REVIEW ARTICLE

Aflatoxin Occurrence, Food Regulations, Dietary Exposure, and Risk Assessment: A Mini Review from the Malaysian Perspective

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ABSTRACT

Aflatoxins are ubiquitous and occur in food. Exposure to aflatoxins seriously impact the health of human and animal. It is concerning especially when aflatoxins are odourless, colourless, and tasteless that hardly be detected through naked eyes. Ingestion of aflatoxin-contaminated food contributes the major route of exposure. The present review is an update on the aflatoxin occurrence in food, aflatoxin regulations in food, and recent risk assessment of aflatoxin exposure in Malaysia. Peanuts and chili were more prone to aflatoxin contamination in Malaysia. The extreme weather experienced in Malaysia and global climatic change may worsen the aflatoxin contamination in food. The regulatory standards for aflatoxins imposed by Malaysia are less stringent than developed countries. The dietary exposure of aflatoxins among Malaysian was relatively high as compared with other Asia countries, ranging from 0.002 to 34.00 ng/kg body weight/day. Nonetheless, Malaysian population had low risk of aflatoxin-related liver cancer, with an estimated liver cancer risk of <1 cancer case/100,000 population/year.
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INTRODUCTION

Aflatoxins are a group of naturally occurring fungal toxins known as mycotoxins that widely contaminate foods and feeds. They are synthesised by *Aspergillus* section *Flavi* through secondary metabolic pathway. The fungi disperse in soil, organic matter, and growing crops through alternative hosts. There are 18 out of the 33 species of *Aspergillus* section *Flavi* capable of producing these toxins but *A. flavus* and the closely related species *A. parasiticus* are responsible for the major production of aflatoxins found in agricultural commodities. The morphology of *Aspergillus* section *Flavi* is identified based on microscopic structure, such as colony colour, conidia, and production of dark sclerotia (1). Unlike *Aspergillus* species which can be identified by naked eyes, aflatoxins are colourless, odourless, and tasteless, thereby the action of controlling and eradicating it is a real challenge.

There are 14 or more aflatoxins occur in nature with three series being significantly important from a food safety perspective, which are B series (aflatoxin B_1, AFB_1 and aflatoxin B_2, AFB_2), G series (aflatoxin G_1, AFG_1 and aflatoxin G_2, AFG_2), and M series (aflatoxin M_1, AFM_1 and aflatoxin M_2, AFM_2). *A. flavus* can produce B aflatoxins, while *A. parasiticus* can produce both B and G aflatoxins. Of these four aflatoxins, AFB_1 is most frequently present in contaminated food and feed, while the others including AFB_2, AFG_1, and AFG_2 are generally occurred only in the presence of AFB_1. These aflatoxins are highly oxygenated, naturally occurring heterocyclic compounds with a common benzene ring (2, 3). B and G aflatoxins are named with letter "B" and "G" because they emit blue (450 nm) and green (425 nm) fluorescence intensely under ultraviolet light respectively which are separable by thin layer chromatography. On the other hand, M aflatoxins are named with letter 'M' due to its common presence in milk and milk products from livestock that ingested contaminated feed. The subscript numbers of 1 and 2 indicate major and minor compounds respectively, with the major compounds occur in high quantities (4).

Several adverse health effects associated with aflatoxin exposure have been widely discussed (5). Liver is considered as the principal target organ of aflatoxins, where they are first metabolised to release the reactive intermediate metabolites, but kidney can also be a vulnerable target. Dose and duration of aflatoxin exposure plays major effect on the toxicology. Most of the toxicological data have been focused on AFB_1. Acute toxicity occurs when an individual is exposed to high dose of aflatoxin in short period of time. It may result in symptoms which include fever, nausea, vomiting, abdominal pain, oedema, impaired digestion, malabsorption, mental change, and liver failure (6). The dose of AFB_1 ingestion resulting in the onset of acute symptoms and possibly fatality was estimated to be 20-100 ug/kg bw/day for a period of 1-3 weeks (7). Gilbert-Sandoval et al. (8) used a modelling approach to predict the acute liver toxicity of AFB_1 in rats and humans and identified 77 ug/kg bw as the benchmark dose lower confidence limit (BMDL10). Adults usually have good tolerance to aflatoxin, and most reported deaths caused by acute poisonings were among children aged 19 years and below (9, 10).

Aflatoxins have been classified as human carcinogen (Group 1) by the International Agency for Research on Cancer (IARC) since 1987 (11). Group 1 refers to the agent that is carcinogenic to humans which supported with sufficient evidence of carcinogenicity in human (11). The cytotoxicity, genotoxicity, mutagenicity, and carcinogenicity of aflatoxins have been widely documented in the literature (12-15), have widely displayed a consistent pattern of aflatoxin potency in the order of AFB_1 > (AFG_1 and AFM_1) ≫ (AFG_2 and AFB_2). All these studies have agreed to the point where AFB_1 is essentially most potent while AFG_2 and AFB_2 are non-toxic. Plausible explanations to the variation in aflatoxin potency have been focused on the structural differences of these compounds. First, the presence of 8,9 carbon-carbon double bond in AFB_1, AFG_1, and AFM_1, as well as the 2,3-double bond in AFB_1 instead of AFB_2, allow the epoxidation to form reactive intermediates (16, 17). The comparison provides more relevant perspective when AFB_1-8,9-epoxide formed more N7-guanine adducts than its equivalent AFG_1 epoxide at equivalent dosage and the saturation of 2,3-double bond in AFB_1 to yield AFB_2 was displayed to greatly reduce the toxicity (15). Second, the unsaturated α-lactone structure in the coumarin moiety of these aflatoxins could act as an alkylating agent, causing damage to the nucleophiles in DNA (18). The presence of cyclopentenone ring in addition to lactone ring in B aflatoxins appeared to produce enhanced DNA binding affinity to form N7-guanine adducts as compared with the second lactone ring in G aflatoxins (19).

Malaysia is a country located in Southeast Asia that comprises of two regions, which are West Malaysia (namely Peninsular Malaysia) and East Malaysia (Sabah and Sarawak). Since Malaysia is located near to the equator, the country has warm temperature (26 to 28 ^oC) and high relative humidity (70-80 % during wet seasons) coupled with seasonal distribution of rainfall throughout the year (20, 21). Historically, the first and only aflatoxicosis outbreak occurred in Malaysia was reported in October 1998 (22). At least 17 persons aged from 2.5-49 years (12 males and 5 females) were affected by the acute exposure of aflatoxins which suspected to be from the contaminated loh su fun noodles. The incidence resulted 13 children aged <11 years died, making a case fatality rate of 76.5 % with duration of survival from 2-6 days (23). The outbreak has threatened the Malaysian population until now due to the high fatality rate. Indeed, the fatality rate of 76.5 % was higher than that of recent Tanzania outbreak in 2016 (30 %, 20 died) (9).

OCCURRENCE OF AFLATOXINS IN FOOD

Fungal contamination on food crops can occur both before and after harvesting. Eskola et al. (24) suggested that up to 80 % of the world's food crops and feeds may contain one or more mycotoxins. Being as a type of mycotoxins, aflatoxins particularly AFB_1 have been reported to contaminate in various food consumed by Malaysian including cereals, nuts, spices, and animal products (25-31), while AFM_1 have been detected in the milk and milk products found in Malaysia (32, 33). Table I lists the aflatoxin occurrence in food commodities from Malaysia. Among all the food commodities, peanuts and peanut products had the highest reported levels of total aflatoxins and AFB_1. Of note is the study by Norlia et al. (28) which showed a maximum AFB_1 level that near to 1000 ug/kg. The previous study randomly collected from peanut stakeholders in Malaysia including importers, manufacturers, and retailers during November 2014 to February 2015. This observation, however, should be interpreted cautiously with the combination of the source or specific location of samples collected from, which was not specified in the previous study. This is because the wet season on East coast of Peninsular Malaysia lies between November to February, which is supportive environment for the growth of fungus and aflatoxin production (34).

Besides that, herbs and spices particularly chili had relatively high maximum level of total aflatoxins, ranging from 31.17 ug/kg to 104.4 ug/kg (26, 29-31). Chili, whether in the form of dry whole, powder, or sauce are heavily used in cooking or consumed by Malaysian. According to Mahadeva et al. (35), nearly half of the urban population (48.3 %) in Malaysia were heavy chili eater. Therefore, extra precautions should be taken in handling herbs and spices as inappropriate storage could facilitate the growth of fungi and aflatoxin production. According to Seetha, Munthali (36), the aflatoxin content in food could increase by three-fold during storage if inappropriate safety measures are taken. While good attitude and practice are a translation of good knowledge, there is an urgent need to educate the population on safety measures to control aflatoxin contamination in food. It is alarming to note that more than half of the Malaysian were not aware of aflatoxins

Table I: Summary of aflatoxin occurrence in food commodities from Malaysia over the past decade

Food commodity		Positive samples, n (%)	Aflatoxin levels (ug/kg)	Reference
Cereal and cereal products				
Rice, wheat, barley, oat, maize-meal	Total AF	40/80 (50.0)	0.12-4.42	(25)
Black and white rice	Total AF	4/5 (80.0)	1.10-5.28	(26)
	AFB_1	1/5 (20.0)	5.28	
Red rice	Total AF	35/46 (70.0)	0.61-77.33	(27)
Legume and nuts				
Peanut	Total AF	4/9 (44.4)	2.15-6.36	(26)
	AFB_1	2/9 (22.2)	3.16-9.00	
Peanuts and peanut products	Total AF	86/178 (48.3)	0.0-1021.4	(28)
	AFB_1	86/178 (48.3)	0.0-995.4	
Herbs and spices				
Chili	Total AF	9/10 (90.0)	5.85-44.2	(26)
	AFB_1	2/10 (20.0)	10.8-33.2	
Mixed spices, fennel, cumin, turmeric, black pepper, white pepper, dried chili, masala, poppy seed, coriander, and cinnamon	Total AF	50/58 (86.2)	0.01-31.17	(29)
	AFB_1	49/58 (84.5)	0.01-28.43	
Commercial dried chilis	Total AF	52/80 (65.0)	0.2-79.71	(30)
	AFB_1	52/80 (65.0)	0.2-56.61	
Commercial chili and chili sauce	Total AF	85/170 (50.0)	0.1-104.4	(31)
Milk and milk products				
Fresh cow milk	AFM_1	4/102 (3.9)	0.02-0.142	(32)
Liquid and powdered milk, cultured milk, cheese, evaporated and condensed sweetened milk, 3-in-1 beverages, and yogurt	AFM_1	19/53 (35.8)	0.004-0.101	(33)

Note. AF: Aflatoxin

and had poor attitude and practice in controlling aflatoxin contamination in food (37). The findings are in line with the studies in other countries, whereby majority (81.0 %) of 579 maize and groundnut value chain actors in Ghana had never heard of aflatoxins and some of them may give the mouldy grains to livestock (16.0 %) or feed producers (7.4 %) (38). A survey conducted among agriculture extension officers, frontline health workers, and small holder farming households in Malawi showed that over half of the respondents did not perceive aflatoxin contamination as a serious problem and they perceived the problem cannot be controlled (39). Large-scale manufacturers who had better knowledge on aflatoxin contamination, had better hygiene practices as compared with importers, small-scale manufacturers, and retailers in Malaysia (40). This indicates that improved knowledge could lead to better attitude and practices.

High occurrence of aflatoxins was acknowledged in red rice with a total aflatoxin range of 0.61-77.33 ug/kg (27). Red rice is commonly found in the traditional Chinese medicine stores and mainly consumed by Malaysian Chinese for its pharmacological properties. Since the samples were quantified by enzyme-linked Immunosorbent assay (ELISA), a further confirmatory analysis such as high-performance liquid chromatography (HPLC) is required to verify the results (27).

Animal-derived food such as milk, egg, cheese, and meat products are contaminated with aflatoxins when the animals consumed contaminated feed. It has been reported elsewhere that about 1- 6 % of AFB_1 could carry over as AFM_1 in milk 10 hours after ingestion (41, 42). The aflatoxin residue may remain in milk for 5 days after withdrawal of AFB_1 diet (42). The AFM_1 level in milk and milk products in Malaysia were ranged from 0.004 ug/kg to 0.142 ug/kg, which lower than those reported in other Asia countries including Iran (0.006-0.188 ug/kg) (43) and Pakistan (0.001-0.26 ug/kg) (44) but higher than those in Europe countries such as Portugal (0.005-0.069) (45) and Greece (<0.005-0.016 ug/kg) (46). Conversely, eggs and poultry require double time, that is at least 10 days after the administration of AFB_1-free diet, for the clearance of aflatoxin residue (47, 48). An experimental study by Aly and Anwer (49) emphasised that the incorporation of AFB_1 residue in hen eggs may occur even at low aflatoxin level with long exposure. These metabolites accumulating in animal-derived food indeed are chemically and thermally stable during food processing and cannot be destroyed by pasteurisation or heating process (49, 50). Therefore, it is possible that these harmful aflatoxins carry over through animal-derived products into human food chain. Up to date, there is limited data exploring on the total aflatoxin levels of meat and poultry in Malaysia. The total aflatoxin levels of chicken meat and eggs in Pakistan by Iqbal et al. (51) were ranged from 0.10-8.01 ug/kg. The range of contaminated levels in this study was higher than those reported in frozen chicken collected in Egypt (0.25-3.2 ug/kg) (52).

A current review examined the AFB_1 occurrence of various food commodities reported across countries (53). Unlike the trends showed in the present review paper, the authors of previous study revealed that maize had the highest reported aflatoxin levels while sorghum had the highest average frequency of aflatoxin contamination (53). The observed variation on the highest occurrence of aflatoxins in food across geographical location indicates that the growth of fungi and aflatoxin biosynthesis strongly depend on ecological and environmental factors, such as temperature, water activity, moisture content, and light. For example, the growth of *A. flavus* was best at 30-35 ^oC and 0.995-0.98 aw, whereas AFB_1 production was optimum at 25-35 ^oC and 0.995-0.95 aw (34). Both *A. flavus* and *A. parasiticus* are more commonly found in warm humid climates and irrigated hot deserts, such as South Asia, sub-Saharan Africa and Southeast Asia (54). The spread of aflatoxins may reduce in warm humid regions due to increased drought or sun exposure, or may increase in cold climate regions with an increased annual temperature accompanying climate change (55).

Magan and Medina (56) proposed that aflatoxin production could be predicted by three-way interacting environmental factors representative of climate change scenarios: water stress x temperature (+2-4 °C) x two- or three-fold elevated CO2 concentration (350-400 vs 650 and 1,000 ppm). Aflatoxin B_1 production by *A. flavus* may have two- or three-fold more than control at 37 °C, 0.97-0.92 aw, and CO2 concentration of 650 and 1,000 ppm. Latest available data in 2013 reported that the water stress in Peninsular Malaysia was 0.08 (57), which was considered as low level (<0.1) based on the classification of water stress index proposed by Pfister et al. (58). Malaysia had an average increase of 0.13-24 °C for climatic temperature every decade (1969-2016) (21), and 7 ppm for CO2 concentration from 387 ppm to 394 ppm (2009-2012 in Peninsular Malaysia) (59). Although the recent climatic condition in Malaysia is considerably not alarming, the long-term impacts of global climatic change on aflatoxin production cannot be neglected. The growing world population which projected to reach 9.7 billion in 2050 (60), coupled with the rising atmospheric CO2 concentrations from >400 ppm to 685 ppm and increased global temperature of >2 °C by 2050 (61), are critical challenges in the 21st century. The extreme weathers experienced in Malaysia, including thunderstorms and strong winds, extreme flooding event, and progressively hotter weather, are the catalyst for aflatoxin production (20).

AFLATOXIN REGULATIONS

Efforts have been made to control aflatoxin exposures in populations. This includes the implementation of maximum acceptable aflatoxin levels in food. Regulations for aflatoxins in food are often set for AFB_1, AFM_1, and/or total aflatoxins (AFB_1, AFB_2, AFM_1, AFM_2) (62-64). The permissible aflatoxin levels set by different countries are varied from each other. Some countries have regulations specifying for individual foods, while others have only one permissible level for "all foods". For example, United States Food and Drug Administration (FDA) set a maximum limit of total aflatoxins at 20 ug/kg for all food while European Union (EU) has different levels for respective food. Malaysian regulatory limit of aflatoxins for food is compared with other countries, as illustrated in Table II.

The Malaysian maximum level of 35 ug/kg for total aflatoxins in all food was relatively higher than other countries including FDA (20 ug/kg), Thailand (20 ug/kg), and Vietnam (10 ug/kg) (64-66). In parallel, Malaysia

Table II: Regulatory limit of aflatoxins for food in Malaysia as compared with other countries

Country	Food commodities	Type of aflatoxins	Regulatory limit of aflatoxins (ug/kg)	Reference
Malaysia	All food	Total AF	35	(65, 66)
	Cereal-based food for infants and children	AFB_1	0.1	(62)
	Nut and nut-based products (for further processing)	Total AF	15	
	Nut and nut-based products (ready-to-eat)	Total AF	10	
	Milk and milk products	AFM_1	0.5	
	Infant formula and infant milk	AFM_1	0.025	
	Other food	Total AF	5	
EU	Cereal and cereal products, as well as dried fruits (for further processing)	Total AF; AFB_1	4; 2	(63)
	Maize and rice, as well as dried fruits (ready-to-eat)	Total AF; AFB_1	10; 5	
	Cereal-based food for infants and children	AFB_1	0.1	
	Nut and nut-based products (for further processing)	Total AF; AFB_1	10-15; 5-12	
	Nut and nut-based products (ready-to-eat)	Total AF; AFB_1	4-10; 2-8	
	Milk and milk products	AFM_1	0.05	
	Infant formula and infant milk	AFM_1	0.025	
FDA	All food	Total AF	20	(64)
	Milk and milk products	AFM_1	0.5	
China	Maize, peanut	AFB_1	20	(65)
Hong Kong	Peanut and peanut-based products	Total AF	20	(65, 66)
	Other food	Total AF	15	
India	All food	AFB_1	30	(65)
Thailand	All food	Total AF	20	(65, 66)
Vietnam	All food	Total AF	10	(66)
	All food	AFM_1	0.5	

Note. AF: Aflatoxin; EU: European Union; FDA: United States Food and Drug Administration and FDA defined the regulatory limit of AFM_1 in milk and milk products at 0.5 ug/kg, while EU had a lower value of 0.05 ug/kg (62-64). In terms of nut and nut-based products, most countries (Malaysia, EU, and Taiwan) except Hong Kong (20 ug/kg) had maximum total aflatoxin levels that complied with the limit set by global food safety regulatory body-WHO/FAO joint Codex Alimentarius Commission (15 ug/kg) (62, 63, 67-69). All in all, Malaysia has less stringent but reasonably achievable regulatory standards for aflatoxins as compared with those set by developed countries such as EU. This trend seems to be more common in other less developed or developing countries (70). There are various factors play roles in the wide range of varying standards across the countries, including the availability of toxicological and exposure data of aflatoxins, knowledge in mitigating aflatoxin contamination in food commodities, and the status of food supply (71, 72). While food availability could be an issue as consequence of extreme weathers in Malaysia (73, 74), imposing a drastic regulatory measure may cause food shortages, food inflation, and other consequences.

While combating the impact of climatic change on food availability is a long-run process, controlling the aflatoxin exposure through safety measures seems more attainable. The common aflatoxin reduction strategies that have been proposed include (i) good agricultural practice; (ii) biocontrol; (iii) proper packaging for storage; (iv) basic processing (shelling, sorting, and blanching); (v) and detoxification by ozonolysis and ultraviolet irradiation (75). Among all, basic processing was the most effective measure for reducing 39.6 % of all total disability-adjusted life years per year (75). Besides that, aflatoxin biocontrol products have shown to effectively reduce aflatoxin content in crops by 70.0 % to 100.0 % as compared with non-treated crops (76). The most common biocontrol method uses atoxigenic strains of Aspergilli flavus that can competitively exclude toxigenic strains from contaminating the crops (76). Despite of that, biocontrol method may offer public health protection in developed nations but have little effect in less developed countries where majority belongs to informal food sector. In Malaysia, more attention should be paid to small-scale industries since they have less knowledge on the control of aflatoxins as compared with large-scare manufacturers (40).

EXPOSURE ASSESSMENT AND RISK CHARACTERIZATION OF AFLATOXINS

Human exposure to aflatoxins occurs mainly through diet. The bioaccessiblity of AFB_1 from food is relatively high, with the consumed AFB_1 may completely release from food matrix during digestion (86-94 %) (77). The dietary exposure of aflatoxins has been widely studied in the past decades. Table III summarises the dietary exposure and risk assessment of aflatoxins in countries of Asia region. The estimation of dietary aflatoxin exposure from spices and other common consumed food items with peanuts as main contributor in Malaysia were 0.002-12.27 ng/kg body weight (bw)/day and 24.37-34.00 ng/kg bw/day respectively. These estimations were relatively high as compared with the average daily intake of aflatoxins in other Asia countries including China, Hong Kong, Japan, Thailand, and Iran (0.0002-3.16 ng/kg bw/day) (78-82) but falls within the range in Vietnam and Bangladesh (5.00-145.96 ng/kg bw/day) (83-85). It should be noted that the accuracy and reliability of dietary exposure data remains conflict due to the difficulties and inconsistencies in estimating food consumption and the levels of aflatoxin in the consumed food (86). Besides, the published data could not be considered representative since only certain food items were focused which could contribute to bias for the highest level of aflatoxin contamination (11). Instead, the direct measure of aflatoxin exposure through biomarkers is more reliable (87). In Malaysia, aflatoxin exposure was studied among healthy adults, with reported serum AFB_1-lysine adduct levels of 1.13-

Table III: Dietary exposure and risk assessment of aflatoxins in Asia

Country	Food sample	Dietary AFB_1 exposure (ng/kg body weight/day)	Estimated liver cancer risk (cases/100,000 population/year)	Reference
Malaysia	Spices	0.002-12.27	0.00-0.31	(96)
Malaysia	Common consumed food items with peanuts as main contributor	24.37-34.00	0.61-0.85	(97)
China	Common consumed food items with home-made peanut oil as main contributor	0.21-3.16	0.0058-1.3802	(78)
Hong Kong	Common consumed food items with legumes, nuts, and seed as main contributor	0.0002-0.0028	0.033-0.039	(79)
Bangladesh	Dates, groundnut, lentils, chili/spices, wheat, maize, rice	6.96-145.96	0.00291-0.06104	(83)
Vietnam	Common consumed food items with maize as main contributor	5.0-449.4	0.23-21.09	(84)
Vietnam	Common consumed food items with maize as main contributor	35.0-43.7	2.38-2.97	(85)
Japan	Rice	1.20-2.34	0.021-0.040	(80)
Thailand	Brown and colour rice	0.12-0.80	0.011-0.013	(81)
Iran	Cheese including cream cheese and white cheese	0.138 (preschool child)	0.6908 (preschool child)	(82)
		0.076 (adult female)	0.378 (adult female)	
		0.065 (adult male)	0.324 (adult male)	

20.24 pg/mg albumin and urinary AFM_1 levels of 0.001-7.678 ng/ml (88). In addition, urinary AFM_1 was detected among 84 adults (40.8 %) in Terengganu and 199 adults (44.8 %) in Selangor, with respective mean level of 0.59 and 1.23 ng/ml (89, 90).

Liver cancer is the eight most common cancer and a cause of premature death in Malaysia (91). The annual mortality rate per 100,000 population from liver cancer in Malaysia was 6.1 % in 2013, which increased 1.9 % every year since 1990 (92). According to Malaysia National Cancer Registry Report 2012-2016, the incidence of liver cancer increased with age and higher in males than female (91). While aflatoxin exposure has been identified as an agent to liver cancer (11), it is important to perform risk assessment to illustrate the extent of health implications particularly liver cancer caused by the aflatoxin exposure. Based on Table III, most countries including Malaysia had reported risks less than 1 cancer case/100,000 population/year, suggesting that the population may not significantly be at risk of liver cancer attributed to the dietary exposure of aflatoxin. More attention should be taken in China and Vietnam to control the aflatoxin exposure.

It is worthwhile to highlight the findings from Nejad (82) which demonstrated two-fold higher estimated liver cancer risk among preschool child than adults due to higher dietary exposure from the consumption of cheese. It is undeniable that children are more likely to be affected by aflatoxin exposure due to their low body weight and higher milk intake (93). Multiple studies have extensively discussed the link between milk consumption and aflatoxin exposure (90, 93, 94). However, a recent study conducted by Saha Turna et al. (95) defended that the aflatoxin M_1 exposure from liquid milk consumption may only contribute to approximately 0.001 % of total annual liver cancer cases worldwide, suggesting the risk is so low against the nutritional benefits of milk consumption.

CONCLUSION

This review details the aflatoxin occurrence, existing regulation, as well as current exposure and risk assessment in Malaysia. Although aflatoxin-related research has been extensively explored, the aflatoxin contamination in food remains a big challenge in food safety globally including Malaysia. While Malaysia has made efforts in preventing and mitigating aflatoxin contamination through regulations, there is still room for improvement as evidenced by high occurrence in food and exposure level in the population.

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