency of aflatoxins in foods and their safety after being irradiated. UV irradiation can effectively control aflatoxigenic fungi, and degrade their metabolites, namely aflatoxins. Several recent studies suggest that UV wavelength, irradiation intensity, exposure time, moisture contents of foods, types of aflatoxins, pH and thickness of irradiated foods, significantly affect UV detoxification efficiency. The applied research and advanced equipment development in UV detoxification will be the focal points in the future.

Introduction

Aflatoxins are secondary metabolites produced by three species of *Aspergillus*, namely *A. flavus*, *A. parasiticus* and *A. nomius* (Rustom, 1997). They are acutely toxic, carcinogenic, mutagenic, teratogenic substances, and immunosuppressive to most mammalian species (Dichter, 1984; Groopman, Cain, & Kensler, 1988; Massey, Stewart, Daniels, & Ling, 1995; Shank, Wogan, Gibson, & Nondasuta, 1972). Since aflatoxins were found, people have been searching effective methods to prevent or control them. Several strategies for the reduction of aflatoxins have been previously reviewed and include diverse physical, chemical, and biological methods (Das & Mishra, 2000; Haskard, Binnion, & Ahokas, 2000; Netke, Roomi, Tsao, & Niedwiecki, 1997). One of the methods is the UV irradiation, which is considered to be practical and cost effective for the detoxification of contaminated foods on a large scale.

This paper will provide a general review of the applications and efficiency of UV irradiation in decomposing aflatoxins in foods. The safety and quality of the foods after being irradiated by UV light were investigated. In addition, we summarized the factors influencing UV detoxification efficiency of aflatoxins in foods, and proposed the future research focus in the UV detoxification of aflatoxins.

UV detoxification efficiency of aflatoxins

The UV irradiation conditions of aflatoxins in various foods and detoxification efficiency are listed in Table 1. As an effective physical method, UV irradiation has been known for many years for the destruction of aflatoxins due to their photosensitivity (Andrellos, Beckwith, & Eppley, 1967; Van Der Zijden *et al.*, 1962). The degradation of aflatoxins in coconut oil by sunlight was demonstrated under the laboratory and plant conditions (Samarajeewa & Arseculeratne, 1974; Samarajeewa, Arseculeratne, & Bandunatha, 1977; Samarajeewa, Jayatilaka, Ranjithan, Gamage, & Arseculeratne, 1985). Shantha and Murthy (1977) reported that the treatment of peanut oil with UV light for 2 h destroyed 40–45% of afatoxins initially present in the oil. Aflatoxin B_1 (AFB_1) in peanut oil (2 mg/kg) was degraded completely within 30 min under the intensity of 800 μw/cm^2 (Liu *et al.*, 2011). A photodegradation reactor (365 nm, 36 Watt) developed by ourselves was used to decompose AFB_1 in peanut oil, and found that AFB_1 was decreased by 86.08% within 10 min (Diao *et al.*, 2014). Irradiation of raw whole milk artificially contaminated with aflatoxin M_1 (AFM_1) with UV light for 20 min at 25 °C decreased the amount of toxin by 60.7%, and its destruction attributes to the opening of the double bond in the terminal furan ring in AFM_1 (Yousef & Marth, 1986).

Also, UV irradiation (30 min) of dried figs artificially contaminated with AFB_1 (250 ppb) reduced the toxin level by 45.7% (Altug, Yousef, & Marth, 1990). AFB_1 in red

* Corresponding author.
[1] These authors contributed equally to this work.

http://dx.doi.org/10.1016/j.tifs.2014.12.001

Please cite this article in press as: Diao, E., et al., Ultraviolet irradiation detoxification of aflatoxins: A review, Trends in Food Science & Technology (2014), http://dx.doi.org/10.1016/j.tifs.2014.12.001

Table 1. UV degradation of aflatoxins in foods with different irradiation conditions.

Aflatoxins and initial concentrations	Sources	UV irradiation conditions					Reduction in aflatoxin content	References
		Wavelength	Intensity	Time	Temperature	Thickness of foods		
AFB_1 (0.05, 0.2, 2 mg/kg)	Peanut oil	220–400 nm	800 μw/cm^2	30 min	8 ± 2 C	< 1 cm	100%	Liu *et al.*, 2011
AFB_1 (20.0 nmol/100 g powder)	Red chili powder	365 nm	n.p.[a]	30/60 min	Ambient temperature	30 cm	77% (30 min) and 87.8% (60 min)	Tripathi & Mishra, 2010
AFB_1 (26.60–46.78 μg/kg, 10 ± 3% MC[b]) (53.12–108.68 μg/kg, 16 ± 3% MC)	Walnut, Almond, Pistachio, Peanut	265 nm	108 J/m^2	45 min	Room temperature	n.p.	AFB_1: 87.76–96.49% (10 ± 3% MC[b]) 87.44–95.27% (16 ± 3% MC)	Jubeen *et al.*, 2012
AFB_2 (0.31–4.32 μg/kg, 10 ± 3% MC) (0.4–16.81 μg/kg, 16 ± 3% MC)							AFB_2: 96.52–99.12% (10 ± 3% MC) 96.03–99.88% (16 ± 3% MC)	
AFG_1 (0–3.88 μg/kg, 10 ± 3% MC) (0.43–7.04 μg/kg, 16 ± 3% MC)							AFG_1: 97.07%–100% (10 ± 3% MC) 94.44–100% (16 ± 3% MC)	
AFG_2 (0–0.27 μg/kg, 10 ± 3% MC) (0–0.29 μg/kg, 16 ± 3% MC)							AFG_2: 100% (10 ± 3% MC) 100% (16 ± 3% MC)	
Total (27.29–51.82 μg/kg, 10 ± 3% MC) (64.87–164.51 μg/kg, 16 ± 3% MC)							Total: 87.81–96.71% (10 ± 3% MC) 87.99–92.31% (16 ± 3% MC)	
AFM_1 (1 μg/kg)	Milk	365 nm	n.p.	20 min	25 °C	1 cm	89.1% (containing 0.05%H_2O_2) 60.7% (H_2O_2-free milk)	Yousef & Marth, 1986
AFB_1 (250 μg/kg)	Dried figs	n.p.	n.p.	30 min	25 °C	n.p.	45.7%	Altug *et al.*, 1990
AFB_1 (51.96 μg/kg)	Peanut oil	365 nm	6.4 mw/cm^2	10 min	Room temperature	< 3 mm	86.08%	Diao *et al.*, 2014
AFB_1 (166–1250 μg/kg)	Coconut oil	365 nm (Solar)	10 cal/cm^2	10 min	Room temperature	1.6 mm	75%	Samarajeewa *et al.*, 1985

[a] Is not provided.
[b] Moisture content.

Please cite this article in press as: Diao, E., et al., Ultraviolet irradiation detoxification of aflatoxins: A review, Trends in Food Science & Technology (2014), http://dx.doi.org/10.1016/j.tifs.2014.12.001