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DIETARY EXPOSURE ASSESSMENT FOR AFLATOXIN B_1 FROM PROCESSED PEANUT PRODUCTS IN MUNICIPALITY OF BOGOR

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ABSTRACT

A research on dietary exposure assessment for aflatoxin B_1 (AFB1) from processed peanut products in Municipality of Bogor was carried out. The objectives of this study were to determine the contents of AFB1 in processed peanut products at retail levels, and to obtain information whether there is a risk to public health caused by the consumption of processed peanut products contaminated by AFB1. Survey of processed peanut product consumption was carried out by interviewing each respondent using a questionnaire of weekly processed peanut product consumption. Sampling of processed peanut products was conducted at the locations where the respondents obtained processed peanut products. The number of roasted peanuts with skin pods, flour-coated peanuts and *pecel* or *gado-gado* sauces samples was 33, respectively, while the number of *siomay* and *satai* sauces samples was 18 and 12, respectively. The total number of processed peanut product samples was 129. AFB1 content was determined using Thin Layer Chromatography method. Estimation of the dietary exposure assessment was determined using the actual survey data consisting of AFB1 content, consumption data and body weight. The highest contaminated sample percentage and mean of AFB1 content was found in roasted peanuts with skin pods i.e. 42% of 33 samples and 43.2 μg/kg, respectively, followed by flour-coated peanuts (30% of 33 samples and 34.3 μg/kg), and *pecel* or *gado-gado* (21% of 33 samples and 17.1 μg/kg). Mean of estimated dietary exposure for AFB1 found in children was 15.2 ng kg^{-1}bw day^{-1} and 95^{th} percentile exposure was 38.9 ng kg^{-1}bw day^{-1}, while in adults 9.0 ng kg^{-1}bw day^{-1} and 95^{th} percentile exposure was 27.0 ng kg^{-1}bw day^{-1}. The excess cancer risk of AFB1 exposure in Bogor from this study on children and adults was calculated as 193 and 115 cancers/year, respectively.

Key words: dietary exposure assessment, aflatoxin B_1, processed peanut products

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INTRODUCTION

Peanuts are next to rice, maize and soybean as the most important secondary crop in Indonesia. Since Indonesia has a humid tropical climate, peanuts can easily be infected by fungi during the drying phase in the field, or under poor storage conditions. According to Sauer *et al.* (1992) fungal infection can cause a decrease in physical quality of kernels and nutritional content, rancidity, discoloration, and production of mycotoxin, among others aflatoxin. The toxin has been recognized as human and domestic animals carcinogen, and is produced following the infection of peanuts among others by certain strains of *Aspergillus flavus*. In general, aflatoxins found in foodstuffs and their processed products are aflatoxins B_1, B_2, G_1 and G_2. The most dangerous aflatoxin is B_1 (AFB1).

The adverse health effects of aflatoxins can be categorized as either acute or chronic. Acute aflatoxicosis occurs when moderate to high levels of the toxins are consumed and may result in hemorrhage, acute liver damage, rapid progressive jaundice, edema of the limbs, alteration in digestion, absorption and/or metabolism of nutrients, high fever, vomiting, swollen livers and possibly death (Fung & Clark 2004).

Hepatocelullar Carcinoma (HCC), or liver cancer, is the third leading cause of cancer deaths worldwide, with roughly 550 000-600 000 new HCC cases globally each year (WHO 2008). It has been known for several decades that aflatoxin causes liver cancer in humans, however, the exact burden of aflatoxin-related HCC worldwide was unknown. Liu and Wu (2010) conducted a quantitave cancer risk assessment i.e. using global data on food-borne aflatoxin levels, consumption of aflatoxin-contaminated foods, and hepatitis B virus (HBV) prevalence. Aflatoxins have been classified as Group 1 human carcinogen by the International Agency for Research on Cancer (IARC) and demonstrated carcinogenic effects on many animal species, including some rodents, non human primates, and fish (International Programme on Chemical Safety 1998). Groopman *et al.* (2008) reported that specific P450 enzyme in the liver metabolize aflatoxin into a reactive oxygen species (aflatoxin-8,9-epoxide), which may then bind to proteins causing acute toxicity (aflatoxicoses) or to DNA causing lesions that over time increase the risk of hepatocelullar carcinoma (HCC) or liver cancer. For cancer risk assessment, it is traditionally assumed that there is no threshold of exposure to a carcinogen below which there is no observable adverse effect. National Research Council (2008) stated that cancer potency factors are estimated from the slope of the dose response relationship, which is assumed to be linear, between doses of the carcinogen and cancer incidence in a population. According to IPSC/WHO (1998), aflatoxin risk assessment selected two different cancer potency factors for aflatoxin : 0.01 cases/ 100 000/year/nanogram/kilogram body weight per day aflatoxin exposure for individuals without chronic HBV infection, and 0.30 corresponding cases for individuals with chronic HBV infection. Kirk *et al*. (2005) and Ok *et al*. (2007) reported that several epidemiological studies confirm that aflatoxin's cancer potency is about 30 times greater among HBV-positive than among HBV-negative individuals.

Acute outbreaks of aflatoxicosis have been reported from Kenya (Ngindu *et al.* 1982, CDC 2004), India (Krishnamachari *et al.* 1975) and Malaysia (Chao *et al.* 1991, Lye *et al.* 1995). Chronic aflatoxicosis results from ingestion of low to moderate levels of aflatoxins and the effects are impaired food convertion (Shane 1993), slower rates of growth (Gong *et al.* 2002, 2004), and a decrease in various micronutrient levels (Pimpukdee *et al.* 2004).

Many countries have determined maximum tolerable levels of aflatoxins in peanuts and their processed products. Maximum tolerable levels of aflatoxins B_1, B_2, G_1 and G_2 in peanuts and their processed products in Australia, Canada, Philippines and Singapore were 15, 15, 20 and 5 μg/kg, respectively (FAO 2004). Based on SNI (2009) in Indonesia, maximum tolerable limit of AFB1 and total aflatoxins in peanuts and their processed products were 15 and 20 μg/kg, respectively.

Researches on *A. flavus* infection and aflatoxin contamination in raw peanut kernels collected from farmers, collectors, wholesalers, retailers at traditional markets have been conducted by Dharmaputra *et al.* (2005, 2007a). The results indicated that in general the highest aflatoxin contamination of raw peanut kernels was at retailers in traditional markets. Dharmaputra *et al.* (2007b) reported that the high AFB1 contents in raw kernels were due to among others by damaged kernels (discoloured, cracked and broken kernels). Lilieanny *et al.* (2005) stated that the highest aflatoxin content was found in *bumbu pecel* compared to in roasted peanuts with skin pods, roasted peanuts without skin pods, flour-coated peanuts, *bumbu pecel*, and *enting-enting gepuk*.

Data on aflatoxin level in processed peanut products and their consumptions are needed to prepare the dietary exposure assessment for aflatoxin. Most ASEAN countries (including Indonesia) have some data on aflatoxin content in foods, however, no formal risk assessment on aflatoxin has been conducted for the region. This may be due to the lack of technical and financial resources to develop the necessary data and information needed to support or to conduct risk assessment. More data on aflatoxin contents in processed peanut products are needed. In addition, a survey of individual processed peanut product consumption should be conducted to determine aflatoxin exposure assessment (Sparringa 2008).

Dietary assessment is a part of risk assessment, i.e. the process of estimating potential exposure of a population to food chemicals (among others aflatoxin) from the diet and comparing the potential exposure against a reference health standard for risk characterisation purpose. Aflatoxin exposure assessment could be used to estimate the potential exposure/intake of the toxin, to assess the potential risk of health for a population group, and to maintain safe food supply.

The objectives of this study were to determine the contents of AFB1 in processed peanut products at retail levels, and to obtain information whether there is a risk to public health caused by the consumption of processed peanut products contaminated by AFB1.

MATERIALS AND METHOD

Pre-survey

Pre-survey consisted of :

a. Determination of data consumption survey location of processed peanut products :

The location of data consumption survey was carried out at *Kecamatan* (subdistrict) Bogor Tengah covering 11 *kelurahan* (lowest local government), i.e. *Kelurahan* Babakan, Babakan pasar, Cibogor, Ciwaringin, Gudang, Kebon kelapa, Pabaton, Paledang, Panaragan, Sempur, and Tegallega. *Kecamatan* Bogor Tengah has the highest population density (13 445 inhabitants/km^2) and was selected to conduct the survey and sampling. In addition the government center including business activities are also found in this *kecamatan* (BPS Kota Bogor 2008).

b. Determination of respondents :

The data of *Kecamatan* Bogor Tengah office showed that the population at *Kecamatan* Bogor Tengah until March 2009 was 116 686 people. The number of respondents was determined based on the square root of population at *Kecamatan* Bogor Tengah, i.e. 342 respondents. In each *kelurahan*, the number of respondents was determined proportionally based on the number of inhabitants. The respondents were grouped into two categories, i.e. children (6-15 years old, 169 respondents) and adults (16-44 years old, 173 respondents). It was assumed, that most children of 6 years and older like to eat processed peanut products, while the adults are more sensitive to hepatitic.

Survey of processed peanut product consumption

Survey of processed peanut product consumption was carried out by interviewing each respondent using a questionnaire of weekly processed peanut product consumption concerning :

- the kinds of processed peanut products (*bumbu pecel* or *gado-gado*, *bumbu karedok*, *bumbu siomay*, *bumbu batagor*, *bumbu satai*, *bumbu ketoprak*, *oncom hitam*, *kacang garing* or *kacang kulit*, *kacang atom*, *kacang telur*, and *kacang bawang*) consumed by each respondent during the last one week
- the frequency of processed peanut products to be consumed by each respondent during the last week
- portion or product number consumed by each respondent during the last week
- the location where each respondent bought the processed peanut products
- the body weight of each respondent

In addition to interviewing each respondent, observation was also conducted to obtain information about the number of processed peanut product sellers found in the surrounding of respondent domiciles. The information was used at the stage of sampling. During survey in each *kelurahan*, the research team was accompanied by one or two staff of the *kelurahan* who are familiar with the sites.

Sampling method of processed peanut products

Sampling of processed peanut products was conducted at the locations where the respondents obtained processed peanut products, i.e. from *warung pecel* or *gado-gado*, *siomay* and *satai* vendors , and small shops.

The number of samples of each processed peanut product was determined based on the number of processed peanut product sellers found in the surroundings of the respondent domiciles. The number of roasted peanuts with skin pods, flour-coated peanuts and *pecel* or *gado-gado* sauces samples were 33, respectively, while the number of *siomay* dan *satai* sauces samples were 18 and 12, respectively. The total number of processed peanut products samples was 129.

Each sample consisted of 5 portions of processed peanut products in the form of sauce (*pecel* or *gado-gado*, *siomay*, and *satai* sauces) and 2 kg (= 100 small packs, weight @ 20 g) of other processed peanut products (roasted peanuts with skin pods and flour-coated peanuts). At the time of purchase, the main materials of *pecel* or *gado-gado*, *siomay* and *satai* were packed separately from their peanut sauces. One portion of *gado-gado*, *siomay* and *satai* contained 75, 50 and 60 g peanut sauces, respectively. Each sample was mixed manually and homogenously, and then divided into two parts to obtain working samples for AFB1 content determination and a reserve sample. AFB1 content was only determined in peanut sauces.

Determination of aflatoxin B_1 content

AFB1 content was determined using Thin Layer Chromatography (TLC) method (AOAC 2005). Two replicates were used from each sample. AFB1 was extracted from ground processed peanut products using methanol-H_2O. The filtrate was diluted using NaCl solution and defatted using hexane. AFB1 was partitioned into chloroform, then it was removed through evaporation, and quantitated using TLC on silicagel plate by visual estimation, i.e. by comparing the spot of standard and sample.

Estimation of the Dietary Exposure Assessment for AFB1

Exposure assessment involves estimating the intensity, frequency, and duration of human exposures to a toxic agent. Dietary exposure to aflatoxin B_1 in *Kecamatan* Bogor Tengah was estimated using the AFB1 concentration data, food consumption data and mean body weight. AFB1 exposure was calculated on the group of average consuming (mean) and high consuming (95% percentile). Consumption data were obtained from Food Frequency Questionnaire. The estimation of dietary exposure assessment for AFB1 was determined based on the following formula (WHO 2008):

$$\underset{(\text{ng/kg bw/day})}{\text{Dietary exposure}} = \frac{\underset{(\text{kg/day})}{\text{Food consumption}} \times \underset{(\mu\text{g/kg})}{B_1 \text{ Aflatoxin concentration}}}{\underset{(\text{kg})}{\text{Body weight}}} \times 1{,}000$$

RESULTS AND DISCUSSION

Pattern of Processed Peanut Product Consumption

Based on five big ranks of consumers, roasted peanuts with skin pods (63% of the total respondent number) ranks first among 11 kinds of consumed processed peanut products in *Kecamatan* Bogor Tengah, followed by flour-coated peanuts (54.5% of the respondents), *siomay* sauce (54% of the respondents), *pecel* or *gado-gado* sauce (49% of respondent number) and *satai* sauce (34% of the respondents) (Table 1).

In general, either child or adult respondents, bought roasted peanuts, flour-coated peanuts, *pecel* or *gado-gado*, and *siomay* from *warung*, *warung pecel* or *gado-gado* and vendors. In general child respondents bought *satai* from vendors, while adult respondents bought it from *warung satai*. The mean highest number of processed peanut product consumption of child and adult respondents was 0.0110 kg/day and 0.0149 kg/day, respectively, for *pecel* or *gado-gado* (Table 2). The mean consumption number was obtained from the mean consumption frequency in one day multiplied by the mean consumption portion.

Aflatoxin B_1 Content

AFB1 contents were determined in five most consumed processed peanut products i.e. roasted peanuts, flour-coated peanuts, *pecel* or *gado-gado* sauce, *siomay* and *satai* sauces.

The highest contaminated sample percentage and mean of AFB1 conteent was found in roasted peanuts with skin pods (42% of 33 samples and 43.2 μg/kg), followed by flour-coated peanuts (30% of 33 samples and 34.3 μg/kg), and *pecel* or *gado-gado* (21% of 33 samples and 17.1 μg/kg). (Table 3).

Table 1. Number of respondents who consumed processed peanut products in *kecamatan* (subdistrict) of Bogor Tengah

Respondent	Gender		Number of respondents	Kind of processed peanut products										
	Male	Female		1	2	3	4	5	6	7	8	9	10	11
Childs	73	96	169	70 (21%)	12 (4%)	109 (32%)	84 (25%)	59 (17%)	25 (7%)	11 (3%)	125 (37%)	109 (32%)	23 (7%)	9 (3%)
Adults	33	140	173	97 (28%)	28 (8%)	75 (22%)	25 (7%)	58 (17%)	30 (9%)	48 (14%)	90 (26%)	77 (22.5%)	23 (7%)	19 (6%)
Total	106	236	342	167 (49%)	40 (12%)	184 (54%)	109 (32%)	117 (34%)	55 (16%)	59 (17%)	215 (63%)	186 (54.5%)	46 (13.5%)	28 (9%)
Rank of the products consumed from 1st up to 5th				4		3		5			1	2		

Note :

1 =	*Pecel/gado-gado*	7 =	*Oncom hitam* (Black oncom)
2 =	*Karedok*	8 =	*Kacang kulit* (Roasted peanuts with skin pods)
3 =	*Siomay*	9 =	*Kacang atom* (Flour-coated peanuts)
4 =	*Batagor*	10 =	*Kacang telur* (Egg-coated peanuts)
5 =	*Sate*	11 =	*Kacang bawang* (Garlic peanuts)
6 =	*Ketoprak*		

Table 2. Frequency, portion and consumption number of processed peanut products in *Kecamatan* Bogor Tengah

Respondent	Kind of product	Place of purchase*)	Mean of consumption frequency per day	Mean of portion (kg)	Mean of consumption number (kg/day)
Children	Roasted peanuts with skin pods	*Warung* (small shop)	0.40	0.0204	0.0082
	Flour-coated peanuts	*Warung*	0.31	0.0096	0.0030
	Pecel/gado-gado sauce	*Warung pecel/gado -gado*	0.24	0.0460	0.0110
	Siomay sauce	Vendor	0.31	0.0164	0.0051
	Satai sauce	Vendor	0.28	0.0224	0.0063
Adults	Roasted peanuts with skin pods	*Warung*	0.34	0.0290	0.0099
	Flour-coated peanuts	*Warung*	0.32	0.0090	0.0029
	Pecel/gado-gado sauce	*Warung pecel/gado-gado*	0.26	0.0572	0.0149
	Siomay sauce	Vendor	0.30	0.0263	0.0079
	Satai sauce	*Warung satai*	0.21	0.0305	0.0064

*) Small part of the respondents bought processed peanut products in traditional- and supermarkets or they prepared the products by themselves

Table 3. Aflatoxin B_1 content of processed peanut products at *Kecamatan* Bogor Tengah and maximum tolerable limit (MTL) of AFB1 based on SNI (2009)

Kind of processed peanut products	No. of samples	Number (%) of samples contaminated by AFB 1	Number (%) of samples contaminated by AFB 1 > 15 μg/kg	Range and mean of AFB1 content (μg/kg)
Roasted peanuts with skin pods	33	14 (42%)	14 (42%)	0 – 316.80 (43.21)
Flour-coated peanuts	33	10 (30%)	10 (30%)	0 – 160.00 (34.28)
Pecel/gado-gado sauce	33	9 (27%)	7 (21%)	0 – 197.80 (17.11)
Siomay sauce	18	2 (11%)	2 (11%)	0 – 39.90 (4.41)
Satai sauce	12	2 (17%)	2 (17%)	0 – 198.58 (23.17)
MTL (SNI 2009)				15

The best way to control the presence of aflatoxins in foods and feeds is through good agricultural and manufacturing practices which could prevent fungal growth. Aflatoxins are thermostable compounds and, once formed, they can persist in animal feeds and food. The usual methods of processing peanuts to make peanut butter and processing nuts for confectionery may appreciably reduce aflatoxin contamination. Effective means of reducing aflatoxin contamination include removing undersized nuts, removing nuts that resist splitting and blanching, and removing discoloured nuts by hands or electric sorting (Cole 1989).

Percentage of samples contaminated by AFB1 and AFB1 content of *pecel* or *gado-gado* sauce was relatively high. It was probably due to the low quality of peanuts used to prepare the sauces or containers used to store peanut kernels and to prepare the sauces were not clean.

Percentage of samples contaminated by AFB1 and the mean of AFB1 content in *siomay* sauce were relatively low (11% of 18 samples and 4.4 μg/kg). The percentage of *sate* sauce samples contaminated by AFB1 was also relatively low, i.e. 17% of 12 samples, but the mean of their AFB1 contents was relatively high, i.e. 23.2 μg/kg (Table 3).

In Indonesia the maximum tolerable limit (MTL) of AFB1 for peanuts and their processed products is 15 μg/kg (SNI 2009). Percentage of roasted peanuts with skin pods, flour-coated peanuts, *pecel* or *gado-gado* sauce, *siomay* sauce and *satai* sauce samples contaminated by AFB1 exceeded 15 g/kg i.e. 42% of 33 samples, 30% of 33 samples, 21% of 33 samples, 11% of 18 samples, and 17% of 12 samples, respectively (Table 3). Based on the mean of AFB1 content, among the five processed peanut products, *siomay* sauce has a mean AFB1 content lower than the MTL (4.41 g/kg). Two out of 18 samples were contaminated by AFB1 exceeding 15 g/kg. The other four processed peanut products contained mean of AFB1 contents higher than MTL. Consequently, risk management of the four products is suggested to be applied.

Lilieanny *et al.* (2005) stated that total aflatoxin contents of roasted peanuts with skin pods (47 samples), flour-coated peanuts (22 samples), *bumbu pecel* (12 samples) and *enting-enting gepuk* (4 samples) collected from several factories, supermarkets, and traditional markets in Bogor, Malang, Pati and Yogyakarta from January up to August 2002, were 1.8, 5.2, 41.6 and 20.8 μg/kg, respectively. Aflatoxin was not detected in roasted peanuts without skin pods (3 samples).

Estimation of the Dietary Exposure for Aflatoxin B_1

Mean of estimated dietary exposure for AFB1 in children was 15.2 ng kg^{-1}bw day^{-1} and 95^{th} percentile exposure was 38.9 ng kg^{-1}bw day^{-1}, while in adults 9.0 ng kg^{-1}bw day^{-1} and 95^{th} percentile exposure 27.0 ng kg^{-1}bw day^{-1} (Table 4). The major contributing foods for AFB1 in children and adults was roasted peanuts with skin pods, followed by *pecel/gado-gado* sauce, *satai* sauce, flour-coated peanuts and *siomay* sauce, while the highest contaminated level was roasted peanuts with skin pods, followed by flour-coated peanuts, *satai* sauce, *gado-gado* sauce and *siomay* sauce. The estimated highest exposures to AFB1 by consuming roasted peanuts with skin pods were 44.5% (adult respondents) and 43% (child respondents) of total exposure to AFB1 (Table 4). Further researches on the risk management of roasted peanuts with skin pods are needed.

The mean dietary intake of aflatoxin for Australian and Swedes were 0.15 and 0.8 ng kg^{-1} bw day^{-1}, respectively (Thuvander *et al.* 2001), for Americans 0.26 ng kg^{-1} bw day^{-1} (JECFA 1998), for French adults (>15 years old) was 0.1 ng kg^{-1} bw day^{-1}, while for children (ages 3-14) was 0.3 ng kg^{-1} bw day. It was assumed, that Bogor community consumed processed peanut products containing higher content of AFB1 compared to other countries. However, Li *et al.* (2001) reported that in Guangxi, China, the probably daily intake of processed peanut products was estimated 3,680 ng kg^{-1} bw day^{-1}.

From the five processed peanut products, the lowest dietary exposure for AFB1 was *siomay* sauce, either on children or adult respondents. Dietary exposure for AFB1 of the five products on children respondents was higher than that of adult respondents (Table 4). This was due to the body weight of children which was lower than that of adults. The lower the body weight of the consumer, the higher the dietary exposure of AFB1.

Table 4. Dietary exposure assessment for aflatoxin B_1 from processed peanut products at *Kecamatan* Bogor Tengah

Respondent	Kind of product	Mean of consumption number (kg/day)	Mean of AFB1 content (μg/kg)	Mean of body weight (kg)	Dietary exposure for AFB1 (ng/kg body weight /day)	Percentage of total daily intake
Childs	Roasted peanuts with skin pods	0.0082	43.21	33	10.6	43.0
	Flour-coated peanuts	0.0030	34.28	32	3.4	13.7
	Pecel/gado-gado sauce	0.0110	17.11	32	5.6	22.8
	Siomay sauce	0.0051	4.41	32	0.7	2.8
	Satai sauce	0.0063	23.17	31	4.4	17.7
Adults	Roasted peanuts with skin pods	0.0099	43.21	56	7.4	44.5
	Flour-coated peanuts	0.0029	34.28	57	1.8	10.7
	Pecel/gado-gado sauce	0.0149	17.11	56	4.4	26.3
	Siomay sauce	0.0079	4.41	56	0.6	3.5
	Satai sauce	0.0064	23.17	57	2.5	15.0

Risk Assessment

To evaluate the potential health risk of Bogor community to AFB1, a risk assessment of AFB1 should be conducted by comparing the estimation of dietary intake and Provisional Maximum Tolerable Daily Intakes (PMTDI). As AFB1 is a genotoxic carcinogen, the safety factors used for non-genotoxic carcinogens cannot be applied. Therefore, most agencies, including JECFA and US FDA, have not determined yet a tolerable daily intake for AFB1.

JECFA proposed the potency value of 0.3 cancer cases per year per 100 000 population per ng aflatoxin per kg body weight for hepatitis B positive individuals, while the potency value for the non-hepatitis B population was 0.01 cancer cases per year per 100 000 population per ng aflatoxin per kg body weight (JECFA 1997). Based on the potency value of 0.3 and 0.01 cancers per year per 100 000 population per ng aflatoxin per kg body weight, prevalence of hepatitis B in Bogor was 1.4% (Departemen Kesehatan Republik Indonesia 2008), while the population of Bogor end 2007 was 905 132 (BPS Kota Bogor 2008). Consequently, the results of this study showed that the cancer risk of AFB1 exposure in Bogor on children and adults was 193 and 115 cancer cases/year, respectively. Therefore, cancer risk could increase due to the consumption of highly AFB1 contaminated processed peanut products.

AFB1 is an unavoidable food contaminant. To evaluate the potential health risk of AFB1 caused by food consumption, it is important to determine the natural occurrence of AFB1 in food and to estimate the risk for liver cancer through dietary exposure to AFB1. Ok *et al.* (2007) reported that the level of AFB1 contamination in 28 of the 32 food products in South Korea was less than 10 kg^{-1}, which is the legal tolerance limit in Korea. From data on daily food consumption, the exposure dose of AFB1 was estimated to be 6.42×10^{-7} mg kg^{-1} body weight day^{-1}. The risk of liver cancer for those exposed to AFB1 through food intake was estimated to be 5.78 x 10^{-6} for hepatitis B-negative individuals and 1.48 x 10^{-4} for hepatitis B-positive individuals.

CONCLUSIONS

The highest contaminated sample percentage and mean of AFB1 content was found in roasted peanuts with skin pods (42% of 33 samples and 43.2 μg/kg), followed by flour-coated peanuts (30% of 33 samples and 34.3 μg/kg), and *pecel* or *gado-gado* (21% of 33 samples and 17.1 μg/kg). The percentage of *sate* sauce samples contaminated by AFB1 was also relatively low, i.e. 17% of 12 samples, but the mean of their AFB1 contents was relatively high, i.e. 23.2 μg/kg. Among the five processed peanut products, *siomay* sauce has a mean AFB1 content lower than the MTL (4.41 g/kg). The other four processed peanut products contained AFB1 higher than MTL. Consequently, risk management of the four products is suggested to be applied. In addition, aflatoxin contamination can be minimized by using good practices, from farm up to table.

Mean of estimated dietary exposure for AFB1 on children was 15.2 ng kg^{-1}bw day^{-1} and 95^{th} percentile exposure was 38.9 ng kg^{-1}bw day^{-1}, while on adults 9.0 ng kg^{-1}bw day^{-1} and 95^{th} percentile exposure was 27.0 ng kg^{-1}bw day^{-1}. The cancer risk of AFB1 exposure in Bogor from this study on children and adults showed 193 and 115 cancer cases /year, respectively. Therefore, cancer risk could increase due to the consumption of highly AFB1 contaminated processed peanut products.

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REFERENCES

AOAC. 2005. Natural toxins. In : Horwitz W, editor. Official methods of Analysis of AOAC International. Association of Official Analytical Chemist, Gaithersburg. 18th ed. Ch.49. p 11

BPS Kota Bogor. 2008. Kota Bogor dalam Angka 2008. Badan Pusat Statistik Kota Bogor, Bogor.

Center for Disease Control and Prevention (CDC). 2004. Outbreak of aflatoxin poisoning - Easter and Central Provinces, Kenya. Morbid Mortal Weekly Report 53: 790 - 793

Chao TC, Maxwell SM, Wong SY. 1991. An outbreak of aflatoxicosis and boric acid poisoning in Malaysia: a clinicopathological study. J Pathol 164: 225 - 33

Cole RJ. 1989. Technology of aflatoxin decontaminantion..:Natoris, Hashimoto K, Ueno Y (editors). *Mycotoxins and Phytotoxins'88*. Elsevier Science Publishers, Amsterdam

DEPKES RI. 2008. Laporan Hasil Riset Kesehatan Dasar Provinsi Jawa Barat Tahun 2007. Departemen Kesehatan Republik Indonesia, Jakarta

Dharmaputra OS, Retnowati I, Ambarwati S, Maysra E. 2005. *Aspergillus flavus* infection and aflatoxin contamination in peanuts at various stages of the delivery chain in Cianjur regency, West Java, Indonesia. Biotropia 24: 1 - 19

Dharmaputra OS, Retnowati I, Ambarwati S. 2007a. *Aspergillus flavus* infection and aflatoxin contamination in peanuts at various stages of the delivery chain in Wonogiri regency, Central Java, Indonesia. Biotropia 14 (2): 9 - 21

Dharmaputra OS, Retnowati I, Ambarwati S. 2007b. Physical quality and relative humidity affecting *Aspergillus flavus* infection and aflatoxin contamination in peanut kernels. In : Sumardiyono YB *et al.* (editors). Proceedings of the 3rd Asian Conference on Plant Pathology, Yogyakarta, Indonesia, 20 - 23 August 2007. p. 306-8

Fung F, Clark RF. 2004. Health effects of mycotoxins: a toxicological overview. J Toxicol Clin 42 (2) : 217-234.

Gong YY, Cardwell K, Hounsa A, Turner PC, Hall AJ, Wild CP. 2002. Dietary aflatoxin exposure and impaired growth in young children from Benin and Togo: cross sectional study. British Med J 325: 20 - 21

Gong YY, Hounsa A, Egal S, Turner PC, Sutcliffe AE, Hall AJ, Cardwell K, Wild CP. 2004. Postweaning exposure to aflatoxin results in impaired child growth: a longitudinal study in Benin, West Africa. Environ Health Perspective 112: 1334 - 38

Groopman JD, Kensler TW, Wild CP. 2008. Protective interventions to prevent aflatoxin-induced carcinogenesis in developing countries. Ann Rev Pub Health 29:187-203

IPCS and WHO. 1998. International Programme on Chemical Safety. Safety evaluation of certain food additives and contaminants. WHO Food Additives Series 40. Available: http://www.inchem.org/documents/jecfa/jecmono/v040je01.htm

JECFA. 1997. Aflatoxins B, G and M. 49th Joint FAO/WHO Expert Committee on Food Additives, Rome 17 - 26 June 1997. WHO Document PCS/FA/97.17

JECFA. 1998. The safety evaluation of Certain Food Additives and Contaminant : Aflatoxin. The forty-ninth meeting of the Joint FAO/WHO Expert Committee on Food Additives. Series No. 40. WHO, Geneva.

Kirk GD, Lesi OA, Mendy M, Szymanska K, Whittle H, Goedert JJ. 2005. 249(ser) TP53 mutation in plasma DNA, hepatitis B viral infection, and risk of hepatocellular carcinoma. Oncogene 24(38): 5858-67

Krishnamachari KA, Nagaarajan V, Bhat RV, Tilak TB. 1975. Hepatitis due to aflatoxicosis - an outbreak in Western India. Lancet 305: 1061 - 63

Li FQ, Yoshizawa T, Kawamura O, Luo XY, Li YW. 2001. Aflatoxin and fumonisin in corn from the high-incidence area for human hepatocelullar carcinoma in Guangxi, China. J Agric Food Chem 49:4122-4126

Lilieanny, Dharmaputra OS, Putri ASR. 2005. Population of postharvest mould and aflatoxin content of processed peanut products. (*Populasi kapang pascapanen dan kandungan aflatoksin pada produk olahan kacang tanah*). J Microbiol Indon 10 (1): 1 - 20. (In Indonesian, with abstract in English).

Lye MS, Ghazali AA, Mohan J, Alwin N , Mair RC. 1995. An outbreak of acute hepatic encephalopathy due to severe aflatoxicosis in Malaysia. American Journal of Tropical Medicine Hygiene 53: 68 - 72

National Research Council 2008. Science and Decisions: Advancing Risk Assessment. National Academic Press, Washington, DC.

Ngindu A, Johnson BK, Kenya PR, Ngira JA, Ocheng DM, Nandwa H, Omondi TN, Jansen AJ, Ngare W, Kaviti JN, Gatei , Siongok TA. 1982. Outbreak of acute hepatitis by aflatoxin poisoning in Kenya. Lancet 1: 1346 - 48

Ok HE, Kim HJ, Shim WB, Lee H, Bae DH, Chung DH, Chun HS. 2007. Natural occurrence of aflatoxin B_1 in marketed foods and risk estimates of dietary exposure in Koreans. J Food Protect 70 (12) : 2824-28

Pimpukdee K, Kubena LF, Bailey CA, Huebner HJ, Afriyie-Gyawu E, Phillips TD. 2004. Aflatoxin-induced toxicity and depletion of hepatic vitamin A in young broiler chicks: protection of chicks in the presence of low levels of Novasil Plus ™ in the diet. Poultry Sci 83: 737 - 44

Sauer DB, Meronuck RA, Christensen CM. 1992. Microflora. In : Sauer DB (editor). Storage of Cereal Grains and Their Product. 4th ed. American Association of Cereal Chemist, Minnesota. 313 - 40

Shane SM. 1993. Economic issues associated with aflatoxins. In : Eaton DL, Groopman JD (editors). The toxicology of aflatoxins: human health, veterinary, and agricultural significance. Acad Press, London. p 513 - 27

SNI. 2009. Standar Nasional Indonesia. Maximum Limit of Mycotoxin Content in Food. (*Batas Maksimum Kandungan Mikotoksin dalam Pangan*). SNI 7385: 2009. Badan Standardisasi Nasional, Jakarta

Sparringa RA. 2008. Total diet study and chemical risk assessment in foods. (*Studi diet total dan kajian paparan bahan kimia dalam pangan*). Paper presented at Seminar Pra-2 Widyakarya Nasional Pangan dan Gizi ke-IX 2008, Kelompok Kerja Mutu dan Keamanan Pangan. Jakarta, 9 June 2008

Thuvander A, Moller T, Barbieri HE, Janson A, Salomonsson Aca, Olsen M. 2001. Dietary intake of some important mycotoxin by Swedish population. Food Additives and Contaminant 18 : 696-706

World Health Organization of United Nation (WHO), 2004. Worldwide Regulations for Mycotoxins in Food and Feed in 2003; FAO Food and Nutrition paper 81. Food and Agriculture Organization of the United Nations, Rome

WHO. 2008. The Global Burden of Disease : 2004 Update. Geneva : World Health Organization. Available at http://www.who. Int/healthinfo/global_burden_disease/ 2004_reportupdate/en/index.html)

WHO. 2008. Dietary Exposure Assessment of Chemicals in Food. Report of a Joint FAO/WHO Consultation. Annapolis, Maryland, USA, 2-6 May 2005. WHO Press, Geneva

Yan Liu, Felicia Wu. 2010. Global Burden of Aflatoxin-indiced Hepatocellular Carcinoma : A Risk Assessment. Environ Health Perspectives 118 (6): 818-24 .