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Exposure and knowledge on peanut aflatoxin B1 among urban consumer in Jakarta, Indonesia

Paparan dan pengetahuan tentang aflatoksin B1 dari kacang tanah di kalangan konsumen perkotaan di Jakarta, Indonesia

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Abstract

Groundnut (*Arachis hypogaea L*), an important food in the Indonesian diet, has been reported to be contaminated with the carcinogenic Aflatoxin B1. However, research on consumer knowledge of and exposure to AfB1 from peanuts in Indonesia is limited. This study aimed to assess the exposure to aflatoxin B1 (AfB1) in peanuts consumed by urban Jakarta and their knowledge of aflatoxin risk. This observational study had a cross-sectional design and involved 192 randomly selected respondents. Peanut intake frequency was measured using a semi-quantitative FFQ instrument. Questionnaires were used to collect data regarding knowledge and income. The AfB1 content was analyzed using HPLC. Pearson Chi-Square test was used for analysis. The results showed that AfB1 contaminants were present in all the samples. Respondents who frequently consumed high amounts of peanuts and processed products were exposed to AfB1, with a median of 22.55 ppb bb/day. There were no significant relationships between knowledge and AfB1 exposure (p= 0.874), age (p= 0.884), or income (p= 0.355). In conclusion, aflatoxin B1 exposure was high in urban areas. No relationship was found between knowledge of and exposure to AfB1 peanuts. Inter-sectoral strengthening of the empowerment and control of aflatoxin exposure is needed, as are economic and health impact studies on AfB1 exposure.

Keywords: Aflatoxin B1 exposure, contaminated peanuts, knowledge, urban

Abstrak

Kacang tanah (*Arachis hypogaea L*) pangan penting dalam diet masyarakat Indonesia, telah dilaporkan terkontaminasi karsiogenik Aflatoksin B1. Namun penelitian di Indonesia tentang pengetahuan konsumen dan paparan AfB1 dari kacang tanah masih terbatas. Penelitian bertujuan untuk mengkaji paparan aflatoksin B1 (AfB1) dari kacang tanah yang dikonsumsi masyarakat perkotaan Jakarta dan mengkaji pengetahuan mereka terhadap risiko aflatoksin. Penelitian observasional berdesain potong lintang, melibatkan 192 responden yang dipilih secara acak. Frekuensi asupan kacang tanah diukur dengan menggunakan instrument Semi kuantitatif–FFQ yang teruji. Kuesioner untuk mengumpulkan pengetahuan dan pendapatan. Kandungan AfB1 dianalisa denganHPLC. Analisis menggunakan uji Pearson Chi-Square. Hasil, menunjukkan kontaminan AfB1 ditemukan pada semua sampel. Responden yang sering mengonsumsi dalam jumlah tinggi produk kacang tanah dan olahannya terpapar AfB1dengan median 22,55 ppb bb/hari. Tidak terdapat hubungan bermakna antara pengetahuan dengan paparan AfB1 (p= 0,874), begitu juga usia (p= 0,884), dan pendapatan (p=0,355). Kesimpulan, paparan aflatoksin B1 masih tinggi dikonsumsi oleh masyarakat perkotaan. Tidak terdapat hubungan antara pengetahuan dengan paparan AfB1 kacang tanah. Diperlukan penguatan antarsektor tentang pemberdayaan dan pengendalian paparan Aflatoksin serta studi dampak ekonomi dan kesehatan terkait paparan AfB1.

Kata Kunci: Kacang tanah terkontaminasi, pengetahuan, aflatoksin, paparan aflatoksin B1

Introduction

People may be at risk of aflatoxin exposure from contaminated food. This is considered a significant risk to human health. Aflatoxin contamination affects up to 26 million Disability Adjusted Life Years (DALY) number and hundred deaths. It has been shown to slow a child's growth, leading to stunting. It is also considered the strongest genotoxic carcinogen and has a high liver cancer risk among hepatitis B and hepatitis C carriers (Jubeen et al., 2022). The total Aflatoxin intake from peanuts, peanut oil, corn, and its products was 4.018 ppb bw/day, resulting in 0.125 extra Hepatocellular Carcinoma cases per year/100,000person in China (Chen, 2022; Jubeen et al., 2022).

Peanuts (*Arachis hypogaea L*) and its products play a major role in the Indonesian diet. Nevertheless, some studies have found that peanuts may be contaminated by aflatoxin B1 (AfB1), but its link to consumer knowledge has not yet been reviewed (Ambarwati & Dharmaputra, 2011; Nugraha et al., 2018). The Indonesian government has set a tolerance limit for aflatoxin B1 of 15 ppb in agricultural products, including peanuts, to protect consumer health (BPOM, 2018).

Jakarta is a densely populated urban area with great exposure to diverse foods owing to a wide variation in sociocultural backgrounds. Some studies among Malawi, Kenya's caregivers, and German students have shown that they have a rather low level of knowledge and a weak perception of aflatoxin and its associated risks (Lesuuda et al., 2021; Matumba et al., 2015; Muñoz et al., 2021). Understanding peanut consumption and AfB1 content is necessary to overcome these problems. However, this type of study is scarce in Indonesia.

The aim of this study was to investigate the dietary exposure to AfB1 in peanut products among urban people living in Jakarta and assess their knowledge, attitude, and practices toward the risk of peanut aflatoxin.

Methods

This observational study used a cross-sectional approach and was conducted in Jakarta, Japan. Stratified multi-stage sampling was used to randomly select (four) sub-districts (four) villages in the study area. The sample size was calculated by using a formula to estimate the population proportion. The population proportion was 44.5%, which is the estimated percentage of the highest exposure to Aflatoxin B1 by consuming roasted peanuts with skin pods in the Bogor study. A confidence level of 95%, absolute precision of 0.1, and a design effect of 2. A total of 192 households were randomly selected to enroll the study coming from Sumur Batu, Paseban, Johar Baru and Rawasari villages. This method will hopefully represent a larger population of urban consumers in Jakarta. The inclusion criteria were household members who were involved in decision-making regarding family food consumption, living in the area for at least one year, available during the interview visit, and no mental disorder. Respondents were excluded if they were allergic to peanut products.

A structured questionnaire was used to obtain respondents' demographic characteristics, knowledge, and perceptions of aflatoxin. A semi-quantitative food frequency questionnaire (SQ-FFQ) was used to assess the respondents' food consumption patterns. Prior to the study, a market basket survey was conducted to prepare a list of peanuts consumed and the places where the food was commonly obtained by the respondents. Finally, it contained 15 items of peanut products. A dietary using 3-consecutive days of Food Records of respondents living in Senen sub-district was used to assess the validity of the SQ-FFQ instrument. The results showed that the item products, menu completeness, and intake amount showed consistent patterns. The WHO/FAO guidelines on dietary exposure food chemicals procedures were used to assess the aflatoxin content.

The respondents' favorite foods derived from their food consumption patterns were collected from the area surrounding their residence. Approximately 250 g of the most frequently consumed peanut products were collected from local vendors or shops. Fifty food samples from 124 individual peanut products were transported in a clean cool box and stored at 4-5 ^{o}C prior to aflatoxin content analysis (FAO/WHO, 2020; Latimer, 2016).

AfB1 content was analyzed using high-performance liquid chromatography (HPLC) with an immunoaffinity column in an ISO 17025 accredited laboratory. A C18 analytical column was used with methanol and water as the mobile phase and fluorescence as the detector. The sample was extracted with methanol and purified through the immuno-affinity column before going to the HPLC detector (Latimer, 2016).

Efforts have been made to ensure the quality of the study. The structured questionnaires were pretested, and enumerators were trained prior to data collection. A paired-check questionnaire was administered twice daily by enumerators and field supervisors after each interview was completed. Field supervisors rechecked the interviews and food sampling procedures daily. Re-interviews with 10% of the respondents were also conducted. The content of the perception instruments consisted of nine knowledge items and six perceptions of attitude- and practice-related items, which were carefully selected and verified its content validity with microbiology experts. Pre-testing of the instruments was performed in different sub-districts but with similar socio-economic characteristics to ensure clarity and acceptance for both enumerators and respondents (face validity). After pre-testing, the updated version of the construct consisted of 6 items from the initial 12 items.

The perception questionnaire was tested with a Cronbach's alpha coefficient of 0,658, showing good reliability of the instrument. The Agilent type 1260 HPLC was calibrated daily, and internal quality control was applied using a control sample.

Data collection and aflatoxin analysis were performed from January to March 2016, and ethical permission was obtained from the Faculty of Medicine Universitas Indonesia number 513/UN2.F1/ETIK/2015, and permission from local governments. Data from the questionnaire were entered and analyzed using SPSS for Windows version 26.0. Correct answers to the knowledge items of the multiple-choice questions were assessed as good knowledge, while incorrect answers were assessed as poor knowledge. A mean score of 4 was used as the cutoff for overall knowledge (0-4 as poor, >4-9 as good). Each statement of the perceptions towards their attitudes and practices items was weighted as "good " for strongly agree and agree statement, while weighted as "weak " for neutral, disagree, and strongly disagree statements. Pearson Chi Square test with 5% significantly level was used to assess the association between their knowledge and perceptions towards attitude and practices of the respondents with the AfB1 exposures.

Result and Discussion

In total, 192 participants completed the study. Table 1 shows the respondents' characteristics, daily peanut consumption, and aflatoxin B1 content.

Table 1. Characteristic, peanut consumption and AfB1 exposure of respondents (n=192)

Age in years, med (25th- 75th)	38 (34-43)
Respondent's weight in kg, med (25th- 75th)	61,1(53,7-69,0)
Educational level	n (%)
Completed primary school	18 (9,4)
Completed junior high school	41 (21,4)
Completed senior high school	117 (60,9)
Completed college	16 (8,3)
Occupation	
Housewife	153 (80,1)
Others *	39 (19,9)
HH Monthly income in IDR, med (25th- 75th) **	3.000.000 (2.000.000-4.875.000)
Ethnics	
Sundanese	42 (21,9)
Javanese	71 (37,0)
Betawi	72 (37,5)
Others (Batak, Minang, Bugis)	7 (3,6)
Owned the house	61 (31,8)
Household member	
≤ 4 people	71(37,0)
> 4-9 people	121 (63,0)
Peanuts consumption and aflatoxin B1 exposure	
Number of peanuts products consumed per day	5 (1-9)

Amount of peanuts consumed in g, med (25th - 75th)	16,07 (6,93-29,96)
Peanut containing aflatoxin B1 consumed in ppb, med (25th – 75th)	77,20 (32,74-144,04)
Dietary exposure to peanut aflatoxin B1 in ppb bwday, med (25th - 75th)	22,55 (3,91-72,03)

*) Entrepreneur, private employee, civil servant, daily laborer
**)1 US$ = 14.000 IDR

The majority of respondents were housewives, with a median age of 38 years, and approximately 2/3 had senior high school education. Most came from a low-income class, with an average monthly income of IDR 3.000.000, lower than the regional minimum wage, and only 1/3 lived in their own house. On average, the respondents consumed about five types of peanut products, about 16.07 g/day, with 77.20 ppb of AfB1 content. Through market surveys and FFQ interviews, it was found that the collected foods were homemade, ready-to-eat, processed foods produced by small- and large-scale industries.

Peanut Aflatoxin B1: Contents and Dietary Exposure

This study found that six types of peanut products were consumed by more than 50%of the study subjects, consisting of ready-to-consume and prepackaged foods. Chicken satay, siomay, and *gado-gado* were types mostly consumed by respondents (79.6 %, 78.6%, and 65.9%, respectively) due to their high accessibility. *Gado-gado* was mostly sold by vendors close to the respondents' housing areas, while satay sauce was used as a dressing for these foods. Flour-coated peanuts produced by industry were considered as favorable food (67.5%) with the highest content of AfB1 (6.96 g/d/person). This flour-coated peanut was packaged in small- or medium-sized plastic packaging and sold at many 24 -hour mini stores surrounding respondents' housing areas, thereby increasing the study subject's accessibility.

Table 2. The top nine peanut products consumed and aflatoxin B1 content

No	Peanut Product	Reported consumed last one month n (%)	No of analyzed samples	Aflatoxin B1 content (ppb) (Min-max)
1	Steam dumpling sauce *(saus siomay)*	302 (78,7)	8	0,92 – 4,88
2	Flour coated peanut *(kacang lapis tepung–tepung olahan pabrik)*	259 (67,5)	2	4,01 – 93,61
3	Grilled/Satay chicken sauce *(saus sate ayam)*	258 (67,2)	8	1,77 – 28,06
4	Gado-gado sauce *(saus gado-gado)*	253 (65,9)	8	0,92 – 17,44
5	Fried dumpling sauce *(saus batagor)*	231 (60,2)	8	0,92 – 14,78
6	Roasted peanut with skinpod *(kacang kulit-olahan pabrik)*	223 (58,1)	1	<0,92
7	Flour-egg coated peanut *(kacang lapis telur-olahan pabrik)*	155 (40,4)	1	<0,92
8	Boiled peanut with skinpod *(kacang kulit rebus)*	120 (31,3)	1	<0,92
9	Roasted peanut without skinpod *(kacang panggang-olahan pabrik)*	109 (28,4)	1	<0,92

Food samples were obtained from food providers who were usually bought by the respective respondents. All analyzed foods contained AfB1. As the study was conducted in Jakarta, which has a hot temperature ranging from 32.7°C to 34 °C with a humidity level of 73%-78%, contamination may occur due to its favorable weather and temperature for *Aspergillus flavus* and *A. parasiticus* to grow, which may produce aflatoxin (Dharmaputra, 2014; Jallow & Li, 2021). Most respondents stored peanuts in the open air at ambient temperatures. Contamination by AfB1 might also be due to limited practices among food vendors, including the use of low-quality raw materials, unhygienic food preparation, and peanut storage practices. The mishandled by food handlers or vendors enables fungi to contaminate, survive, and grow in food (Balendres & Karlovsky, 2019; Gichohi-wainaina et al., 2022).

The favorable flour-coated peanut containing aflatoxin B1 concentration is a manufacturing good, in which contamination might have occurred since the raw peanut was received by the manufacturer. Fungal invasion may occur during pre-harvest, which can be controlled by implementing Good Agricultural Practices (GAP), such as good irrigation, management of insect pests, and harvest time, such as harvesting immediately after physiological maturity (Dharmaputra, 2014; Kaburi et al., 2023; Yu et al., 2020).

Unfavorable weather, contaminated soil, and humidity are environmental factors that are mainly challenged by peanut farmers. *Aspergillus spp.* are the major causes in regions where rain-fed plants grow, producing high levels of aflatoxin contamination in infected plants. This type of contamination occurs when seed pods are in contact with the contaminated soil. The fungi invade, grow, and produce toxins in kernels before harvest, during drying, and storage (Dharmaputra, 2014; Jallow & Li, 2021; Liu et al., 2020; Sserumaga et al., 2020). Farmers in Congo have identified crop management practices as the most effective measures to control contamination. After receiving education, they are willing to pay for such practices and apply preharvest crop management as a measure of controlling contamination (Udomkun et al., 2018).

Post-harvest aflatoxin contamination in peanut products might also be a problem. The highest aflatoxin B1 content is clearly associated with post-harvest spoilage of food commodities stored under unfavorable conditions, such as unhygienic storage, handling, and distribution (Awuor et al., 2023; Muñoz et al., 2021).

As aflatoxin contamination of food might increase during storage and distribution periods, it is necessary to implement good hygienic practices along the production chain; however, limited facilities may constrain the implementation. A study in Eastern Kenya showed that farmers' perceptions of improvement through education may create their willingness to adopt technology and hygienic agricultural practices, including pre- and post-harvest. Decomposition of aflatoxin requires high temperature; however, prolonged boiling or pressure cooking could reduce 28-89 % due to water soaking and dilution processes. Education related to food processing to mitigate mycotoxins, such as milling, steeping, and extrusion as well as other heat treatments related to mycotoxin decomposition showed such effective result (Karlovsky et al., 2016; Marechera et al., 2014; Me et al., 2020).

Production and distribution to smallholders of genetically modified peanuts with aflatoxin resistance would be a promising innovation and cost-benefit strategy to cascade the prevention of farmers and their families from their exposure to aflatoxin risk (Hoffmans et al., 2022; Yu et al., 2020). This study found that median dietary exposure of Af B1 was 22.55 ppb bw day which was higher than the only one previous study conducted in Bogor, Indonesia (9.0 ppb bw day) (Ambarwati & Dharmaputra, 2011). The types of ready-to-eat and prepackaged peanut products, such as flour-coated peanut, satay sauce, fried dumpling sauce, gado-gado, and roasted peanut, are available in both areas, as shown in Table 2. However, the variation may occur due to socio-demographic issues in which Bogor has peri-urban characteristics, or certain local peanut production may influence the variation in the total intake. Nevertheless, this study's exposure was lower than that in a study conducted in China with an AfB1 exposure of 2027 ppb bw day, which is approximately a 2004 ppb bw day difference (Ding et al., 2015). The Indonesian Food and Drug Agency has set standards for aflatoxin limits in food, including peanuts and their products. Enforcement of food business operators to meet the government standard as well as continuous control of the post-market of peanut products would limit the exposure and protect the consumer from this carcinogenic substance (BPOM, 2018; Jallow & Li, 2021).

Knowledge on Aflatoxin

Most respondents understood the effect of air humidity on the growth of fungi (74.5%) and the types of microbiological hazards contained in the foods (62.5%). They also knew about the risk of eating contaminated food to their health and the type of food that may be contaminated by fungi (54.7%). However, most of them did not know about the characteristics of peanuts that may contain toxins, either the impact of product color change (93.8%) or the flavor change (94.8%). They had limited awareness of the health effects of prolonged consumption of toxin-containing food.

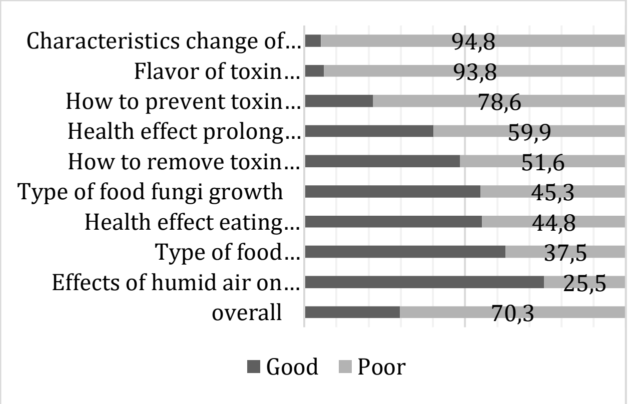

Figure 1. Knowledge of respondent on aflatoxin related (%)

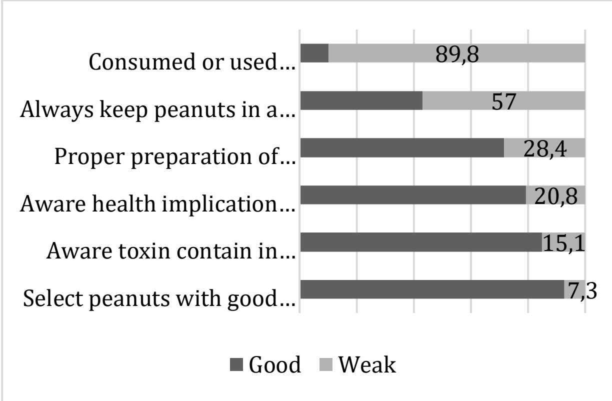

Figure 2. Respondents' practices related toxin and peanuts products

The study found that many respondents (70.3%) had limited overall knowledge of peanut mycotoxin risks (Figure 1). The relatively poor overall knowledge among the respondents could be partially attributed to the fact that most of the population had low socioeconomic status, including education level, thus limiting their access to such information. Similar findings were found among people, including caregivers in Malawi and Kenya, and among farmers in Congo, in which high exposure to aflatoxin risk among people with poor knowledge and awareness of mycotoxin control measures (Awuor et al., 2023; Lesuuda et al., 2021; Matumba et al., 2015; Udomkun et al., 2018).

Respondents' attitudes were good toward the selection of peanuts before they were consumed (92,7%). They were aware that any hazards may be contained in peanuts (84,9%), were aware of the health implications of consuming food containing any toxin (79.2 %), and selected only good-quality raw peanuts before consuming it. However, good practices for storing peanuts and consuming safe peanuts were poor (Figure 2). They still consumed the peanuts even though it changes to the "black" or discolored. Moreover, the forms of peanut products consumed by customers were mostly pastes or sauces mixed with various spices, causing respondents to be unable to identify the risk from the appearance of peanuts.

Table 3. Association between knowledge, age and income with dietary aflatoxin B1

	Dietary peanut aflatoxin B1 (n, %)			P-Values
	High	Low	Total	
Overall knowledge				
Poor (0 – 4 total score)	28 (49,1)	29 (50,9)	57	0,874
Good (>4 total score)	68 (50,4)	67 (49,5)	135	
Respondent age *				
>38 years	47 (51,1)	45 (48,9)	92	0,884
≤ 38 years	47 (49,5)	48 (50,5)	95	
Household income				
< IDR 3.000.000	29 (51,8)	37 (56,1)	66	0,355
≥ IDR 3.000.000	59 (51,8)	55 (48,2)	114	

*Median cut off

The Pearson Chi-Square test showed that there was no significant association between peanut aflatoxin B1 consumption and respondents' overall knowledge (p=0,874), age (p=0,825), and household income (p=0,312). This finding contradicts those of other studies, such as those conducted in Kenya and Tanzania (Ayo et al., 2018). The Lesuuda study among Kenyan farmer families with under five children found that respondents' age, education level, and household income were significantly associated with mycotoxin knowledge (Lesuuda et al., 2021).

This study has some weaknesses and strengths. Assessment of other potential food sources may provide a more comprehensive understanding of aflatoxin contamination. However, preliminary studies have shown undetectable levels of AfB1 in rice and maize in this area (unpublished). HPLC, which is known as a sensitive chromatographic technique and specific method to assess a wide range of chemical contaminants, including aflatoxins, provides reliable and valid data (Ding et al., 2015). The quality of this study was controlled by using the validated Semi-Quantitative-FFQ with a verified food list obtained from a local market survey and the Semi-Quantitative-FFQ checked with a 3-days 24-hr food consumption record. In addition, the participants in this study were limited to housewives, who were available at the time of the interview, whereas involving other family members might provide a more comprehensive aflatoxin exposure assessment of the community. The number of enrolled respondents was calculated not intended to assess mean differences between two populations but using a formula for estimating population proportion. Thus, this study was not sufficiently sensitive to detect an association between consumer knowledge and peanut AfB1 exposure.

Conclusion

Urban consumers in Jakarta are concerned about AfB1 exposure due to the consumption of various peanut products. Consumers aware of hazards may be contained in peanuts and the health implications of consuming food containing any toxin. However, most consumers had poor practices regarding the safe selection and consumption of peanuts. Consumers' knowledge was not associated with AfB1 exposure, which may be due to the high prevalence of contamination of local products in the area, leading to limited accessibility and availability of the consumer towards safe peanuts and their products. Enforcing the implementation of Good Hygienic Practices in primary production and both pre- and post-harvest crop management would help mitigate the risk of peanut aflatoxins entering the retail supply.

Effective and sustainable empowerment and control involving other stakeholders, including the health and agricultural sectors, are necessary to reduce the risk of peanut aflatoxin exposure in the market. Further studies covering a wider community evaluating the economic and health impacts of consuming food containing aflatoxin would provide comprehensive evidence for public health decision-making.

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