Aflatoxin and nutrient contents of peanut collected from local market and their processed foods

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Abstract. Peanut is susceptible to aflatoxin contamination and the sources of peanut as well as processing methods considerably affect aflatoxin content of the products. Therefore, the study on aflatoxin and nutrient contents of peanut collected from local market and their processed foods were performed. Good kernels of peanut were prepared into fried peanut, pressed-fried peanut, peanut sauce, peanut press cake, fermented peanut press cake (tempe) and fried tempe, while blended kernels (good and poor kernels) were processed into peanut sauce and tempe and poor kernels were only processed into tempe. The results showed that good and blended kernels which had high number of sound/intact kernels (82.46% and 62.09%), contained 9.8 - 9.9 ppb of aflatoxin B1, while slightly higher level was seen in poor kernels (12.1 ppb). However, the moisture, ash, protein, and fat contents of the kernels were similar as well as the products. Peanut tempe and fried tempe showed the highest increase in protein content, while decreased fat contents were seen in all products. The increase in aflatoxin B1 of peanut tempe prepared from poor kernels > blended kernels > good kernels. However, it averagely decreased by 61.2% after deep-fried. Excluding peanut tempe and fried tempe, aflatoxin B1 levels in all products derived from good kernels were below the permitted level (15 ppb). This suggests that sorting peanut kernels as ingredients and followed by heat processing would decrease the aflatoxin content in the products.

Keywords: aflatoxin, nutrient, peanut, processing

1. Introduction
Peanut is primarily used for foods in Indonesia with a consumption level of 0.27 kg/capita/year [1]. A number of peanut products is available, such as sauces (bumbu kacang) for salads/satay, snacks (boiled, deep-fried, roasted, flour-coated, bakery filler, traditional snacks), oil and fermented of defatted peanut (peanut tempe/oncom) [2]. As ingredients for such products, peanut is not directly obtained from the farmer. Medium to large-scale food industry normally get supplied from the middle men, while small-scale food processors purchase peanut from the retailers, particularly at local markets [3, 4]. It takes about 40-110 days for marketing of peanut from farmer to consumer [2], suggesting that handling of peanut during such period, particularly storage would ultimately determine the quality of peanut and its safety for human consumption.

The presence of aflatoxins, the secondary metabolites produced by toxigenic fungi of A. flavus, A. parasiticus, and A. nomius [5, 6] incontaminated peanut is widely highlighted in the literature due to their hazardous effects to humans and animals. Aflatoxins that may belong to B, G, and M are reported to be hepatocarcinogenic, mutagenic, teratogenic, and immunosuppressive [7, 8]. Aflatoxin
B₁ is the most toxic and classified as the first class of carcinogen to humans [9, 10], thus it is normally used to set the permitted limit in foods and feeds. The maximum level of aflatoxin in peanut food products marketed in Indonesia has been established as low as 15 ppb for aflatoxin B₁ and 20 ppb for total aflatoxins [11], while Codex Alimentarius set a lower level for total aflatoxins (15 ppb) [12].

High A. flavus infection and aflatoxin contamination in peanut during distribution/marketing is of concerned, particularly for those samples collected from local/traditional markets [3, 13-15]. The level of aflatoxin B₁ in these samples may range from 3.6 up to 1,859 ppb [4], even up to 6,073 ppb in case of Cianjur Regency [14]. In fact, most of small-scale peanut food processors and household consumers obtain their ingredients from retailers in local markets. The processors also tend to purchase low price of peanut (meaning low quality peanut) to get more profit since their awareness of aflatoxin hazards to humans is still low [4, 12]. This is crucial as processing, such as washing, heat treatment (boiling, drying, roasting, frying), and fermentation cannot eliminate 100% of aflatoxins [7, 16-17] as they are heat resistant and insoluble in water, reflecting the high exposure risk of contaminated peanut.

Selected peanut products, such as peanut sauce for satay, pecel, and gado-gado, boiled peanut, oncom, oil and peanut press cake were reported to contain aflatoxin B₁ > 15 ppb, while roasted unshelled peanut and flour coated peanut gave lower levels of aflatoxin B₁ (< 15 ppb) [18]. This suggests that initial quality of peanut kernel and processing may affect the final aflatoxin content in peanut products. In addition, nutritional aspects of peanut is also essential as it is rich in fat and protein as well as vitamins and minerals [19], which also may change during processing. Therefore, this project was performed to study the aflatoxin and nutrient contents of selected peanut food products processed from peanut kernels collected from a traditional market as ingredient. This information would be useful for selection of peanut as food ingredient and processing methods in terms of aflatoxin reduction in the products.

2. Materials and Methods

Peanut kernels (Local Ponorogo variety) were obtained from a local market in Ponorogo, East Java. The kernels were then sorted into 3 groups (good, blended, and poor/damaged kernels) [20]. The good kernels were processed into fried peanut, pressed-fried peanut, peanut sauce, peanut press cake, fermented press cake (peanut tempe) and fried peanut tempe. This trial was carried out at the ILETRI Laboratory of Food Chemistry and Technology, Malang using a randomized complete design with three replicates. In addition, the blended kernels (good and poor kernels) were processed into peanut sauce and peanut tempe, while the poor kernels were only processed into peanut tempe since normally peanut tempe in the market was prepared from low quality peanut press cake. Peanut tempe processed from blended and poor kernels were also fried. Observations included physical quality of the kernels (intact, shriveled, and damaged kernels) [20], chemical composition of dry kernels and peanut products, including: (a) moisture (gravimetric), ash (muffle furnace) and fat (Soxhlet) contents [21], (b) protein content using Micro Kjeldahl method [22]. A. flavus infection was observed through growing 100 peanut kernels on 10 petridishes containing Aspergillus flavus and parasiticus agar (AFPA). The number of mold infected kernels with orange/dark yellow colour was noted on the fourth day and calculated in percentage [2]. The ELISA method was used for analysis of aflatoxin B₁ content both in the kernels and peanut products [23].

3. Results and Discussion

3.1. Physical quality, A. flavus infection and aflatoxin content of peanut kernels

The moisture contents of peanut kernels were relatively low and similar for the three kernel categories (Table 1). These levels were slightly higher than the requirement for national quality standard (≤ 6%) [20], however they were already safe for storage (7.5%) [24]. Even though the kernels were stored in a perforated plastic sack when purchased in the market, the moisture content was fairly low due to dry season air conditions. The blended kernels (real peanut quality) obtained at present study had lower moisture content relative to those samples collected from retailers (>8%) in Banjarnegara [2].
Different methods and period of storage as well as temperature and relative humidity of the surrounding air may contribute to such differences in moisture content. In addition to perforated plastic sack, retailers may also store the peanut kernels in an open wooden box, plastic basin, bamboo tray or bamboo basket [2].

Sorting by hand picking gave a high number of intact kernels and low number of shriveled and damaged kernels in good kernels, while poor kernels showed a high number of damaged kernels (Table 1). Normally, these kernels are used for oil extraction purposes and the press cake is further processed into tempe, namely oncom [25]. The number of damaged kernels in blended peanut kernels (24.12%) was lower compared to those collected from retailers in Banjarnegara which ranged from 26.6% up to 69.9% [2]. Peanut maturity and post-harvest handling considerably dictate the physical quality of peanut. Peanut kernels from three categories showed much higher shriveled and damaged kernels than the maximum levels (4% and 2%, respectively) set by the national standard quality [20], reflecting high risk of aflatoxin contamination for further storage marketed as the samples were collected one month after harvesting season in Ponorogo area.

| Category of peanut kernel | Moisture content (%) | Physical quality | A. flavus infection (%) | Aflatoxin B<sub>1</sub> (ppb) |
|--------------------------|----------------------|------------------|------------------------|-----------------------------|
| Good kernels             | 6.34 ± 0.40          | 82.46 ± 1.68     | 5.68 ± 1.81            | 11.86 ± 0.14                | 1  | 9.9 ± 0.9 |
| Blended kernels          | 6.22 ± 0.16          | 62.09 ± 1.44     | 13.79 ± 1.48           | 24.12 ± 2.66                | 1  | 9.8 ± 0.9 |
| Poor kernels             | 6.62 ± 0.20          | 12.28 ± 1.61     | 26.12 ± 2.78           | 61.6 ± 3.93                 | 2  | 12.1 ± 0.7 |

Values are means ± SD from three replicates.

The level of aflatoxin B<sub>1</sub> was similar for both good and blended peanut kernels, while it was slightly higher in poor kernels (Table 1). Poor kernels consisted of more damaged and shriveled kernels, which had a higher possibility for aflatoxin contamination [3]. However, aflatoxin B<sub>1</sub> levels in three categories of peanut kernels were yet lower relative to the maximum level established in Indonesia (15 ppb). These facts were in agreement with the low levels of A. flavus infection which were relatively low (1-2%). Low levels of moisture and relatively dry air storage environment may account for low levels of A. flavus infection and aflatoxin contents in peanut kernels as the mold would favourably grow and produce toxins at high moisture (15-30%), temperature (25-30°C), and relative humidity (85%) [26]. This is also the reason for relatively low aflatoxin content in poor kernels, even though the number of damaged kernels was quite high. Similar finding was also noted in peanut kernels stored in an opened wooden box for 4 months with an initial moisture content <7%, which contained aflatoxin B<sub>1</sub> <10 ppb, even though the damaged kernels was up to 80.9% [27].

The aflatoxin content observed in this study was within the range of aflatoxin levels reported from previous studies in peanut samples collected from traditional markets, which ranged from 0-1,154 ppb [13], 3.6-6.073 ppb [14], 4.4 - 205 ppb [28], and > 5-> 100 ppb [3]. A study in Kenya also reported that aflatoxin B<sub>1</sub> content in 37% peanut samples obtained from 1,263 vendors in various markets exceeded the permitted limit (>10 ppb) [10]. This highlights the critical point of storage at market level in aflatoxin development [24]. Moisture content, physical quality, and air environment conditions are the main factors in controlling mold contamination and aflatoxin production [29].

3.2. Nutrient content of peanut kernels and their products

The moisture content of peanut kernels significantly changed through processing into peanut products (Table 2). Deep-fried products, like fried peanut and pressed-fried peanut showed the lowest moisture
content due to releasing some moisture during frying. Conversely, peanut tempe gave the highest moisture level as soaking, steaming and fermentation were involved in the preparation method. Fried peanut tempe had similar moisture content to that of peanut tempe as it was covered with wheat flour dough prior to frying, thereby increasing the moisture content and only small amounts of moisture can be released during frying. Peanut sauce had medium moisture content. Even though frying was involved in the preparation method, the addition of water during blending with palm sugar and spices increased its moisture level. Low moisture (<8%) is desired for peanut products to maintain the quality from mold contamination and lipid oxidation (rancidity), thus can be stored longer.

The ash content of good peanut kernels was about 2.46 % dw (Table 2). Similar values (2.86%-2.89% dw) were also noted for Mahesa and Kancil varieties [27] and slightly higher in Nigerian peanut (3.8%) that primarily consisted of K, Na, P, Ca, and Mg [30]. Preparation into peanut products significantly influenced the ash content. The highest levels were examined for peanut sauce as palm sugar and spices, like salt, chili, garlic, citrus leaves, and tamarind were added. A slight increase in ash content was observed for fried peanut products due to the use of salt, garlic, and edible oil, while peanut tempe showed the lowest ash content due to leaching out of water soluble minerals during overnight soaking.

Good peanut kernels contain 26.02% dw of protein (Table 2) that was slightly lower than those of Mahesa and Kancil varieties (32.06-34.47% dw) [27] and 29 peanut cultivars originated from Peru (26.3-30.9%)[31]. The protein content of peanut kernels were significantly different after processing into different products (Table 2). The highest values were seen in peanut tempe, reflecting an increase in protein after fermentation as the mold itself predominantly consists of protein. Peanut tempe in this study contained higher protein compared to oncom that made from commercial defatted peanut mixed with cassava starch with a protein content of 26.9% dw[32]. Peanut press cake and pressed-fried peanut also gave considerable increase in protein. Pressing the peanut kernels to remove part of the oil, could reduce 20% of fat and consequently increased the protein content by 16%[33].

Table 2. Chemical composition and aflatoxin B₁ content of good peanut kernels obtained from a local market and their food products

| Peanut products                  | Moisture (% dw) | Ash (%) | Protein (% dw) | Fat (% dw) | Aflatoxin B₁ (ppb fw) |
|----------------------------------|-----------------|---------|----------------|------------|----------------------|
| Good peanut kernels              | 6.34 ± 0.40      | 2.46 ± 0.04 | 26.02 ± 0.69    | 49.23 ± 1.02 | 9.9 ± 0.9          |
| Fried peanut                     | 1.21 ± 0.13      | 3.41 ± 0.14 | 26.20 ± 1.50    | 46.49 ± 1.25 | 7.9 ± 1.3          |
| Pressed-fried peanut             | 1.77 ± 0.11      | 4.08 ± 0.13 | 31.47 ± 1.60    | 44.54 ± 0.93 | 4.4 ± 1.7          |
| Peanut sauce                     | 11.11 ± 0.65     | 4.52 ± 0.17 | 19.18 ± 0.62    | 34.48 ± 0.91 | 12.4 ± 3.6         |
| Peanut press cake                | 4.31 ± 0.38      | 3.33 ± 0.12 | 33.31 ± 0.96    | 35.87 ± 1.74 | 9.2 ± 0.4          |
| Peanut tempe                      | 48.28 ± 2.83     | 2.20 ± 0.05 | 39.23 ± 1.00    | 41.32 ± 2.71 | 26.3 ± 7.5         |
| Fried peanut tempe              | 51.74 ± 2.00     | 2.73 ± 0.20 | 37.30 ± 1.02    | 41.13 ± 2.43 | 16.5 ± 8.9         |

Values are means ± SD; fw = fresh weight; dw = dry weight

Values in the same columns followed by different superscript are significantly different at 5% level of LSD test.

1 Soaking in boiled water (45 min), removing the seed coat, oven drying (80°C, 20 min), soaking (10 min) in garlic and salt solution, deep-frying (120°C, 15 min), centrifuge to remove the excessive oil.
2 Oven (120°C, 20 min), pressing using hydraulic press, removing the seed coat, soaking (10 min) in garlic and salt solution, deep-frying (120°C, 15 min), centrifuge to remove the excessive oil.
3 Washing, deep-frying (120°C, 10 min), grinding, mixing with water, salt, palm sugar, spices.
4 Grinding, oven drying (80°C, 10 min), pressing using a hydraulic press
5 Grinding, oven drying (80°C, 10 min), pressing using a hydraulic press, soaking (24 h), washing, steaming (1.5 h), cooling (4 h), inoculation of mold (Rhizopus spp), fermentation (room temperature, 24 h).
6 Treatment followed by steeping in wheat flour containing salt and garlic, deep-frying (120°C, 10 min).
Meanwhile, peanut sauce had the lowest value of protein due to a large proportion of palm sugar (40%), hence decreased the proportion of protein derived from peanut kernels.

Higher level of fat was seen in good peanut kernel (Table 2) relative to those of Kancil and Mahesa varieties (45-47% dw) [27]. As a result of processing, fat contents in peanut products were significantly different (Table 2). Peanut sauce gave the lowest value of fat due to the addition of palm sugar, thus decrease the peanut fat proportion in the product. Removing part of the oil through pressing also gave a significant decrease in fat content of peanut press cake. However, it was only a slight decrease in fat values of fried peanut and pressed-fried peanut and were not significant for both products. This was due to a relatively low pressing capacity of the hydraulic press used in this study (15 tons), hence only 8-13% of oil can be removed and subsequently increased after deep-frying. A higher capacity of the hydraulic press (45 tons) can remove oil up to 20% during pressing [33]. An increase of fat was seen in peanut tempe and fried peanut tempe, however the fat contents of both products were similar as the flour dough that covered peanut tempe was excluded prior to analysis. The fat content of peanut tempe in this study was much higher compared to that of oncom (6% fw) [32] as commercial defatted peanut press cake was used as ingredient in the latter study which contained very low fat (4.6%).

In terms of blended and poor kernels, the moisture, ash, and protein contents were approximately similar to that of good kernels, while it was slightly lower for fat content of poor kernels (Table 2 and 3). High number of damaged kernels due to discoloured skin, broken, mold and insect attacks in poor kernels may associate with oxidation/degradation of fat in the kernels.

**Table 3.** Chemical composition and aflatoxin B$_1$ content of blended and poor peanut kernels obtained from a local market and their peanut products

| Peanut products | Moisture (% w/w) | Ash (% dw) | Protein (% dw) | Fat (% dw) | Aflatoxin B$_1$ (ppb fw) |
|-----------------|------------------|------------|----------------|------------|------------------------|
| Peanut kernels: |                  |            |                |            |                        |
| Blended kernels | 6.22 ± 0.16      | 2.45 ± 0.02| 25.49 ± 0.67   | 49.35 ± 0.68| 9.8 ± 0.9              |
| Poor kernels    | 6.62 ± 0.20      | 2.58 ± 0.02| 25.41 ± 0.52   | 46.37 ± 0.49| 12.1 ± 0.7             |
| Peanut sauce:   |                  |            |                |            |                        |
| Blended kernels | 12.10 ± 1.35     | 4.49 ± 0.05| 17.96 ± 0.84   | 33.04 ± 0.41| 16.8 ± 2.4             |
| Peanut press cake: |               |            |                |            |                        |
| Blended kernels | 4.59 ± 0.26      | 3.26 ± 0.11| 34.32 ± 1.33   | 35.99 ± 1.70| 12.4 ± 4.9             |
| Poor kernels    | 4.91 ± 0.31      | 3.36 ± 0.10| 33.31 ± 1.52   | 32.88 ± 0.42| 15.5 ± 4.5             |
| Peanut tempe: Blended kernels | 50.55 ± 1.36 | 2.12 ± 0.09| 37.65 ± 0.73   | 43.09 ± 0.18| 65.8 ± 8.3             |
| Poor kernels    | 55.69 ± 1.72     | 2.12 ± 0.05| 38.75 ± 0.88   | 40.91 ± 0.76| 83.5 ± 9.7             |
| Fried tempe kacang: |              |            |                |            |                        |
| Blended kernels | 51.71 ± 0.93     | 2.51 ± 0.28| 38.23 ± 0.22   | 43.00 ± 1.06| 17.3 ± 7.0             |
| Poor kernels    | 56.77 ± 1.44     | 2.87 ± 0.31| 38.80 ± 0.95   | 41.16 ± 0.94| 21.1 ± 5.6             |

Values are means ± SD, dw = dry weight, fw = fresh weight

Peanut sauce prepared from blended and good kernels showed relatively similar moisture, ash, protein and fat contents as their initial levels in peanut kernels were also similar (Table 2 and 3). Both protein and fat contents decreased in peanut sauce processed from blended kernels (Table 3) as also previously discussed in good kernels. Similar moisture, ash, and protein contents was also seen for peanut press cake derived from blended and good kernels, however lower fat was found in poor kernels, following its initial fat content (Table 2 and 3). The moisture, ash, protein and fat contents of peanut tempe and fried peanut tempe were approximately the same for the three kernel categories. The increase in protein and decrease in fat content after fermentation for peanut tempe processed from blended and poor kernels also followed the phenomenon occurred in good kernels. This suggests that
3.3. Aflatoxin content of peanut products

Aflatoxin B₁ content was significantly different in peanut products processed from good kernels (Table 2). An increase or decrease in aflatoxin B₁ content in peanut products compared to their initial contents in peanut kernels were shown in Fig. 1. The lowest level of aflatoxin B₁ was noted for pressed-fried peanut, which was not significantly different with fried peanut and peanut press cake. An average decrease in aflatoxin B₁ content was about 55.6%, 20.2%, and 7.1% for pressed-fried peanut, fried peanut, and peanut press cake, respectively (Fig. 7). In fact, aflatoxins are relatively heat resistant with a melting point about 267-268°C for aflatoxin B₁ [17]. However, it can be reduced up to 80% in inboiled peanut [16], 73% in deep-fried peanut at 150°C for 2 min[34], 68.5% in roasted peanut at 150°C for 25 min [35], and 80.2% in oven-dried peanut at 130-150°C [36] due to changes in aflatoxin chemical structure. The use of spices, like garlic and salt in combination with heat treatments would be also effective in degradation of aflatoxins [37-38]. A relatively higher aflatoxin B₁ levels (1.6-20.6 ppb) were obtained previously in fried peanut [39] relative to this study. Both fried peanut and pressed-fried peanuts prepared from good kernels contained aflatoxin B₁<15 ppb, suggesting that they are safe for consumption.

Peanut sauce and peanut press cake showed an increase and a slight decrease in aflatoxin B₁ compared to the initial content in good peanut kernels (Fig. 7), however the values were not significant (Table 2). This suggests that the addition of palm sugar, chili, and spices, particularly in peanut sauce may be attributed to a slight increase in aflatoxin B₁ as expectedly it would decrease during deep-frying. However, both peanut sauce and peanut press cake yet contained safe level of aflatoxin B₁ (<15 ppb). A wide range of aflatoxin levels in peanut sauce samples (0-221 ppb) collected from traditional markets [18], as well as in peanut press cake samples (126 ppb) [18]. Normally, low quality of peanut kernels is used as ingredients for both products, particularly peanut press cake.

The highest aflatoxin B₁ content was observed in peanut tempe (Table 2) with an increase of 165.7% (Fig. 1). This was unexpected as a considerable decrease in aflatoxin B₁ level was noted during black and red oncom preparation (86.6% and 58.9%, respectively) [25]. However, fermentation during oncom preparation takes 72 hours, while for peanut tempe performed in this study was only 24 hours, suggesting that longer fermentation might be more effective for R. oligosporus to degrade aflatoxin enzymatically as well as to compete with A. flavus as both molds are antagonist [40]. Deep-frying (120°C, 10 min) of peanut tempe gave a significant decrease in aflatoxin content (Table 2 and Fig. 1), even though it was slightly higher than the permitted level (<15 ppb).

Peanut products prepared from poor kernels seemed to contain higher aflatoxin B₁ content compared to those derived from blended kernels and good kernels (Table 2 and 3) following its initial aflatoxin in the kernels (Table 1). Peanut sauce, peanut press cake, peanut tempe, and fried peanut tempe prepared from blended kernels also showed lower aflatoxin relative to those of poor kernels. Physical cleaning and sorting/hand picking may reduce 40-80% aflatoxin level due to removing the mold-damage kernels [41].

Peanut tempe using poor kernels as ingredients showed the highest aflatoxin content (83.5 ppb) compared to other products (Table 3), however it considerably decreased by 74.7% after deep-frying. This final value (21.1 ppb) was only slightly higher compared to those of fried tempe derived from good and blended kernels (16.5 ppb and 17.3 ppb, respectively), while the initial contents of aflatoxin in their raw tempe were much lower (26.3 ppb and 65.8 ppb). This suggests that the higher initial content of aflatoxin in peanut tempe, the higher reduction of aflatoxin occurred during deep-frying. On average, the reduction of aflatoxin B₁ in fried peanut tempe was 61.2% for the three kernel categories. Oncom that is normally prepared from defatted low quality of peanut contained aflatoxin B₁ about 67 ppb, which was within the range values of peanut tempe derived from blended and poor kernels (Table 2). However, fried oncom showed higher content of aflatoxin B₁ (41 ppb).
Differences in initial aflatoxin content as well as methods of fermentation and frying may be attributed to final aflatoxin content in peanut tempe and fried peanut tempe.

4. Conclusion
Peanut kernels collected from local market had relatively low moisture and aflatoxin B₁ contents (9.9 ppb), but high number of damaged kernels (24.12%). Higher aflatoxin was seen in particular poor kernels (12.1 ppb). However, the moisture, ash, protein, and fat contents of good, blended, and poor kernels were similar as well as the peanut products. The highest increase in protein content was seen in tempe peanut, while fat content decreased in all products. Peanut tempe prepared from poor kernels showed the highest increase in aflatoxin B₁ that was > blended kernels > good kernels. However, it averagely decreased by 61.2% after deep-fried. Excluding peanut tempe and fried peanut tempe, aflatoxin B₁ levels in all products derived from good kernels were below the permitted level (15 ppb).

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6. References
[1] Data and Information Centre of Agriculture 2014 Bul. Food Consumption 4 16-15 [In Bahasa Indonesia]
[2] Ginting E and Rahmianna AA 2015 Proc. Food Sci. 3 280-88
[3] Rahmianna AA et al 2007 J. Pert. Tan. Pangan 26 2 137-44 [In Bahasa Indonesia]
[4] Rahmianna AA and Purnomo J 2015 Iptek. Tan. Pangan 10 1 29-37 [In Bahasa Indonesian]
[5] Klich MA 2007 Molecular Plant Pathol. 8 713-22
[6] Reddy KR et al 2010 Toxin Rev. 1 3-26
[7] Mobeen AK et al 2011 J. Pharm. Nutr. Sci. 1 1 1-3
[8] Abdalla MS et al 2014 Egyp. J. Environ. Res. 2 51-56
[9] Bankole SA et al 2005. Food Chem. 89 503-06
[10] Mutegi C et al 2013 J. Stored Products Res. 52 118-27
[11] Indonesian National Council for Standarization 2009 National standard of maximum mycotoxin

Figure 1. An increase (+) or decrease (-) in aflatoxin B₁ content in peanut products compared to initial aflatoxin B₁ content in good peanut kernels collected from local market.
content in food (SNI 7385:2009) [In Bahasa Indonesia]

[12] Anukul N et al 2013 J. Food Drug Anal. 21 227-41
[13] Dharmaputra OS et al 1989 Proc. 12th ASEAN Sem. on Grain Postharvest Tech. (Bangkok: AGGPT) p. 110-23
[14] Dharmaputra OS 2005 Biotropia 24 1-19
[15] Rahmianna AA and Yusnawan E 2015 J. Exp. Biol. Agri. Sci. 3 4 346-52
[16] Siwela et al 2011 Food Nutr. Sci. 2 105-08
[17] Jalili M 2016 Iran J. Health Safety Environ. 3 1 445-59
[18] Mahmud M 1989 Proc. Int. Workshop on Aflatoxin Contamination of Groundnuts (Patancheru, India:ICRISAT) p. 215-22
[19] Boli ZA et al 2013 J. App. Biosci. 72 5822-29
[20] Indonesian National Council for Standarization 1995. National standard for peanut (SNI 013921-1995) [In Bahasa Indonesia]
[21] Indonesian National Council for Standarization 1992 Testing procedure for food and drinks (SNI 01-2891-1992) [In Bahasa Indonesia]
[22] AOAC 2005 Microchemical determination of nitrogen using micro Kjeldhal method (12.1.07), Official Methods of Analysis of AOAC International. Vol. I. Agricultural Chemicals, Contaminants, Drugs. (Gaithersburg, Maryland, USA: AOAC International)
[23] Lee A 2004. Workshop on Prevention and Control of Mycotoxin in Food and Feed stuff (Bogor: SEAMEO Biotrop) 12 pp.
[24] Waliyar F et al 2015 World Mycotoxin J. 8 2 245-52
[25] Fardiaz S 1991 J. Trop. Agr. 3 1 27-31.
[26] ICAR 1987 Aflatoxin in Groundnuts. (New Delhi: International Centre for Aflatoxin Research)
[27] Ginting E 2006 J. Agrikultura 17 3 165-72 [In Bahasa Indonesia]
[28] Paramawati R 2006 J. Enjineering Pert. 4 1 1-8 [In Bahasa Indonesia]
[29] Hell K and Mutegi C 2011 African J. Microbiol. Res. 5 459-66
[30] Atasie et al 2009 Pakistan J. Nutr. 8 2 194-97
[31] Nelson RG and Carlos AG 1995 J. Agr. Food. Chem. 43 102-05
[32] Sofyan HMI 2003 Infomatek 5 2 74-86 [Indonesian]
[33] Santosa BAS 1993. Peanut. Monograph No. 12. (Malang, MARIF) p. 286-303 [In Bahasa Indonesia]
[34] Reddy U 1996 Food Nutr. News Acharya NG RangaAgr. Uni. 1 4 1-4
[35] Ogunsanwo BM et al 2004 African J. Biotechnol. 3 9 451-55
[36] Arzandeh S and Jinap S 2011 Int. J. Food Sci. Technol. 46 3 458-91
[37] Farah Z 1983 Lebensm Wiss Technol. 16 122-24
[38] Farag RS 1989. J. Food Sci. 54 74-76
[39] Ansori M 2004 Master Thesis Faculty of Graduate School, Gadjah Mada University (Yogyakarta) 119 pp
[40] Gourama H and Bullerman B 1995 J. Food Protec. 58 12 1395-404
[41] Park DL 2002 Adv. Exp. Med. Biol. 504 173-79.