AFLATOXIN CONTAMINATION OF FOOD AND FOOD PRODUCTS IN THAILAND: AN OVERVIEW

Wirachit Waenlor and Viroj Wiwanitkit

Department of Laboratory of Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

Abstract. This paper presents an overview of reports of aflatoxin contamination in various foods and products, which have been carried out in Thailand between 1967-2001. Thirteen available international and local reports (n=3,206 samples) focused on type of food, season and geographic areas, and have been collected for statistical analysis. The accumulated data showed 1,248 (38.9%) of 3,206 samples were highly contaminated with aflatoxin. Over half (728) of the contaminated samples (1,248) were peanuts, milk, and poultry. In addition, analysis of the number of aflatoxin-contaminated samples in the above categaries, which were tested by chi-square test, indicated that there was a significant difference between the type of food and seasonal influence ($p<0.05$), but not geographical influence ($p>0.05$). Furthermore, detection methods for aflatoxin contamination, based on fundamental techniques, have been also reviewed. However, little research has been conducted on comparisons of the seasonal and geographical influences on aflatoxin contamination. Further study should be directed at these influences in larger samples.

INTRODUCTION

Living at the present is dangerous, not only because of accidents and environmental hazards, but also because of the foodstuffs that we consume every day. Most foods are contaminated with microorganisms as well as their toxins (Imwidthaya *et al*, 1987). In Southeast Asia, the occurrence of aflatoxins in corn (Juan-Lopez *et al*, 1995; Yoshizawa *et al*, 1996), peanuts, copra meal, and other commodities is well known as a serious problem (Fukal *et al*, 1987; Imwidthaya *et al*, 1987; Vinitketkumnuen *et al*, 1997; Thuvander *et al*, 2001), because of harmful effects on human and animal health and consequent losses in agricultural trade (Yamashita *et al*, 1995). Aflatoxin contamination has been detected in various foods, such as fermented food and beverages (Sripathomswat *et al*, 1981), milk and dairy products (Galvano *et al*, 2001; Srivastava *et al*, 2001), melon seeds (DiProssimo and Malek, 1996), poultry (Bintavihok *et al*, 1997), dried seafood (Shank *et al*, 1972; Pasura, 1999), chillies (Reddy *et al*, 2001), and spices (Vrabcheva, 2000).

Aflatoxin is a naturally occurring mycotoxin produced by *Aspergillus flavus* and *Aspergillus parasiticus* (Vrabcheva, 2000). *Aspergillus flavus* is common and widespread in nature and is most often found when certain grains are grown under stressful conditions, such as drought. Different types of aflatoxin are produced in nature with aflatoxin B1 considered the most toxic. Approximately 25% of the world's food supply is contaminated with mold and fungi that produce mycotoxin (USDA GIPSA, 1998). The potential of aflatoxin as a carcinogen, mutagen, teratogen, and immunosuppressive agent is well documented (Wogan, 1975; Sashidhar, 1993; Yamashita *et al*, 1995; Saitanu, 1997) with increased risk of hepatocellular carcinoma (Wogan, 1975; Dichter, 1984; Srivatanakul *et al*, 1991). Despite cumulative knowledge of the occurrence of aflatoxins, little information is so far available regarding the comparison of aflatoxin contamination in several areas, including geographical and seasonal distribution, and type of food, in Thailand. The aim of this study is to perform an analysis of reports focused on these topics to depict the aflatoxin situation from 1967 until 2001, in Thailand.

Correspondence: Wirachit Waenlor, Department of Laboratory Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand.

MATERIALS AND METHODS

Thirteen international and local reports (n=3,206 samples) on aflatoxin contamination in Thailand and elsewhere, which were published between 1967 and 2001, have been searched and analyzed statistically. The main key words used were 'Aflatoxin, Contamination, Detection, Methods, Thailand, and Food.' Food was defined by each type of food, such as rice, peanut, bean, etc. The reports of aflatoxin contamination rates in variety of foods and food products in Thailand have been summarized as overall contaminated percentages. The chi-square test was used to test the fit of the association between each topic, including type of food, seasonal and geographical distribution, and aflatoxin contamination rate. Comparative studies of the geographical and seasonal distributions, over as long a period as available, were chosen for collection and statistical testing.

Table 1
Percentage of aflatoxin contamination in various food products in Thailand.

Food and food products	Year	Authors	No. of samples	Contaminated samples (%)
Rice	1967	Shank *et al*,	364	2
	1980	Glinsukon *et al*,	32	6
	1981	Sripathomswat *et al*,	20	5
	1987	Imwidthaya *et al* ,	40	10
Total			456	2.8
Peanuts	1967	Shank *et al*,	216	49
	1975	Thasnakorn	29	75
	1976	Karunyavanich	354	55
	1980	Glinsukon *et al*,	38	45
	1981	Sripathomswat *et al*	20	10
		Eumviteevanich *et a*	20	100
	1985	Kenniford *et al*,	170	34.7
	1987	Imwidthaya *et al*,	30	43
Total			877	51.4
Corn	1967	Shank *et al*,	62	35
	1980	Glinsukon *et al*,	46	46
	1981	Eumviteevanich *et al*,	1	0
	1987	Imwidthaya *et al*,	20	20
	1995	Yamashita *et al*,	27	63
	1996	Yoshizawa *et al*,	18	72
Total			174	44.2
Soybeans	1981	Sripathomswat *et al*,	20	0
	1987	Imwidthaya *et al*,	40	25
Total			60	16.7
Other beans[a]	1981	Sripathomswat *et al*,	20	10
	1987	Imwidthaya *et al*,	322	3
Total			342	3.2
Milk and dairy products	1997	Saitanu,	270	95.56
Total			270	95.56
Spices	1967	Shank *et al*,	248	4.8
	1981	Eumviteevanich *et al*,	10	80
Total			258	8.5
Dried seafood	1967	Shank *et al*,	139	5
	1999	Pasura,	180	100
Total			319	58.6
Poultry tissue	1997	Bintavihok *et al*,	450	48.67
Total			450	48.67
Overall			3,206	38.9

[a]Other beans including garden pea (lantao bean), flava bean, pigeon pea, red bean, black bean, and green bean.

RESULTS

Results of the analysis of the cumulative data, 3,206 samples from international and local reports, are shown as overall percentages of aflatoxin contamination of foods and food products in Thailand (Table 1). For all Thai foods and food products examined, 1,248 samples (38.9%) with aflatoxin contamination are summarized. The highest contamination rate was found in peanuts (36% of all contaminated foods), followed by milk (20.7%) and poultry (17.5%).

The associations of type of food, geographical and seasonal distribution, which influence aflatoxin contamination, are presented in Table 2. A significant difference in aflatoxin contamination of Thai foods, was found between types of food and seasonal distribution ($p<0.05$).

Aflatoxin contamination was highest in the rainy season and lowest in the hot season. For most of Thailand, during the years 1967 to 2001, each of the seasons that extended from month to month overlapped; however, the rainy season extended from July to September, the dry season from November to January, and the hot season from March to May. A disproportionate number of food samples collected in a given season could therefore result in an erroneous interpretation of the seasonal effect. However, large number of cumulative samples could be tested for the association of seasonal distribution and aflatoxin contamination.

For geographical distribution, the highest sample of contamination was in the northern part of the gulf of Thailand, in particular the northwest and central provinces. When the chi-square test was applied to test the fit of association of aflatoxin contamination and geographical distribution, there was no significant difference between them ($p>0.05$).

DISCUSSION

This report suggests that the overall contamination of aflatoxin in Thai foods and food products is higher than those reported from aflatoxin surveillance, for

Table 2
Aflatoxin contamination of food and food products in Thailand, by type of food, season and geographical area, 1967-2001.

Parameters	No. of samples	No. of contaminated samples	Chi-square test
Types of food			
Rice	456	13	
Peanuts	877	451	
Corn	174	77	
Soybean and other beans	402	21	$p< 0.05$
Milk	270	258	
Spices	258	22	
Poultry	450	219	
Dried seafood	319	187	
Season			
Summer (Mar–May)	980	97	
Rainy (Jul- Sep)	956	179	$p<0.05$
Winter (Nov-Jan)	693	156	
Geographical areas			
Northwest	433	47	
Central	803	80	
West	128	10	
Northeast	308	30	$p>0.05$
Southwest	231	18	
South	227	22	
East	49	5	

example, in Hong Kong (7.6%) (Risk Assessment Section, 2001), Tunisia (14 of 1,076 samples) (Boutrif *et al*, 1977), and in Botswana (40%) (Siame *et al*, 1998).

Although data for the occurrence of aflatoxin in a variety of Thai foods and food products have been reported, some types of food are quite small in number, such as milk and dairy products, meat, poultry, dried seafood, various types of bean, and spices. Most samples were restricted to foods offered for sale in local markets. Samples in other settings, such as in houses, warehouse, farms, and barns, should increasingly be performed comparing the influence of the various settings on aflatoxin contamination. Moreover, there are also few data that represent geographical and seasonal distribution. The results, for geographical and seasonal effects therefore, may be interpreted erroneously. When further examinations of aflatoxin contamination have been carried out, the accumulated

Table 3
The determination procedures for aflatoxin contamination in a variety of food and food products.

Procedures	Authors	Year	Types of food[a]
Thin-layer chromatography (TLC)	Shank *et al*, Thasnakorn, Sripathomswat *et al*, Eumviteevanich *et al*, Gilbert *et al*, Imwidthaya *et al*, DiProssimo *et al*, De Sylos *et al*, Panariti,	1967 1975 1981 1981 1984 1987 1996 1996 2001	Rice, peanuts, corn, melon seeds, soybean and other beans, milk, spices, dried seafood
High-performance liquid chromatography (HPLC)	Sripathomswat *et al*, Gilbert *et al*, Yamashita, De Sylos *et al*, Yoshizawa *et al*, Saitanu, Bintavihok *et al*,	1981 1984 1995 1996 1996 1997 1997	Milk, rice, peanuts, corn, soybean and other beans, poultry tissue
Rapid liquid chromatography	Stubblefield and Kwolek Stroka *et al*,	1986 2001	Milk
Enzyme linked immunosorbent assay (ELISA)	Hahn and Bransch, Reddy *et al*,	1988 2001	Chillies (indirect ELISA), milk
Monoclonal immunoaffinity column	Juan-Lopez *et al*, Srivastava *et al*, Stroka *et al*,	1995 2001 2001	Corn, milk
Minicolumn chromatography	Holaday,	1981	Milk
Photoacoustic technique and transient infrared spectroscopy	Gordon *et al*,	1999	Corn
Rapid radioimmunoassay (Charm II test)	Saitanu,	1997	Milk

[a]including products based on them.

new data should be compared with the results year by year, or to our study.

The highest aflatoxin contamination rates are still confined to peanuts and peanut-based products (Shank *et al* 1972; Thasnakorn, 1976; Glinsukon *et al*, 1980; Eumviteevanich *et al*, 1981) compared with the previous data. Aflatoxin contamination in peanuts and peanut products in Thailand is also very similar to other countries, such as the 71% contamination rate in Botsawana (Siame, 1998), 51% in Brazil (Freitas and Brigido, 1998), and 56.7% in Cyprus (Ioannou-Kakouri *et al*, 1999). In all of these, inappropriate post-harvest (USDA GIPSA, 1998) and seasonal influences, particularly late rainy or early dry season (Shank *et al*, 1972; Imwidthaya *et al*, 1987), were the common causes. These conditions enhance the growth of aflatoxin-producing fungi in Thai foods and foodstuffs.

Aflatoxin M1 (AFM1) is the major aflatoxin found in milk. It had been reported that only AFM1 which was detected in milk in Thailand and other countries (Holaday, 1981; Gilbert *et al*, 1984; de Sylos *et al*, 1996; Saitanu, 1997; Galvano *et al*, 2001; Panariti, 2001; Srivastava *et al*, 2001) because the occurrence of AFM2 in milk has been found to be less than 10% of the total aflatoxin content and its cross-reactivity with the antibody is about 10%, which should not affect the quantitation of AFM1 (Saitanu, 1997). Although the data for aflatoxin contamination in milk in Thailand has been made available in only one report (Saitanu, 1997), the level of aflatoxin (>0.5 ppb) was higher than the levels found in other countries (Gilbert *et al*, 1984; de Sylos *et al*, 1996; Galvano *et al*, 2001; Srivastava *et al*, 2001). A national strategy for the reduction and elimination of AFM1 contamination is urgently needed (Saitanu, 1997), because everybody could be exposed at all times.

Different assay methods for screening and quantitative estimation of mycotoxins in food and food products (Richard *et al*, 1993) have been used depending on the need to detect the differences in major aflatoxins in each type of food and food products (Table 3). Each method has limits for the detection of each mycotoxin (Holaday, 1981; Tapia, 1985, Fukal *et al*, 1987; Sashidhar, 1993; DiProssimo and Malek, 1996; Simon *et al*, 1998; Chiavaro *et al*, 2001).

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