COST EFFECTIVENESS OF SELECTED POST HARVEST POD HANDLING TECHNIQUES AGAINST DAMAGE, MOULDINESS AND AFLATOXIN CONTAMINATION OF SHELLED GROUNDNUT IN GHANA

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ABSTRACT

Some post harvest pod handling methods were evaluated at Ejura and at KNUST, Kumasi to determine the costs and effectiveness of the methods in minimising post harvest damage, mouldiness and aflatoxin (AF) contamination of shelled groundnut. The study was conducted in 2002 (dry season) and repeated in 2003 (wet season). Four treatments were imposed on pods from 180 m^2 plots at harvest. The treatments were (i) inverted windrowing (1wk) followed by drying of the pods on mats (3wk) (ii) random windrowing (1wk) followed by drying of the pods on mats (3wk) (iii) stripping and drying of pods on mats (4wk) and (iv) storage of pods without drying (control). Costs involved in carrying out the treatments were estimated. Fungi associated with the kernels and AF levels were also determined at harvest and at 4 weeks. In both seasons, Aspergillus niger was the most common fungus associated with kernels at harvest and after the 4 wk pod handling periods. Aspergillus flavus was also encountered at both periods. When pods were dried for 4 wk, the amounts of damaged/mouldy ones that were rejected were low (2.7-13.1%; av. 8.6 %) compared with undried pods where 18.9-25.94% (av. 22.08%) were rejected. Aflatoxins were not detected in kernels at harvest and generally, dried pods had lower levels of AFs (0 - 0.7µg/kg) than the undried control pods (7278.1µg/kg). Visibly healthy pods sorted from the dried lots had kernel AF levels of 0.2 - 0.6µg/kg which were similar to the 0 - 0.7µg/kg levels associated with the unsorted lots. Sorting, however, cost an extra ¢31,354/100 kg lot (¢8,200 = $ US1), making the practice uneconomical for well dried pods. Total cost of pod drying up to 4 wk was the same for the random and the inverted windrowed crops (¢89,980/100 kg pod) but was ¢95,440 when pods were dried on mats immediately after stripping. When pods were not dried, cost of handling was ¢69,600/100 kg pods but due to the high AF contamination (7278.1µg/kg), kernels from such pods constitute total loss. Thus, both windrow and mat drying of groundnut pods are cost effective in controlling damage/mouldiness and AF contamination but costs are lower when windrowed.

Keywords: *Groundnut, windrow drying, mouldiness, aflatoxin.*

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed and a valuable source of protein for humans and animals. The crop is cultivated in all the ten regions of Ghana but nearly 85 % of total national production comes from the three northern regions (Atuahene-Amankwa *et al.*, 1990). The total national production of in-shell groundnut for the years 2002, 2003 and 2004 were 520,000, 439,000 and 439,200 MT, respectively (FAO, 2004). Although production has not been consistent, the annual area under groundnut cultivation has increased over these years from 384,000 hectares in 2002 to 470,000 hectares in 2004 (FAO, 2004).

Constraints to groundnut production in Ghana include mouldiness of kernels in storage. This results from high kernel moisture due to unsatisfactory post-harvest pod handling and the humid condition in some producing areas (Atuahene-Amankwa *et al.*, 1990). Mouldiness of groundnut kernels leads to marked reduction in dry matter. Such kernels are unsafe for consumption because they may be contaminated by the mycotoxin, aflatoxin (AF) if aflatoxigenic fungi are involved in the mouldiness. The main aflatoxigenic fungi are *Aspergillus flavus* Link. ex Fries and *A. parasiticus* Speare.

Aflatoxins have assumed greater significance because they are potent liver carcinogens and acutely toxic (Wogan, 1992; Cheng, 1992). The harmful health effects of the toxins are well known (Oyelami, *et al.*, 1995; Obasi *et al.*, 1996; Jonsyn, 1999). Since AFs occur in diets of humans and animals (Anon., 1995), the maximum permissible level of the toxin established by FAO and the WHO for human consumption is 30 μg/kg (Frazier and Westhoff, 1987) even though some importing countries have their own limits (Manzo and Misari, 1989; Read, 1989; Richard, 2000). Aflatoxin contamination of groundnut kernels above the safe limits has been reported in Ghana (Beardwood, 1964; Mintah and Hunter, 1975; Awuah and Kpodo, 1996). This makes AF contamination of groundnut an issue of national concern.

Insects and their damage pre-dispose groundnut to higher post harvest fungal infection (Lynch and Wilson, 1984; Bowen and Mack, 1993; Umeh *et al.*, 1998) and contamination by AFs (Gwinner, 1991; Lynch *et al.*, 1991; Umeh *et al.*, 1998). Post harvest mouldiness and subsequent AF contamination of groundnut kernels is, however, mostly influenced by high kernel moisture (Heathcote and Hibbert, 1978). Rapid drying of kernels to 7% moisture has been recommended to inhibit growth of aflatoxigenic fungi (Dick, 1987). One way to achieve this is by inverted windrowing after harvest (Dickens and Khalsa 1967). This exposes the pods to sunlight and circulating air, which facilitate rapid and efficient kernel drying. A'Brook (1963) found that further drying of pods after 4-6 days windrow drying in the field resulted in AF-free kernels. Devi and Hall (2000) reported reduction in kernel AF levels from rapidly dried, inverted windrow groundnut. Some farmers in Ghana have adopted inverted windrow drying of groundnut even though information on AF reduction and economic analysis of the practice is lacking in Ghana.

Damaged/mouldy kernels usually have high AF levels (Awuah and Kpodo, 1996; Hamid, 1997) and should be sorted out to ensure that AF levels are minimized in the groundnut consumption chain. Since mouldy kernels usually originate from mouldy/damaged pods, such pods also should be sorted and discarded. While mechanised sorting is commonly practiced in developed countries (Parker, 1989), hand sorting is the usual practice in Ghana (Ellis, 2000). Hand sorting is time consuming, laborious and could be costly. The cost effectiveness of sorting groundnut in relation to AF reduction in Ghana must therefore be properly studied.

This study therefore determined cost effectiveness of sorting groundnut against AF contamination. Costs and efficacies of using windrowing and mat drying (without windrowing) of groundnut pods in reducing pod damage/mouldiness and AF accumulation in the kernels was also studied.

MATERIALS AND METHODS

Demarcation of Field Plots and Post Harvest Activities

Two groundnut fields, about 1 km apart, both planted with the variety *Shi-tao-chi* (popularly called Chinese in Ghana) were obtained during the dry (minor) season (August – November, 2002) at Ejura in the transitional agro-climatic zone of Ghana. On each field, the desired land required was marked out and sub-divided into 12, 180 m^2 plots. At harvest, the following treatments were imposed on the plants/pods from the plots: (i) pulling and inverted windrowing of plants for 1 wk, followed by stripping of pods and further drying on interlaced polypropylene mats at KNUST for 3 wk (ii) pulling and random windrowing of plants for 1 wk, followed by stripping of pods and further drying on interlaced polypropylene mats at KNUST for 3 wk (iii) pulling, immediately stripping of pods and sun drying on interlaced polypropylene mats at KNUST for 4 wk and (iv) pulling, immediately stripping of pods and storage in interlaced polypropylene sacks without drying for 4 wk (control). Each treatment was replicated three times in a randomised complete block design (RCBD). Yield per field was estimated at harvest by averaging pod weights from treatments (iii) and (iv) and converting the weight into kg pods/ha.

Soil Analysis

Five rhizosphere soil samples were bulked and analyzed for pH, total nitrogen, organic matter, available phosphorus, exchangeable potassium, particle size and moisture content at the Soil Science Laboratory of the Faculty of Agriculture, KNUST using standard procedures (Anon, 1979). Soil pH was measured with Suntex pH meter in a 1:1 (soil:water) suspension. Total nitrogen was measured using the macro-Kjeldahl method and Walkley-Black dichromate oxidation method used for soil organic matter determination. Available soil phosphorus was extracted with Bray P_1 extractant and the phosphorus determined with a Bausch and Lomb spectronic 20 spectrometer. Soil exchangeable potassium was extracted with 1.0 N ammonium acetate (neutral) and the potassium quantified with a flame photometer. The soil particle sizes were determined using the hydrometer method (Anon, 1979). Soil moisture contents were determined gravimetrically by oven drying 10 g representative samples at 80 ^{0}C to constant weight.

Determination of Moisture, Mycoflora and Aflatoxin Levels of Kernels

Kernel moisture contents were determined gravimetrically at harvest (Awuah and Ellis, 2001) and subsequently at weekly intervals for 4 wk. After the 4 wk pod handling period, the various pod lots were sorted manually and percent damaged/mouldy (rejected) pods estimated from the weight of the rejected pods.

Weather Data

Average temperature, relative humidity (RH) and total rainfall data from harvesting to the end of the 4 wk pod handling were obtained from a weather station at the Department of Mechanical Engineering, KNUST, located about 0.5 km from the drying site. Weather data for Ejura was obtained from a Ministry of Food and Agriculture (MOFA) weather station about 2 km from the fields.

Cost of Post-harvest Pod Handling Activities

Costs of labour and materials (sacks and drying mats) for carrying out the four post harvest treatments were estimated using prevailing wages and prices. From these, the cost for sorting 100 kg pods was also obtained.

Data Analysis

Apart from kernel moisture content, all data in percentage were arc sine transformed (Sine $-1\sqrt{Y}$) before statistical analysis. Analysis of variance (ANOVA) was performed on the data with MSTAT C package (Michigan State University). Differences in the means were compared using the least significant difference (LSD) test ($p \leq 0.05$).

The entire experiment was repeated from April-July in 2003 during the wet (major) groundnut growing season. Only one field was used in the repeat experiment.

RESULTS

Edaphic Characteristics of Fields and Groundnut Pod Yields

The fields used for the study were sandy (79.7-84.8 % sand particles) with moderate amount of macro-nutrients. The pH ranged from 5.2-6.8 (Table 1). Fresh groundnut pod yield was higher during the wet growing season (2010.55 kg/ha) than in the dry season where yields obtained from fields 1 and 2, respectively, were 925.00 and 1851.85 kg/ha.

Fungi Associated with Groundnut Kernels

Approximately 19 % of all kernels assayed from pods at harvest in the wet season were infected by *Aspergillus flavus* and 5.0 and 14.3 %, respectively, of freshly harvested kernels from fields 1 and 2 in the dry season harboured the fungus (Table 2). Other fungi associated with the freshly harvested kernels were *Aspergillus niger*, *Aspergillus tamarii*, *Rhizopus stolonifer*, *Fusarium* spp., *Penicillium* spp., *Rhizoctonia* sp., *Mucor* sp and *Trichoderma* sp (Table 2). In general, *A. flavus* was more frequently encountered on kernels from undried pods than those from dried pods after the 4 wk post harvest pod handling period.

Post Harvest Pod Handling and Kernel Moisture Contents

In the dry season, moisture contents of kernels from the windrowed and the mat dried pods from field 1 decreased from an average of 37.1% at harvest to 9.4% and 6.7%, respectively, after 1 wk (Fig 1A). These moisture contents were not significantly different ($P \leq 0.05$) from each other and stabilised at 4 % (aprox.) after further drying the pods on mats for 3 wk (Fig 1A). Similar results were obtained for field 2 during the dry season (Fig 1B).

Table 1: Groundnut pod yield, kernel moisture content and soil characteristics of field plots at harvest

Field	Yield (Kg/ha)	Kernel MC (%)	Soil Characteristics at harvest [1] MC (%)	OM (%)	pH	N (%)	P (Mg/Kg)	K (cmol/Kg)	Sand (%)	Clay (%)	Silt (%)
Field 1 (dry season)	925.00	37.12	5.23	0.75	6.85	0.03	16.00	0.12	84.80	7.60	7.60
Field 2 (dry season)	1851.85	43.14	8.99	0.80	6.86	0.04	20.25	0.15	80.08	7.60	11.60
Field 1 (wet season)	2010.55	40.89	3.03	0.17	5.28	0.05	29.10	0.11	79.73	6.94	12.35

[1]MC = moisture content; OM = organic matter; pH was determined for a 1:2.5 (soil: water) suspension; N= total nitrogen; P= available phosphorus; K= exchangeable potassium.

Table 2: Frequency (%) of fungi associated with freshly harvested groundnut kernels

Fungus	Field 1 (dry season)	Field 2 (dry season)	Field 1 (wet season)
Penicillium spp.	4.38	27.50	5.0
Aspergillus niger	68.75	86.25	78.8
Aspergillus flavus	5.00	14.38	18.8
Aspergillus tamarii	0.00	0.00	3.1
Rhizoctonia sp.	30.63	27.50	21.9
Rhizopus stolonifer	30.63	4.38	5.0
Mucor sp.	1.88	0.00	0.6
Trichoderma sp.	13.75	0.63	17.5
Fusarium spp.	0.63	0.63	0.6
Unidentified	0.00	0.00	0.6

In the wet season, moisture contents of kernels from the windrowed and the mat dried pods decreased from an average of 40.8% at harvest to 14.3% and 20.4%, respectively, after 1 wk (Fig 1C). These values were significantly different ($P \leq 0.05$) from each other. The moisture contents stabilised at 5% (aprox.) after further drying the pods on mats for 3 wk. In all instances, moisture contents of kernels from non-dried pods remained high ($P \leq 0.05$) during the 4 wk post harvest pod-handling period (Fig 1A, B and C).

Weather Conditions during Pod Handling

Average temperature and RH at the end of the 1 wk windrow drying at Ejura were, respectively, 25.1 ^{0}C and RH 76.6 % in the dry season and 23.6 ^{0}C and RH 78.4 % in the wet season. Temperature and RH at KNUST, Kumasi for the same period when pods were mat-dried immediately after harvesting were, respectively, 25.8 ^{0}C and RH 78.1 % in the dry season. In the wet season, the values were 23.6 ^{0}C and RH 84.6%. A total of 0.2 mm rain fell during the initial 1 wk mat drying in the wet season at KNUST. There was no rainfall at Ejura during the 1 wk windrowing in both seasons.

During the additional 3 wk mat drying period at KNUST in the dry season, average RH was 89.1 %, average temperature was 26.6 ^{0}C and total rainfall ranged from 44.1-44.7 mm (Av. 44.4 mm). In the wet season, however, average RH was 94.1%, average temperature was 24.3 ^{0}C and total rainfall was 43.7 mm during the additional 3 wk mat drying period.

Aflatoxin Levels and Economics of the Pod Handling Techniques

Cost of pulling groundnut plants and stripping pods was the same (¢69,600/100 kg of fresh pods, ¢8,200 = $ US1) irrespective of the treatment (Table 3). Total costs of drying (labour and materials) was higher when pods were immediately stripped and mat-dried for 4 wk (¢25,840) than when windrowed (¢20,380) in the field for 1 wk before stripping and further drying on mats for 3 wk (Table 3).

When pods were dried for 4 wk, the amounts of rejected (damaged/mouldy) ones were low (2.7-13.1%; av. 8.6 %) compared to undried pods where 18.94-25.90% (av. 22.08%) were rejected. In each field, the estimated value of kernels lost from the dried pods were not significantly different from each other and ranged from ¢5,491.69 - ¢25,057.47/100 kg pod lots (Av. ¢16,617.70). In all three fields, the estimated kernel loss from the discarded undried pods cost between ¢ 36,277.14 and ¢49,553.00 (Av. ¢42,254.15) (Table 4).

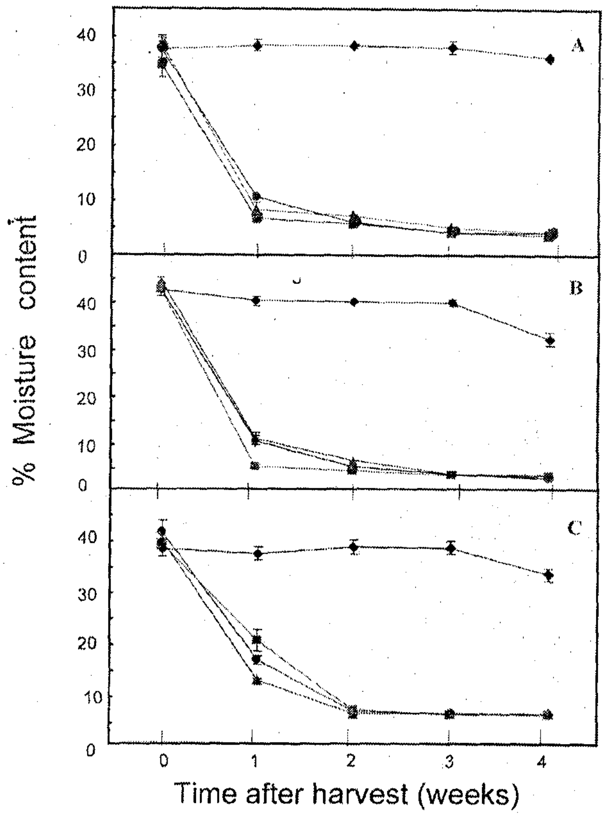

Fig 1. Moisture content of groundnut kernels of pods receiving various post harvest treatments. A, dry season (field 1); B, dry season (field 2); C, wet season. ♦—♦=stripping of pods and storage without drying; ■—■ = stripping of pods and drying on mats; ●—● random windrowed crop; ▲—▲= inverted windrowed crop. Each point is the mean kernel moisture from three replicate samples.

Table 3: Cost (¢) of various activities from harvesting to sorting of groundnut pods

Treatment[1]	Pulling/ Windrowing[3]	Stripping[3]	Drying[4] Mats	Drying[4] Labour	Sorting[5] Field 1 (Dry season)	Sorting[5] Field 2 (Dry season)	Sorting[5] Field 1 (Wet season)
A	34,800	34,800	4,000	16,380	18,114.30	32,071.50	32,990.01
B	34,800	34,800	4,000	16,380	31,428.62	40,857.23	30,769.77
C	34,800	34,800	4,000	21,840	26,785.76	39,714.30	29,462.92
D	34,800	34,800	0	0	55,785.77	48,642.97	43,482.78
LSD (5%)	NS	NS			9,722	1,944	3,737.08
CV (%)					14.7	2.4	6.64

[1]Treatments are A = pulling and inverted windrowing of plants (1 wk), stripping and further drying of the pods on mats (3 wk); B = pulling and random windrowing of plants (1wk), stripping and further drying of the pods on mats (3 wk); C = pulling, stripping and sun drying of pods on mats (4 wk); D= pulling, stripping and storage of pods without drying (control).
[2]Four (4) drying mats were required for 100 kg of unshelled nuts per treatment, costing ¢16,000. Mats can be used for at least four seasons; so each season's cost per treatment is ¢4,000. Labour for spreading pods to dry and for sending them indoors at the end of day is ¢780 a day.

Table 4: Groundnut pods rejected after various post harvest pod treatments

Treatment[1]	Rejected pods (%) and value (¢) of the kernels					
	Field 1 (Dry season)		Field 2 (Dry season)		Field 1 (Wet season)	
	Pod	Value[2]	Pod	Value[2]	Pod	Value[2]
A	6.30	11,992.33	8.10	15,517.24	10.32	19,782.89
B	2.70	5,491.69	11.90	22,860.79	8.66	16,673.05
C	6.80	13,154.53	9.90	19,029.37	13.08	25,057.47
D	21.40	40,932.31	25.90	49,553.00	18.94	36,277.14
LSD (5%)	8.10	22,587.20	9.10	17,937.97	3.51	8,189.96
CV (%)	24.70	63.18	20.70	33.58	8.48	16.77

[1]Treatments are A = pulling and inverted windrowing of plants (1 wk), stripping and further drying of the pods on mats (3 wk); B = pulling and random windrowing of plants (1wk), stripping and further drying of the pods on mats (3 wk); C = pulling, stripping and sun drying of pods on mats (4 wk); D= pulling, stripping and storage of pods without drying (control).
[2]Cost for handling 100 kg pods (¢8,200 = $ US1).

Table 5: Cost (¢) and aflatoxin levels (µg/kg) of kernels after post harvest plant/pod handling[1]

	Field 1 (Dry season)				Field 2 (Dry season)				Field 1 (wet season)			
	Sorted pods		Unsorted pods		Sorted pods		Unsorted pods		sorted pods		Unsorted pods	
	Cost	AFL	Cost	AFL	Cost	AFL	Cost	AFL	Cost	AFL	Cost	AFL
A	108,094.30	0.6	89,980	0.0	122,051.50	0.6	89,980	0.0	122,970.00	1.7	89,980	1.0
B	121,408.62	0.2	89,980	0.7	130,837.23	0.3	89,980	0.8	120,749.77	2.4	89,980	0.4
C	122,225.76	0.6	95,440	0.7	135,154.30	0.1	95,440	0.2	124,902.92	0.3	95,440	0.4
D	125,385.77	8034.8	69,600	7279.1	118,243.00	648.1	69,600	1086.8	113,082.78	4551.9	69,600	5217.8

[1]Cost for handling 100 kg pods (¢8,200 = $ US1); AFL= aflatoxin levels. AFL at harvest for field 1 (dry season) = 0 µg/kg; field 2 (dry season) = 0.7 µg/kg and field 1 (wet season) = 0.06 µg/kg.
[2]Treatments are A = pulling and inverted windrowing of plants (1 wk), stripping and further drying of the pods on mats (3 wk); B = pulling and random windrowing of plants (1 wk), stripping and further drying of the pods on mats (3 wk); C = pulling, stripping and sun drying of pods on mats (4 wk); D= pulling, stripping and storage of pods without drying (control).

In the dry season, total AF levels associated with freshly harvested kernels from fields 1 and 2, respectively, were 0 and 0.7µg/kg (Table 5). In the season, levels of the toxin for kernels from sorted clean pods and unsorted pods in the windrowed and the mat dried pods were also low, ranging from 0 to 0.8µg/kg (Table 5). In the wet season, the total AF level in the freshly harvested kernels was 0.06 µg/kg and levels associated with kernels from sorted clean and unsorted pods in the windrowed and the mat dried pods ranged from 0.3 to 2.4 µg/kg (Table 5).

In all experiments, total costs ranging from ¢ 108,094 - ¢135,154/100 kg pods were incurred when the dried pods were sorted to reduce kernel AF levels (Table 5). Total costs of ¢89,980 - ¢ 95,440 were incurred when the dried pods were not sorted but kernels from such pods also had low AF levels comparable to those of sorted clean pods (Tables 5). High kernel AF levels ranging from 648.1 to 8034.8 µg/kg were associated with undried pods (Table 5).

DISCUSSION

During the dry season, random windrow drying of groundnut was as effective as inverted windrowing in reducing kernel moisture content after 1 wk to the acceptable level of below 10 % reported by Daren (1989). Differences were not detected in the moisture contents of the inverted and the random windrow crops during the dry season because the low relative humidity (76.6 %) prevailing in the area greatly facilitated drying. Therefore, if the weather is dry, pods may be stored after 1 wk of either inverted or random windrowing without further mat drying at home. This will minimise production cost.

During windrow drying in the wet season, the weather was generally humid resulting in less rapid drying of the pods. Moisture loss from the inverted windrow crop however was faster than that of the random windrow crop. The current study, thus, confirms the findings of Person and Sorenson (1969) that inverted windrowing enhanced rapid drying of pods in humid weather.

Because kernel moisture contents of both inverted and random windrowed crops during the wet season were high after 1 wk, an additional week of further mat-drying the windrowed crops was required to lower their kernel moistures to approximately 6 % which was within the less than 10% acceptable limit reported by Daren (1989). Hence, where further mat drying of pods from windrowed crops is desired, it should not exceed 1 wk provided the weather is dry and it does not rain.

Aflatoxin levels of kernels from pods dried for 4 wk in the dry and the wet seasons were very low (0 - 0.8 μg/kg; Av. 0.4 μg/kg) and fall within the safe AF levels of foods meant for consumption (Frazier and Westhoff, 1987; Richard, 2000). This is attributed to the low kernel moisture achieved with drying during the period. Drying of kernels to low moisture is known to be effective in reducing growth of aflatoxigenic fungi and AF contamination of groundnut (Dick, 1987). The study agrees with the reports of other workers that groundnut kernel moisture during storage correlates well with AF levels (Dorner *et al.,* 1989; Sanders *et al.,*1993). Because of this, we presume that the kernels AF levels would have been low if they had been determined immediately after the 1 wk windrow/mat drying since moisture contents of such kernels were very low. This, however, needs verification in subsequent studies.

Though aflatoxigenic fungi were detected in the freshly harvested kernels, AF was either absent or detected in extremely low levels in such kernels. This agrees with reports that presence of aflatoxigenic fungi in kernels is not indicative of AF accumulation (Cole *et al.,* 1985 and Sanders *et al.,*1985). Aflatoxin formation depends on certain factors including end-of-season moisture stress on the crop, mean soil temperatures of 28-31°C in the pod zone, overly mature crops, etc (Anon, 2000). Cole *et al.* (1985) and Sanders *et al.* (1985) previously alluded that kernel invasion and subsequent AF accumulation involves separate processes.

In Ghana proper drying of groundnut pods to control accumulation of AF in kernels is recommended but this is the first report of assigning cost to the practice. Without pod drying, the kernels were highly contaminated by AF and constituted a complete loss. Financially, the loss due to the AF contamination was estimated at ¢ 191,551.72/100 kg pod lot. Drying accounted for 23 % (windrow drying) to 27 % (immediate stripping with mat-drying) of total post harvest pod handling cost and was able to reduce AF contamination to the acceptable levels of 30 μg/kg recommended by the FAO/WHO for consumption (Frazier and Westhoff, 1987). Both drying practices (i.e. windrowing and immediate stripping with mat drying) are therefore cost effective in managing AF accumulation to levels within the FAO/WHO recommended level of 30 μg/kg and even the 20 μg/kg reported by Richard (2000). However, because it costs more to strip and mat-dry, windrowing in the field for 1 wk and at most an extra wk of mat drying (in cases of humid weather) is recommended. In the event of intermittent rainfall during the windrow period, pods must necessarily be stripped from plants and mat dried at home for 1-2 weeks (Awuah, 2000). If the weather is dry and the rains have ceased, crops should not be left in the windrow for more than 2 wk since the present study has shown that the safe kernel moisture for storage is attainable after 1 wk windrowing in the dry weather. Besides, continued drying of pods in the windrow will expose them to attack by rodents and arthropods.

Sorting of kernels (Awuah and Kpodo, 1996) and of discoloured or damaged/shriveled pods is often recommended for minimizing AF levels. The basis of sorting pods is that damaged pods often contain damaged/mouldy kernels and these kernels have high levels of AF (Hamid, 1997). In the present study, sorting of properly dried pods increased cost both in terms of labour and kernel loss with no effects on AF levels. Sorting of properly dried pods constituted 20-44% of the post harvest handling cost, though the AF levels of kernels from both the sorted clean pods and the unsorted pods were low and similar. This is attributed to the effective pod drying during the 4 wk pod-handling period. Pod sorting of properly dried pods is, therefore, not recommended as it resulted in kernel loss averaging approximately 2.9 % with an estimated value of ¢ 16,617.70/100 kg pod lot. Proper pod drying alone is, thus, cost effective in reducing AF contamination of groundnut to levels acceptable for human consumption.

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