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Comparative Study of Different Storage Methods for Postharvest Preservation of Wheat Grain

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Abstract: Present study was carried out to find out the extent of grain deterioration during storage. Grain samples were collected from three traditional structures (i.e., room store, earthen bin and metallic bin) and one from designed structure (concrete block bin) at an interval of 3 months for a storage period of 12 months. The results indicated that moisture content (14-14.36%), insect-infestation (0-18.2%) and aflatoxin (0.8-9.7 µg kg^{-1}) increased significantly ($P< 0.01$) with respect to storage period, whereas, 1000 grain weight (43-40.2 g) and germination ability (96-62.2%) significantly ($P< 0.01$) decreased with increasing storage. Among the storage structures, the highest moisture content (14.64%), insect-infestation (12.4%) and aflatoxin (7.62 µg kg^{-1}) with least values of 1000 grain weight (41.48 g) and germination ability (77.4%) were observed for the grains kept in the room store. Moreover, concrete block bin resulted suitable for retaining better quality of wheat grains.

Key words: Wheat storage, Moisture, Aflatoxin, Germination, Insect-infestation.

INTRODUCTION

Wheat (*Triticum aestivum*) is the most essential cereal crop grown all over the world, which is also an important source of human nutrition (Nadeem *et al*., 2010). In Pakistan, total area of wheat is around 8.693,000 hectares with a production of around 24.2 million tons, which contributes 2.2% to the Gross Domestic Product (Government of Pakistan, 2013). Different grain storage methods, such as, earthen bins, room, heaps covered with straw, metal bins and bags, have been adopted by farmers, which can not assure safety from storage pests along with various defects mainly occurring in wall, foundation and roof of the structures (Alonge, 2005). Grain moisture, humidity and temperature are the major factors affecting the ecosystem of the stored wheat (Sorour and Uchino, 2004). These factors affect the quality of the stored wheat by inducing the growth of the microbes, insects and molds (Nithya *et al*., 2011). Insect infestation causes severe damage in the form of cracks and holes in grains, which can cause half of wheat loss during storage period (Fornal *et al*., 2007). The grain is being retained by farmers for consumption and seed purpose (Ahmad and Ahmad, 2002). Lack of suitable storage structures also lets farmers to sell out their grains directly as harvested to avoid losses (Kimenju *et al*., 2009).

Highly infested grain contains less nutritional content (Oke and Akintunde, 2013) and may have toxic materials that harm health of the consumers (Modgil, 2003). Toxin contaminated food when ingested can cause severe impact on human health (Bryden, 2012). Around 1000 million metric tons of food is deteriorated universally every year because of poisons created by storage fungi (Bhat *et al*., 2010). Cereal grains, polluted by fungi and the related poisons created during lack of proper storage, reduces market value (Prakash *et al*., 2011). Therefore, it is required that proper and low cost storage structures should necessarily be intended. Keeping in view the above facts, present study was carried out to evaluate the traditional and designed grain storage methods in terms of grain quality.

MATERIALS AND METHODS

Current study was conducted during 2015-16 at Latif Experimental Farm of Sindh Agriculture University, Tandojam, in Hyderabad district of Sindh province, which is located at 25°18′05″ N, 68°28′37″ E, 18 m, above sea level. Climatically, the

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region is damp and gets normal yearly precipitation of around 241.9 mm. The normal most extreme temperature is recorded with 40.8 °C in May and normal least of 11.5 °C in the month of January. The month of August is recorded to have maximum relative humidity with 80%, while in January, it is recorded to be minimum with 58%.

Storage methods: The detail of grain storage methods, used in the study, is given below:

(i) Room stores usually made of burnt clay bricks laid with cement mortar. The grains were packed in jute bags and placed inside the room as shown in Fig. 1 A.

(ii) Earthen bins were constructed using clay, for strengthening, straw was mixed as a binding material. (Fig. 1 B).

(iii) Metallic bins cylindrical shaped made of iron sheet (Fig. 1 C).

(iv) A concrete block bin, which was designed and constructed using hollow concrete blocks, laid with cement mortar. Hollow concrete blocks have thermal insulation property, which keep the stored grain cool and prevent from moisture migration and condensation problems. A layer of damp-proof membrane was provided at the lower portion of the bin in order to protect the grain from moisture uptake from the ground. The top portion of the bin was constructed from the wooden frame covered with asbestos sheet; this also has heat insulation property, which protects the grain from heating during day time (Fig. 1 D).

Fig. 1. Grain storage structures.

Grain sampling and quality analysis: Grain samples were collected from each storage structure, using grain sampler at an interval of 3 months for a period of 12 months, which were then analysed in the laboratory for quality parameters. For determination of moisture content sample of grain, weighing 3 gm, was dried in air forced draft oven at a temperature of 105 ± 5 °C till to constant weight. The methodology of American Association of Cereal Chemists (2000) method No. 44-15A was utilized for the estimation of moisture in each sample. Counting method described by Wambugu *et al.* (2009) was adopted for insect damage, where 200 grains were randomly collected from each storage structure and were visually observed. Methodology described by Giray *et al.* (2007) for high performance liquid chromatography (HPLC) was adopted for determining aflatoxin contamination with some minor modifications. Weight of grains was measured using digital weight balance. Germination capacity was recorded by setting 25 seeds on Whatman No. 3 filter paper immersed with 5.5 ml of refined water in a 90 mm measurement Petridish. The dishes were heaped one over the other in a stand and were secured with polythene wrap for the initial 4 days at room temperature (22 ± 1 °C). After that, the wrap was evacuated, the dishes were then kept to surrounding air for 3 days, where the number of seeds germinated were checked (Wallace and Sinha, 1962).

Statistical analysis: Analysis of variance using 2-factorial model and mean multiple comparison was carried out using statistical software (Statistix 8.1).

RESULTS AND DISCUSSION

Moisture content: Mean squares revealed significant variations in moisture of wheat grains, due to storage methods and storage time. The interaction between storage methods and storage time (S×D) also showed significant effect on grain moisture (Table 1). A variation in moisture content was observed during entire storage period. Maximum moisture of 14.64% was observed during 6th month of storage (Table 2) kept in room store followed by metallic bin (14.61%) and earthen bin (14.57%). However, the minimum moisture (13.39%) was noted in concrete block bin (Table 2). Change in grain moisture content might be due to respiration of insects, fungi and grain itself which release heat, CO_2 and water content. Fluctuation in relative humidity and temperature can also be the cause for the variation in moisture content. The present findings are in close agreement with the results of Sawant *et al.* (2012), who also observed an increase in moisture content of contaminated grains with increased storage periods under different storage methods. Stephen and Olajuyigbe (2006) also recorded an increasing trend in moisture content of the cereal grains mainly because of respiration of fungi during storage at 25-30 °C. Hossain *et al.* (2011) have also reported the same, observing a rise in grain moisture stored in various types of structure (sealed container, polyethylene bag and gunny bag) with storage period.

Insect-infestation: Mean squares showed significant differences in insect-infestation under the effect of storage methods, storage durations and interaction of storage methods × storage duration (Table 1). Insect-infestation indicated an increasing trend throughout the experiment, whereas the highest value with 18.2% was noted at the end of storage period (Table 2). The highest insect-infestation (12.4%) was observed with the grains, kept in stored room, followed by metallic bin (8.6%), earthen bin (6.6%) and then concrete block bin (5.4%) as shown in Table 2. The highest insect-infestation percentage in room store may be because of high temperature and moisture conditions, which favors the development and proliferation of insects. Dubale *et al*. (2012) observed an increase from 2.42- 20.75% over 6 months of the storage period in gombisa and sacks traditional storage methods. Similarly, it has been reported that infestation of millet grains with lesser grain borer and flour beetle increased with increasing storage period (Mali and Satyavir, 2005).

Aflatoxins: Mean squares revealed significant differences in aflatoxins of wheat grains due to storage methods, storage time and interaction of storage methods × storage duration (Table 1). Before storage aflatoxin value of wheat grains was about 0.8 $\mu g\ kg^{-1}$, which gradually increased during the entire storage period reaching the highest to 9.7 $\mu g\ kg^{-1}$ (Table 2). The highest aflatoxins content was observed in grain stored in room store (7.62 $\mu g\ kg^{-1}$), followed by metallic bin (5.5 $\mu g\ kg^{-1}$), earthen bin (4.68 $\mu g\ kg^{-1}$) and concrete block bin (3.28 $\mu g\ kg^{-1}$) as shown in Table 2. This increase of aflatoxins in stored wheat could be due to the presence of high temperature and moisture conditions. The existing results are supported by Iqbal *et al*. (2006), who observed that food grains and nuts during long time storage (18 months) increased aflatoxins level of seeds when contrasted with short time storage (2-3 months). Lutfullah and Hussain (2012) similarly reported that maximum aflatoxins were recorded in samples of wheat, maize barley, which were above the safe limit set by EU regulations.

Weight of thousand grains: Mean squares showed significant differences in weight of thousand grains under the effect of storage methods and storage durations. The interaction of storage methods × storage duration also showed significant effect on thousand grain weight (Table 1). It was observed that loss of weight in 1000 grain decreased with respect to storage period. Weight of thousand grains decreased from 43.0 to 40.2 g after 12 months (Table 2). The minimum loss in 1000 grain was observed in grain samples from the room store (41.48 g), followed by metallic bin (41.73 g) and earthen bin (41.84 g), whereas the highest 1000 grain weight (42.82 g) was observed to be from the concrete block bin (Table 2). The loss of thousand grain weight might be because of high insects attack. The current findings are also in correlation with the earlier results of Mailafiya *et al.* (2014) that grain deterioration in both quantity and quality results from insect-infestation and their proliferation. Vales *et al.* (2014) likewise reported that insect feeding of pigeon pea seed essentially decreased weight of grains. The same loss in weight has also been reported by Soomro *et al.* (2016), that onions kept open on ground had a loss of 19.38% after 3 months of storage.

Germination-ability: The mean squares for germination-ability of wheat grains showed significant variations among storage methods, storage durations and interaction of storage methods × storage duration (Table 1). Germination ability of stored wheat decreased (96 to 62.2%) with the prolonged storage of 12 months (Table 2). Among the storage methods, concrete block bin had a maximum value of seed germination (86.6%) and the minimum (77.4%) germination was found in room store (Table 2). The loss of germination ability of the stored wheat may be because of higher moisture and temperature conditions during storage. Deterioration of germination ability could also be due to insects, fungi and rodents attack. The present information are in concurrence with the results of Dubale *et al.* (2012), who recorded a negative relationship between infestation and germination capacity of the grains during storage. Singh *et al*. (2000) found loss in seed germination capacity when grain was kept for 5 months, while Vales *et al.* (2014) observed that seeds, stored in triple layer PICS bags for 8 months, retained germination superior as compared to seeds stored in conventional gunny bags.

Table 1: Mean squares of quality parameters of wheat grains under the effect of storage systems and storage durations.

SOV	df	Moisture content (%)	Insect infestation (%)	Aflatoxins ($\mu g\ kg^{-1}$)	1000 grain weight (g)	Germination ability (%)
Replication	2	0.009	8.45	0.16	0.003	0.80
Storage (S)	3	5.538**	140.95**	49.42**	5.153**	242.95**
Duration (D)	4	0.424**	668.63**	142.82**	16.589**	2434.73**
S × D	12	0.775**	25.83**	5.21**	1.070**	68.33**
Error	38	0.006	1.082	0.034	0.001	1.220
Total	59					

** Highly significant at $p<0.01$.

Table 2: Means of quality parameters of wheat grains under the influence of storage systems and storage durations.

Factor	Quality characteristics				
	Moisture content (%)	Insect infestation (%)	Aflatoxins (μg kg^{-1})	1000 grain weight (g)	Germination ability (%)
Storage system					
Room Store	14.64^{a}	12.4^{a}	7.62^{a}	41.48^{d}	77.4^{d}
Earthen bin	14.57^{b}	6.6^{c}	4.68^{c}	41.84^{b}	83.0^{b}
Metallic bin	14.61^{ab}	8.6^{b}	5.50^{b}	41.73^{c}	79.6^{c}
Concrete block bin	13.39^{c}	5.4^{d}	3.28^{d}	42.82^{a}	86.6^{a}
LSD (5%)	0.054	0.768	0.136	0.022	0.816
Storage duration					
Initial	14.00^{d}	0.0^{e}	0.80^{e}	43.0^{a}	96.0^{a}
3 months	14.44^{a}	3.0^{d}	3.30^{d}	42.8^{b}	92.7^{b}
6 months	14.46^{a}	6.7^{c}	5.25^{c}	42.5^{c}	85.2^{c}
9 months	14.27^{c}	13.2^{b}	7.30^{b}	41.2^{d}	72.0^{d}
12 months	14.36^{b}	18.2^{a}	9.70^{a}	40.2^{e}	62.2^{e}
LSD (5%)	0.061	0.859	0.152	0.025	0.913

Means followed by the same letter in each column are not different significantly according to least significant difference (LSD) at 5% probability level.

CONCLUSION

Quality of wheat grains was significantly affected by storage methods and storage periods. The lowest loss of wheat grain quality was observed in grain samples taken from concrete block bin, followed by earthen bin, metallic bin and room store. The use of concrete block bins can decrease grain storage losses. Therefore, the adoption of concrete block bins is strongly suggested, which should also be encouraged at farmer level for food security.

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