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Research article

Major Contaminants in Some Stored Grain and Grain Products in Central Sudan

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Abstract

Contaminants of grain and flour become an international state of concern. That is due to the hazards they pose on human health. These contaminants include living objects such as insects, mites and microbes. However, some insects endanger the quality and reduce the shelf life of grain and flour drastically beside the mycotoxins and their catastrophic impacts. Samples of grain and some grain products (flour and semolina) were checked for major contaminants *viz*. living objects and aflatoxins. These samples were collected from the five largest storage and milling firms in Sudan. The insects reported in the test samples belong to *Tribolium castaneum* (Herbst), the red flour beetle. Aflatoxin contamination was checked for using Aflacheck^{TM} rapid test of the Waters Incorporation (USA) at 10 ppb level. Only two samples from two test firms were found positive for this test which constituted 20% of the samples per firm and only 8% of the total test samples. Concerning the living contaminants there was a recurrent infestation by the acarid, *Acarus siro* L. in one firm and *T. castaneum* infestation in four firms of which one had a high flour infestation (10s of beetles/ Kg). Considering the silo tightness and its general situation in the test firms it was excellent in only one firm and unsatisfactory in the other four. Moreover, the fumigation with phosphine was intensive (every 2 – 3 month) in the firm free of infestation which had a fully computerized system. The aeration was insufficient in three firms that showed some storage drawbacks, aflatoxins, insect and mite contamination in one; aflatoxins contamination in the second and heavy insect infestation in the third. The insect contamination was mainly due to eggs because the milling process left neither living intact larvae nor adults. This study concluded into a reported unsatisfactory technical guidance, plans and supervision in controlling insects, mites and toxigenic microbes in these firms inspite of their relatively advanced operating systems.

Keywords: Aflacheck^{TM}, grain, flour, insects, mites, silo and Sudan.

Introduction

Food contaminants include, firstly food – chain contaminants such as the presence of plant toxicants of fungal metabolites in food, or the contamination of food from environmental sources (airborne, aquatic and terrestrial); and secondly, food – production contaminants – contaminants of man – made origin brought about by a desire to facilitate food production and distribution . However, the biological contaminants include insects (dead or alive) and the mycotoxins which are fungal metabolites when ingested, inhaled or absorbed through the skin cause lowered performance, sickness or death in man or domestic animals including birds [1]. The discovery of aflatoxins began immediately after an outbreak of a disease of turkeys of unknown etiology in England in 1960. The disease was called Turkey "X" disease and was eventually attributed to a toxic groundnut meal imported from Brazil. From that point, an extensive effort to find the cause eventually elucidated that a species of mold, called *Aspergillus flavus*, was involved and the hepatotoxic products of this mold, found also as components in the toxic groundnut meal, were called aflatoxins. The finding that the aflatoxins were carcinogenic caused concern for their occurrence in human foods and led to worldwide efforts to determine the relationships of these carcinogens to human disease and determine their occurrence in human foods as well as in animal feeds [2] & [3]. However, a thorough overview of the mycology and toxicology of five important agricultural mycotoxins which include deoxynivalenol, zearalenone, fumonisin, ochratoxin and aflatoxins was done [4]. In Sudan the last two mycotoxins are the most important fungal contaminants of food and feed (*viz*. aflatoxins and ochratoxins) [5]. Nonetheless, there may be no need for more recommendations for aflatoxins control but to implement the present findings which are enough. That is, good management can reduce but not solve the problem which is huge in China, Africa and Asia especially in maize and groundnut mainly by preventing aflatoxins formation, the only effective long term solution [6].

Several cosmopolitan insect species are commonly found in stored – grain. The most damaging insect pest of stored wheat in USA is the rice weevil [*Sitophilus oryzae* (L.)] and the lesser grain borer [*Rhyzopertha dominica* (F.)] [7]. The khapra beetle (*Trogoderma granarium* Everts) was considered the most important pest of stored grain under high temperature and dry conditions [8]. It was probably gained entrance to Sudan in 1944 on imported wheat and established itself as a common pest there [9]. A comprehensive report [10] mentioned 17 insect species (including the primary pest, *Sitophilus* spp. and *Rhyzopertha dominica* L. and one acarid (*Acarus siro* L.) to infest grain, grain flour and graminaceous products in Sudan. In Tanzania, up to 34% losses have been observed after 3 months storage on the farm, with an average loss of 8.7% [12]. *P. truncatus* is a much more damaging pest when compared to other storage insects including *Sitophilus oryzae*, *S. zeamais* and *Sitotroga cerealella*, under similar conditions; maize losses due to these other species were 2 – 6, 3 – 5 and 2 – 5%, during a storage season in Zambia, Kenya and Malawi, respectively. It was indicated that the dura stored in underground pits shortly after harvesting reflected only 2% or less loss in a couple of 13 months in Sudan [12] whereas another report mention that transportation and long – term storage, causing an estimated overall loss of up to 30% [13]. Moreover, a recent report valuated grain loss in traditional stores to reach 50%, it had a range 5 – 13% for modern storage facilities; 6% in the underground pits and only 1% in silos [14]. However, insects represent a major contaminant of grain and grain products. Stored – grain Insects often cause as much loss after harvest as crop pests cause during the growing season. Insects cause losses by direct feeding damage and also deterioration and contamination of grain [15]. That is, six steps were mentioned to prevent and control insect damage which are: keep bins clean and repaired; use residual sprays; store only clean, dry grain; aerate the grain; protect the grain; and inspect the grain regularly [15]. However, the overall achievements of the integrated methods of management of insect pests of grain failed in getting rid of egg contamination which results in a recurrent infestation in the packed flour (Magboul, personal communication).

This study aimed at reporting the major contaminants of grain and some grain products in the largest storage firms in Sudan.

Material and Methods

Materials

Samples were taken from five silos in firm A using a vacuum machine. However, the sampling of the remainder four firms (B, C, D & E) was by taking five packets (each of I Kg wt) of flour with different production dates, randomly. Magnifying lens and a binuclear were used for the insect and mite infestation and damage. Afalcheck™ test kids (tests dilution tubes, paper rack, 250 µL test pipettor, Aflacheck test strip), glass rod, pure methanol, distilled water, etc…. were all used in this study. The experiment was taken at the grain technology department of the Food Research Center, Kahrtoum North.

Methods

Visits were organized for two great storage facilities outside Khartoum State and other three great ones in Khartoum. These plants will be coded with the alphabets A, B, C, D and E. Five samples were taken from each of these great stores. Samples were tested for insect infestation and damage, total aflatoxins (AFB1, AFB2, AFG1 and AFG2) using Aflacheck™ test kids of Vicam® which belongs to Waters© Incorporation, USA. Insects and insect damage were observed for each sample. The aflatoxins tests were made using Afalcheck™ kids (mycotoxins testing system) following Vicam® testing procedure. The recommended steps are as follows

Sample Extraction

1. Weigh 5 grams and add to a 40 extraction tube.
2. Measure 10 ml of 70% methanol with a 10 ml graduated cylinder and pour the solution into the 40 ml extraction tube.
3. Cover the 40 ml extraction tube and shake the mixture by hand for 1 minute.
4. Allow the sample to stand for 3 minutes.

Aflacheck™ Procedure

1. Place a strip test dilution tube in the paper rack. When the kit first arrives, the paper rack will be nested upside – down inside the box.
2. Add 250 µL of distilled water to the strip test dilution tube with a 250 µL strip test pipettor.
3. Transfer 250 µL of sample extract to the strip test dilution tube using a new strip test pipettor.
4. Mix the solution by capping the strip test dilution tube and shaking by hand.
5. Insert an Aflacheck™ strip test (arrows pointing down) into the strip test dilution tube and allow the test to develop.
6. A negative result (less than 10 ppb) can be determined once you can see both a test line and a control line. This can occur in as little time as 3 minutes.
7. To check for a positive result (≥ 10 ppb), allow the Afalcheck™ strip test to develop in the strip test dilution tube for at least 5 minutes. If after 5 minutes no test line appears then the results can be interpreted as positive.
8. If no line appears this may imply an invalid test strip. Use another one.

The inspection of the operating systems of the storage containers in the test firms was done jointly with the staffs in charge.

Results and Discussion

Table 1 displays the situation of each storage system of the test firms (A – E) according to the international standards. These parameters include: aeration, temperature, relative humidity, pressure (tightness), fumigation, insect infestation, mite infestation, storage duration, aflatoxin contamination etc.. That is, the aeration may be improper in firms A, C and E that may account for the presence of aflatoxins in their grain stocks for the first two and the high insect infestation in the latter. That is, aeration in the wet holding bin helps provide some temperature control but is not a substitute for timely drying. Hopper bottom bins are preferred to hold wet corn since they are self-cleaning. It is a good idea to periodically check that these bins empty completely before more wet grain is added. If a flat bottom bin is used to hold wet corn, use a power sweep auger to unload the bin completely each day or form a "false" hopper bottom with dry corn to facilitate daily unloading of wet grain. Wet grain should not be left in an aerated holding bin more than 48 hours before drying [16]. The temperature is rather okay in all the five firms yet the high temperature in Sudan may aggravate the problem of mycotoxins if the RH is not well controlled. The relative humidity might be relatively high in firms C and E which might be reflected by the mycotoxins contamination and the insect infestation both mentioned in these storage containers, respectively. The silos tightness is only excellent in firm A (monitored by a computer system) and these silos are made of concretes. However, the leakage and/ or insufficient fumigation might be inferred by the results of insect infestation in all the other four firms. However, firm E had a lot of maintained cracks at some of its silos bases which may account for the high insect infestation reported. That is, they might fumigate before such maintenance. However, the other stages (larvae and pupae) appeared from the 3rd month of storage of the packed bread wheat flour definitely from the egg infestation due to the absence of proper treatment during the milling process [17]. The insect infestation was reported in the packets whereas the complete absence in samples from firm A may be attributed to the intensive fumigation and/ or the silo tightness observed there. However, the insect damage in some grain from this depot may be referred to earlier infestation before been stored. The concentration of phosphine needed to control all stages of the insects is 100 ppm throughout the silo. Control will not be achieved unless this concentration is maintained for at least seven days. A seven to ten day fumigation period is recommended to allow time for the tablets to fully liberate their gas followed by a ventilation period of an additional three days. Fumigation will fail if the silo leaks. When wind blows against a leaky silo, the chimney effect caused by the pressure difference draws the gas out of the silo [18]. This may give an elucidation of the infestation occurred in the four test firms stores (Table 1). The great storage capacities of the five firms reflect their importance as a major tool in strategic grain sector and the front defense line in national food security. However, accordingly any fallacies in this sector will aggravate the negative impacts on the citizen health. Therefore, a lot of care is needed in this respect geared to official technical inspection to help the private sector considering the international standards of storage and human health. Moreover, 25 collected samples from the five test firms were analyzed for total aflatoxins. That is, only two samples were found positive for 10 ppb from firm A and firm C. This experiment was done using Aflacheck™ from Waters Incorporation of USA (Table 2). It may be worth mentioning that the EU regulatory limit of total aflatoxins is 5μg/ kg (5 ppb) [19] and the codex level for groundnut and pistachios is 10μg/ kg (10 ppb) [20]. These results can be exploited to improve the storage systems in the strategic grain sector in Sudan. However, this work is part of a research and training components of a work plan on return (WPR), a post course component of a residential training supported by the AAA (Australian Awards in Africa) program.

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Table 1: Situation of the Storage System in the Test Firms

Firm No.	Aeration	Temp.	R. H.	Tightness	Fumigation	Insects	Mites	Storage Duration & Capacity (tons)	Aflatoxins	System Nature & Capacity
A	Insufficient	O. K.	O. K.	Excellent	Intensive (every 2 – 3 months)	No insects reported yet some Damage observed	No complaints	Very long (> year – 3 years). 100,000	One Silo contaminated (20%)	Very advanced and fully computerized
B	O. K.	O. K.	O. K.	Unsatisfactory	Unsatisfactory	Eggs reported	No complaints	Up to Few months. 180,000	Not reported	Advanced and computerized
C	Insufficient	O. K.	Relatively high	-Do-	-Do-	Eggs reported	A lot of complaints (*Acarus siro* L.)	Up to Few months. 95,000	Reported in one of the test samples (20%)	Advanced and partially computerized.
D	O. K.	O. K.	O. K.	-Do-	-Do-	Eggs Reported	Not reported	Up to Few months. 150, 000 ton	Not reported in any of the test samples.	Computerized.
E	Insufficient	O. K.	Somewhat high	-Do-	-Do-	A lot of beetles and eggs of *T. castaneum* .	Not reported	Up to Few months. 70, 000 ton	-Do-	Partially computerized

Table 2: Total Aflatoxins in Test Samples from Five Test Firms

Firm No.	**Samples / Aflatoxins (10 ppb)**				
	1	2	3	4	5
A	+ve	- ve	-ve	-ve	-ve
B	- ve	-ve	-ve	-ve	-ve
C	-ve	-ve	+ve	-ve	-ve
D	- ve	-ve	-ve	-ve	-ve
E	- ve	-ve	-ve	-ve	-ve

Conclusion

The study concluded into reporting all or some of the following: unsatisfactory drying, aeration, silo tight sealing, phosphine dosage in all or some silos of the test firms. The reported aflatoxins in 8% of the test samples constitute a sizable threat in this strategic storage sector. The insect infestation constitutes a major dismerit for the quality and the potential shelf life of the stored grain. The upgrading of the capacities of the operating cadre of the system is mandatory together with stringent follow up and adoption of the recommended methods to avoid or reduce any contamination by aflatoxins and/ or insects and mites in the future grain industry in Sudan.

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