

Physical and microbial quality of peanuts collected from different sources of the marketing chain

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Abstract. Groundnut is a healthy food by the presence of Calcium and Magnesium, vitamin E, oleic acids, fibre, arginine, and phenolic compounds. Relates to human health, however, peanut is susceptible to *Aspergillus flavus* infection and aflatoxin contamination. The study aims to evaluate the physical quality, aflatoxin contamination, and phenolic of peanuts collected from farmers, collectors, wholesalers, and retailers at Sinjai District, South Sulawesi, Indonesia during wet season. The results showed that intact seeds reduced from 82.8% in farmer's level to 75.9% in retailers at traditional markets, as the increase of shrivelled and damage kernels. The average moisture content in marketing chain was 9.5%, which was >8% as recommended. The infection of *A. flavus* was high in big traders and drastically reduced in retailer level. Aflatoxin B1 contamination went up from farmer to retailer beyond the permitted level of 15 µg kg⁻¹. Total phenolic contents of peanuts collected from marketing chain ranged from 42.6 – 88.6 mg GAE/g that 60-80% lower than the ones contained by the newly harvested peanuts (81.9 – 116.6 mg GAE/g). Reasonable low physical quality and potentially high aflatoxin contamination of peanuts in retailer level suggest the essential of good handling practices to be introduced to peanut stakeholders.

Key words: aflatoxin, *Aspergillus flavus*, phenolic, sound mature kernel

1. Introduction

Peanut (*Arachis hypogaea* L.) is one of the major oilseed crops in the world. Instead of producing oil, the grains are also an important source of protein. In many countries, peanuts are consumed as snacks, desserts, dip (sauces) and spreads after being roasted, boiled, fried, or mixed with other foods. The Indonesian peanut varieties contain 17-32% protein and 31-53% lipid [1], while the overseas varieties

contain 22%–34% protein and 44%–56% lipid [2]. The lipid is dominated by monounsaturated fatty acids [2, 3, 4]. It has been well recognized that peanut is a healthy food by the presence of minerals (especially Calcium and Magnesium), vitamins (especially tocopherols or vitamin E), fatty acids (especially oleic acids), fibre, arginine, and bioactive compounds (especially phenolic compounds) [5, 6, 7].

The bioactive compounds present in peanuts are polyphenols (phenolic acids, flavonoids, A-type procyanidins, p-Coumaric acid), isoflavones, phytosterols, and resveratrol [2]. Recently, peanut sprout is introduced as a new healthy vegetable in China. The cotyledons and sprouts contain significantly higher water, minerals, aspartic acid, methionine, proline, folic acid, thiamine and total phenolics than those contained by the intact, non-germinated seeds. On the contrary, the content of fat, riboflavin and ascorbic acid drastically reduces [8]. Meanwhile, seed coat (testae) comprises of fibres, oils, proteins, and phenolic compounds [7] where that phenolics content is higher than that contained by the hulls, roasted kernels flour, and raw kernels [5, 9, 10] although seed coats contribute around 2.6-3.0% of total seed weight only. Looking at the function, seed coat is the external part of seeds that protects the cotyledons and embryo from stress conditions and therefore most polyphenols are synthesized in testae [11].

The high nutritive values encourage peanut to be essential to human health through its function as functional food. Relates to human health, however, peanut is highly susceptible to *Aspergillus flavus* infection and aflatoxin contamination. Aflatoxin is a secondary metabolite produced by *A. flavus*, and this metabolite is hazard to human health because it is carcinogenic, teratogenic, mutagenic, and immuno suppressive. These infection and contamination are easily to occur especially when peanut kernels are under favorable conditions for infection of *A. flavus* as well as the toxin production i.e. 15-30% of moisture content of subtracts [12] with warm temperatures of 25-30°C and humid conditions with around 85% RH [13]. Since of its hazardous impact, Indonesia has established the maximum permitted level of aflatoxin B1 i.e. 15 µg kg⁻¹ for peanut-based food products [14].

In Indonesia, peanuts go through the marketing chain starts from producers in the fields (farmers) to collectors, wholesalers, and retailers, and ended in consumers for food processing. While moving along the marketing chain, the fresh pods transferred to dry seeds/kernels and to end-products. Since the final destination is for human consumption, the health aspect is becoming an important issue. The objective of the study, therefore, to evaluate the physical quality, aflatoxin contamination, and phenolic of peanuts collected from different points in marketing chain.

2. Materials and methods

The study was undertaken in Sinjai District, South Sulawesi Province during the wet season 2012. A total of 19 samples were collected from the existing peanut marketing chain that consisted six local farmers, three collectors (village traders who bought peanuts from farmers), two big traders in central market, and eight retailers in traditional markets from 4 sub-districts. Samples in the form of pods were then manually un-shelled. The amount of 2 kg of shelled peanuts (seeds) from each sample were divided into eight working samples using a sample divider for the observations: seed moisture content (gravimetric method), phenolic content of testae or seed coat (used Folin-Ciocalteu reagent), number of seeds infected by *A. flavus* (used AFPA: *Aspergillus Flavus* and *Paraciticus* Agar media), aflatoxin B1 content (used ELISA method: Enzyme Linked-Immunosorbent Assay) with one part of working sample, respectively, and the rest of 4 parts for physical quality. For the physical quality those 4 parts of samples were bulked and then grouped into sound mature kernels (intact, mature, clean/no fungal infection), shrivelled kernels (>50% seed coat surface shrivelled, or shrinkage seeds), and damage kernels (with at least one of these conditions: rotten, split cotyledons, physically broken cotyledons, pest bitten, torn up testa, discoloured/stained testa, germinated seeds [15].

3. Results and discussion

3.1. Physical quality of seeds

The physical quality of peanut seeds in the marketing chain gradually decreased from farmers to retailer level. The SMK reduced from 82.8% in the farmer's level to 77.4% in collectors and 78.9% in big traders, and then reduced to 75.9% in retailers at traditional markets. The reduction of SMK in collector and big trader levels was mainly caused by increasing the shriveled seeds. In farmer and retailer levels, moreover, low SMK was caused by increasing both the shriveled and damage kernels (Table 1). In summary, the decrease in quality was expressed by reducing the SMK or intact kernels and increasing the shriveled and damage kernels. The current survey pointed out that the average of SMK, shriveled and damage seeds were 78.8, 12.1, and 9.1%, respectively. All these physical quality values were lower compared to those obtained from the genotypes adaptation study that was conducted in the same area and at the same time. The genotypes tested obtained better quality by higher SMK, lower shriveled and damage kernels with average of 81.9%, 10.6% and 7.5%, respectively [16]. This better physical quality was more likely because the improved and higher productivity genotypes were used in the adaptation study, where the local variety that was used as standard check performed low SMK by 78.9% with shriveled and damage kernels were 13.0 and 8.1%, respectively [16]. It can be summarized that peanuts collected from the survey were the local variety with the same characters as the local variety used as standard check in adaptation study.

The physical quality of peanuts in the marketing chain was reasonably good, despite the percentage of damage seeds was mostly higher than the standard suggested by the government with total damage seeds were 1, 8, and 15% for grade I, II, and III [15]. It can be seen from Table 1 that no sample was in Grade I, 47.4% samples in Grade II, and 31.6% samples were in Grade III, and the rest 21.0% samples had damage seeds more than 15%. One sample obtained from the survey was fresh pods, where the physical quality of this sample was dominated by intact kernel by 94.4%. Fresh pods and seeds with high moisture content as the pods have not received any drying treatment yet. The increase of shriveled kernels percentage was because the huge reduction of moisture when the pods were dried up. Once the immature pods were getting dry, the kernels lost most of moisture out of the pods. As a result, the pods as well as the kernels were shrinkage. The condition surrounding the kernels in the storage also influenced the moisture loss from the kernels through evaporation process.

The increasing percentage of damage seeds along the marketing chain were most likely to occur because of improper handling and packaging of the kernels. The improper handling during storage and transportation along the chain, which is started from producers (farmers) through to retailers, enabling the incident of physical damage of kernels such as broken or split up, seed-coat ruptured, discoloration, fungal infection. About the discoloration, darkening seed coat color generally occurs during long storage as a result of the available phenolic compounds had oxygen and light contact [17]. Further [17] mentioned that peanut seeds also reduce its hardness under long storage. High temperature and relative humidity in tropical areas also induced fungal infection such as *A. flavus* infection.

3.2. Moisture Content

Among 19 samples obtained from farmers, collector, big traders and retailers, as many as 12 samples were in dry seeds and contained moistures between 6.6-12.2% (Table 1). The maximum moisture content of dry seeds as recommended by [15] i.e. $\leq 8\%$, and 75% of those samples contained higher moisture than the recommendation. There were six dry-pod samples with the moisture content of seeds ranged from 9.0-11.0% (Table 1). Among six samples, there was 83.3% samples had $>9\%$ of moisture content while the [15] recommends $\leq 9.0\%$. Since the survey in the marketing chain in Sinjai region was conducted during wet season, which notably high humidity was exist, peanuts had the average moisture content of 9.5%, which this value was higher than that is recommended by the government. High moisture is very probable as the commodity was transported with the very simple packaging. The dry seeds were only packed in the perforated plastic sacks with no inner layer. In the fresh or traditional markets, most peanuts were stored in the open-wooden box, plastic bucket, bamboo tray, or in the perforated plastic sack. All these conditions provide the chance for the pods or seeds to absorb more moisture from the surrounding air. High moisture content obtained from the current study was

supported by previous study conducted during wet season in Banjarnegara District, which reported that seed moisture content in the farmer's level ranged from 9.7-17.6% with 11.9% of mean value; while the seed moisture content in the retailer level ranged from 6.4 – 11.3% with 8.7-8.8% in average and at least 76% of samples contained moisture >8% [18, 19]. The current survey obtained one fresh-pod sample from farmer who did harvesting at the same time as the survey, and therefore the seed moisture content was high *i.e.* 44.0%. This moisture content was in line with the moisture content of seeds obtained from fresh pods of the adaptation trial conducted at Sinjai, which ranged from 41.2-61.3%. The average seed moisture content from the adaptation trial was 51.2%, while local variety had the moisture of 53.7% [16]. Moisture content negatively affected the percent of damaged seeds, as indicated by correlation coefficient of -0.34, and damage seeds were negatively correlated with total phenolic content (TPC) based on the coefficient of correlation of -0.24. It means that 34 and 24% of damaged seeds were negatively correlated with its moisture content and TPC, respectively; the rests were affected by other factors.

Table 1. The physical quality of kernels in various points of marketing chain.

Origin of peanut sample	SMK (%)	Shriveled Kernel (%)	Damage Kernel (%)	Seed moisture content (%)
Farmer, Sinjai Utara Subdistrict ^a	94.4	3.3	2.3	44.0
Farmer, Bulupoddo Subdistrict ^b	80.1	4.4	15.5	9.6
Farmer, Bulupoddo Subdistrict ^b	75.8	12.4	11.8	9.0
Farmer, Bulupoddo Subdistrict ^c	89.8	3.8	6.5	9.6
Farmer, Bulupoddo Subdistrict ^b	90.5	4.9	4.6	9.8
Farmer, Bulupoddo Subdistrict ^b	78.0	18.2	3.8	9.2
Average farmer	82.8	8.7	8.4	9.4
Collector, Lamatii Rillan Subdistrict ^b	83.3	10.8	5.9	10.0
Collector, Lamatii Riaja Subdistrict ^b	75.3	7.0	17.7	11.0
Collector, Bulupoddo Subdistrict ^c	73.7	21.1	5.2	10.3
Average collector	77.4	13.0	9.6	10.4
Big trader, Central Market ^c	72.7	23.5	3.8	10.4
Big trader, Central Market ^c	85.1	6.7	8.2	7.4
Average big trader	78.9	15.1	6.0	8.9
Retailer, Sinjai Utara Subdistrict ^c	69.5	20.2	10.3	12.2
Retailer, Telu Limpoe Subdistrict ^c	75.5	10.4	14.2	10.8
Retailer, Central Market ^c	83.7	7.3	9.0	10.2
Retailer, Sinjai Selatan Subdistrict ^c	74.7	11.9	13.4	6.6
Retailer, Telu Limpoe Subdistrict ^c	72.5	7.8	19.7	8.0
Retailer, Sinjai Selatan Subdistrict ^c	88.4	4.8	6.7	8.8
Retailer, Sinjai Utara Subdistrict ^c	59.4	21.8	18.8	9.6
Retailer, Sinjai Timur Subdistrict ^c	83.9	8.3	7.8	8.4
Average retailer	75.9	11.6	12.5	9.3
Grand mean	78.8	12.1	9.1	9.5

^a: fresh pods, ^b: dry pods, ^c: dry seeds

3.3. *Aspergillus flavus* infection and aflatoxin contamination

The number seeds infected by *A. flavus* was very low in the farmer's level which was 0.4% in average. The number of seeds infected by *A. flavus* slightly increased in collectors (1.3% in average) and drastically increased in big traders with 11% infection rate. The infection rate, however, drastically reduced to 2.4% in retailer level (Table 2). The general mean of infection rate, therefore was low by 3.8% only. This result was significantly different with the previous work of [19] who reported the

infection rate of *A. flavus* ranged from 21-99% in retailer level, 9-34% in processor level, 2-11% in collector and 12-82% in farmer's level, with the general mean of 45%.

The data indicated that aflatoxin B1 (AfB1) contamination went up from farmer to retailer beyond the permitted level of 15 $\mu\text{g kg}^{-1}$ (Table 2). Base on [14] the maximum level of AFB1 in peanut and their products that is safe for human consumption is $\leq 15 \mu\text{g kg}^{-1}$ while for total aflatoxin is 20 $\mu\text{g kg}^{-1}$. So, any amount that is higher than 15 $\mu\text{g kg}^{-1}$ is unsafe and non-permissible for human. The AfB1 contamination was in the similar trend to that of *A. flavus* infection. Aflatoxin contamination increased by increasing the time from the harvesting time and increasing the distance from the place where the peanuts are produced to end users. The contamination is very probable to increase when handling is improperly undertaken during transportation and storage along the chain. High AfB1 contamination occurs because the postharvest handling was not handled properly by the actor in every point in the marketing chain. As a result, the kernels had become the proper media to the infection of *A. flavus* and the suitable condition for the fungus to produce aflatoxin. There was each one sample in farmer and big trader and three samples in retailer level with contamination higher than the permitted amount of 15 $\mu\text{g kg}^{-1}$ of AfB1 (Table 2). The data from this survey indicated that AfB1 contamination positively correlated with the rate of *A. flavus* ($r: 0.47$), meanwhile the AfB1 contamination had less influenced by damage seeds ($r: 0.19$). The contamination on peanut at farmer level was alarming for the increasing contamination once the peanuts move to the following marketing chain.

Table 2. *Aspergillus flavus* infection and aflatoxin contamination in various points of marketing chain.

Origin of peanut sample	Seeds infected by <i>Aspergillus flavus</i> (%)	Aflatoxin contamination ($\mu\text{g/kg}$)	Total phenolic content (mg GAE/g seed testae)
Farmer, Sinjai Utara Subdistrict ^a	0.0	0.8	69.5
Farmer, Bulupoddo Subdistrict ^b	0.0	3.0	47.7
Farmer, Bulupoddo Subdistrict ^b	0.0	0.4	67.9
Farmer, Bulupoddo Subdistrict ^c	0.0	3.1	84.4
Farmer, BulupoddoSubdistrict ^b	0.0	17.9	56.0
Farmer, Bulupoddo Subdistrict ^b	2.0	4.7	61.3
Average farmer	0.4	5.8	63.5
Collector, Lamatii Rillan Subdistrict ^b	0.0	3.7	73.7
Collector, Lamatii Riaja Subdistrict ^b	1.0	2.6	59.7
Collector, Bulupoddo Subdistrict ^c	3.0	0.1	88.6
Average collector	1.3	2.1	74.0
Big trader, Central Market ^c	2.0	1.4	71.2
Big trader, Central Market ^c	20.0	41.3	38.8
Average big trader	11.0	21.4	70.0
Retailer, Sinjai Utara Subdistrict ^c	0.0	34.2	73.0
Retailer, Telu Limpoe Subdistrict ^c	8.0	161.6	46.8
Retailer, Central Market ^c	1.0	0.1	68.7
Retailer, Sinjai selatan Subdistrict ^c	4.0	47.0	77.9
Retailer, Telu Limpoe Subdistrict ^c	0.0	0.7	69.0
Retailer, Sinjai Selatan Subdistrict ^c	3.0	0.5	42.6
Retailer, Sinjai Utara Subdictrict ^c	1.0	0.4	55.3
Retailer, Sinjai Timur Subdistrict ^c	2.0	0.5	65.4
Average retailer	2.4	30.6	62.3
Grand mean	3.8	15.0	67.4

3.4. Total phenolic compounds

Total phenolic contents (TPC) of peanut collected from several points of peanut marketing chain ranged from 42.6 – 88.6 mg GAE/g of dried testae (Table 2), that were 60-80% lower than the ones

averagely contained by the newly harvested peanuts. The TPC of newly harvested peanut ranged from 81.9 - 116.6 mg GAE/g of dried testae [16]. In other words, TPC in testae of new harvested grains was higher compared to those contained by testae of peanut grains obtained from marketing chain. Peanuts obtained from collectors, big traders and retailers were the grains that have been staying in the chain several days up to more than 3 months after being harvested. Once the grains entered the marketing chain, they would be exposed to ambient environment. As the grains are alive, the physiological activities such as oxidation were continuously occurring, and it was probably the main reason for reducing TPC. Other factors that might influence TPC in the seed coats were genotype, growing site, and plants condition during the growing season. It was experienced by peanuts obtained from six farmers, *i.e.* 54-77% lower TPC than those of newly harvested genotypes. This result was in agreement to old study, which stated that TPC in fresh pods (kernel and shell) were approximately three times higher than those were in nine month stored pods [20]. Further [20] reported that the huge reduction of TPC in the stored pods, especially in kernels, might be due to their activity as antimicrobial and antifungal agents during storage through the greater activities of phenolases and laccases in the kernels that converted the native phenolic compounds into their quinones that presumably increased the seeds resistance against the invading phytopathogens. The current survey indicated this phenomenon, as the *A. flavus* infection rate was negatively correlated with TPC content ($r:-0.49$). The existing environmental conditions experienced by peanut grains along the marketing chain in the current survey resulted in various amounts of TPC. This result is supported by [11] who reported that the different results of TPC were attributed to variety, the place of origin, harvesting time and storage time.

The adaptation study for 16 genotypes obtained TPC ranged from 81.9 to 116.6 mg GAE/g of dried testae [16]. As these genotypes were grown in the same site, at the same time and received the same cultivation practices, their different levels of TPC were mostly caused by genotype. This result was in agreement to the observation undertaken by [6] on four Tunisia varieties, and [11] on two marketing types of peanut. The recent work by [21] on six varieties obtained from six different areas with the same crop year obtained TPC ranged from 97.3 – 133.5 mg GAE/g of seed coat. Meanwhile, the TPC of raw kernels were 3.28-9.20 mg GAE/g and for cotyledons were 0.88-1.85 mg GAE/g of the same varieties. This study concluded that the TPC of seed coat was the main contributor (67-87%) for the TPC of raw kernel.

4. Conclusion

The physical quality of peanuts in farmers, collectors, traders and retailers was various. The SMK or intact seeds reduced from 82.8% in farmer's level to 75.9% in retailers at traditional markets, as the increase of shriveled and damage kernels. The average moisture content in most actors in marketing channel was higher than that has been recommended. The infection of *A. flavus* was high in big traders and drastically reduced in retailer level. Aflatoxin B1 contamination went up from farmer to retailer beyond the permitted level of 15 $\mu\text{g kg}^{-1}$. The total phenolic content of seed coat/testae/skin of peanuts was high in the producer's level (farmers) at harvesting time. The amounts gradually reduced along the food delivery/marketing chain: from farmers to collectors, big traders and retailers. Total phenolic contents of peanuts collected from marketing chain ranged from 42.6 – 88.6 mg GAE/g that 60-80% lower than the ones contained by the newly harvested peanuts (81.9 – 116.6 mg GAE/g). Reasonable low physical quality and potentially high AfB1 contamination of peanuts in retailer level suggest the essential of good handling practices to be introduced to peanut stakeholders.

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