Effect of harvest timing and postharvest storage conditions on aflatoxin contamination in groundnuts harvested from the Wonogiri regency in Indonesia

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Groundnut (*Arachis hypogaea*) is a major food legume in Indonesia and is consumed as snack and used in a number of culinary preparations. Despite its importance as food, the presence of aflatoxin has the potential to limit its use in the human diet. Dharmaputra et al. (2003) reported that 100% of *bumbu pecel* (groundnut sauce) samples collected in the wet and dry seasons in the Wonogiri region contained aflatoxin in the range of 80–140 ppb and 37–107 ppb, respectively with more than 15 ppb found in all the samples. Goto et al. (1999) reported that four out of eight groundnut samples obtained from traditional markets in Malang (East Java), Muntilan (Central Java) and Denpasar (Bali) had aflatoxin B_1. In addition, Dharmaputra et al. (2003) found that 33 and 17% of 12 raw seed samples collected in wet and dry seasons from retailers in traditional markets in Pati, Bogor, Yogyakarta and Malang cities were contaminated with more than 15 ppb of aflatoxin B_1. These surveys showed that aflatoxin B_1 in groundnuts is an emerging and widespread food safety issue for Indonesian consumers throughout the food delivery chain. The surveys demonstrated that there appears to be a significant build up of aflatoxin in the groundnut delivery chain, with alarming levels reached at the retail sector, hence suggesting poor postharvest storage conditions may have a major contributing role. Earlier work suggested that proper harvesting management practices (including early uprooting and direct stripping) as well as efficient postharvest drying and storage practices should significantly reduce aflatoxin contamination, predominantly by reducing the time that groundnut seeds remain in the critical limits of moisture and temperature range for *Aspergillus flavus* growth and subsequent aflatoxin production. This article presents results of an experiment designed to compare traditional versus improved systems of postharvest management practices as a way of reducing aflatoxin build up in the Indonesian food chain.

Materials and methods

Assessment of the effect of harvest timing and post-farm storage conditions on aflatoxin contamination in groundnuts was undertaken in the central production area in Wonogiri, Central Java during the 2003 wet season. A local cultivar (Spanish type) was grown by a local farmer. At 75 days after sowing (DAS), the farm was divided into four blocks wherein every block was then sub-divided into three harvesting time treatments: (1) 10 days early; (2) farmer's harvest time (90 DAS); and (3) 10 days late. Pod stripping was undertaken in the field due to the high demand for fodder. The harvested groundnuts in each harvesting time treatment were then divided into two sets for postharvest handling treatments: (1) Improved handling and storage management; and (2) Farmer's handling and storage management. The normal farmers practice for handling of harvested groundnuts was as follows: sun drying (for 6 days after harvest); packing of sun-dried groundnuts (in polypropylene bags); and storing under 'farm' conditions (in a store room) without pre-cleaning damaged and diseased pods. The improved management practice, as recommended by Indonesian Legumes and Tuber Crops Research Institute (ILETRI), was as follows: all gynophores were detached, pre-cleaned and pods spread in a well ventilated room. Since the harvesting occurred during the rainy season, harvested pods were air dried for 6 days inside a glasshouse with the pods turned over everyday. After drying, the pods were packed into polypropylene bags layered with a thin polypropylene bag and then tied (one bag per treatment and replication). All four bags were then kept in a dry and cool room (room temperature 24–28°C). A 2.5-kg pod sample was obtained from each storage system at monthly intervals for three months. The pods were shelled manually and segregated into three categories of seeds [sound mature seeds (SMS), damaged, shriveled] and the weight of each category was measured. Aflatoxin B_1 analysis was performed using the ELISA (enzyme-linked immunosorbent assay) method.

Table 1. Percentage weight of sound mature seed (SMS), shriveled seed and damaged seed of groundnut at different harvest timings, storage systems and lengths of storage in Wonogiri, Indonesia, 2003[1].

Treatment	SMS (%)	Shriveled seed (%)	Damaged seed (%)
Harvest timing			
10 days early	25.9	16.6	9.3
Farmer's harvest timing	29.9	19.7	7.9
10 days late	27.1	21.3	9.8
	NS	**	NS
Storage system			
Improved management	30.8	19.4	7.4
Farmer's management	24.5	19.0	10.6
	***	NS	***
Length of storage			
One month	33.1	16.4	9.1
Two months	29.2	21.0	7.9
Three months	20.6	20.3	9.9
	***	***	**
Grand mean	27.7	19.2	9.0

1. NS = Not significant; ** = Significant at 5% level; *** = Significant at 1% level.

Results and discussion

The observation on physical category indicated that the weight of SMS was the highest (27.7%), followed by shriveled seed (19.2%) and damaged seed (9.0%). Postharvest storage practice (ie, at room temperature of 24 to 28°C) introduced by ILETRI had significantly higher number of SMS (30.8%) compared to 24.5% in farmer's practice (ie, storing at room temperature of 25 to 35°C) primarily due to pre-cleaning of pods in the former. Cool storage resulted in less proportion of damaged seed (7.4%) compared to 10.8% in farmer's practice. Length of storage had significant effects on the seed grades with SMS reducing with increase in storage time and damaged and shriveled seeds increasing with increase in storage time (Table 1).

Statistical analysis showed that aflatoxin B_1 contamination positively correlated with percentage weight of damaged seed ($R = 0.363$, $P < 0.05$). Table 2 shows that farmer's practice of storage treatment in general had higher frequency as well as high levels of aflatoxin compared to recommended practice (ie, storing at cool temperatures). Timing of harvest did not have significant effect on aflatoxin. Although farmer's management had lower aflatoxin content (7 ppb), the aberration in this data can only be explained as sampling error rather than treatment effect.

Farmer's management in two treatments resulted in positive contamination in excess of 15 ppb, ie, the maximum allowable level for groundnut seeds as raw material for foods stated by Codex Alimentarius Commission (Dharmaputra et al. 2003). The aflatoxin B_1 content among three seed categories in each treatment indicated that damaged seed had higher contamination (Table 3). The improved postharvest and storage management practice developed at the ILETRI significantly reduced aflatoxin B_1 content especially in shriveled and damaged seeds.

In summary, farmer's practice of postharvest handling of groundnut resulted in high aflatoxin contamination.

Table 2. Aflatoxin B_1 content (ppb) of groundnut at various combinations of harvest timing, storage system and length of storage in Wonogiri, Indonesia, 2003[1].

Treatment	Improved management	Farmer's management
Harvest timing		
10 days early	5b	59a
Farmer's harvest timing	9b	7b
10 days late	7b	57a
		***
Length of storage		
One month	6c	54a
Two months	9c	37b
Three months	6c	32b
		**

1. Values followed by the same letter within a column are not significantly different.
** = Significant at 5% level; *** = Significant at 1% level.

Table 3. Aflatoxin B_1 content (ppb) of three groundnut seed categories at various combinations of harvest timing, storage system and length of storage in Wonogiri, Indonesia, 2003[1].

Treatment	SMS[2]	Shriveled seed	Damaged seed
Harvest timing			
10 days early	6	8	18
Farmer's harvest timing	4	4	2
10 days late	6	10	16
	NS	NS	**
Storage system			
Improved management	3	3	2
Farmer's management	8	11	22
	NS	**	***
Length of storage			
One month	8	12	11
Two months	6	5	11
Three months	2	4	13
	NS	*	NS
Grand mean	5	7	12

1. NS = Not significant; * = Significant at 10% level; ** = Significant at 5% level; *** = Significant at 1% level.
2. SMS = Sound mature seed.

The results of seed infection by toxigenic strains of *A. flavus* showed that all the three catogeries of seeds had high levels of seed infection (up to 55% in SMS, up to 74% in shriveled seed and up to 80% in damaged seed). Yusnawan and Rahmianna (2004) reported that the *A. flavus* strain isolated from groundnut seed from the Wonogiri region produced very high levels of aflatoxin B_1.

The mean pod moisture content at the time of harvest for the three harvesting time treatments was very high (39–52%). However, the mean seed moisture content, after either 1 or 3 months storage, was reduced dramatically to below 9%, prior to the ELISA aflatoxin test. Although the mean seed moisture content before ELISA was <9%, it could be possible that some individual seed may have had higher moisture levels which supported the production of aflatoxin B_1 levels in storage.

It can be concluded that proper harvesting practices such as harvesting at appropriate time, followed by pod stripping soon after harvest, and rapid drying and cleaning of any extraneous matter including damaged pods and gynophores is necessary to reduce aflatoxin contamination in storage. Further, to reduce aflatoxin production in storage, it is recommended to store dry pods in air-tight polypropylene bags and place in airy, dry and clean room.

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