Studies on Storage of Rough Rice in Traditional Bamboo Bin and Modern Paper Bag Storage Systems

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Abstract

This paper presents experimental studies on storage of rough rice in traditional split bamboo made storage bin, called “dool” in Bangladesh, and paper bag, commonly used by the Japanese farmers, storage systems. During the storage period, temperature, moisture content, germination percentage, percentage of damage kernel and thousand-kernel weight were recorded and the changes in the quality of stored rough rice were evaluated in terms of these variables. There was no significant difference in temperature changes between the two storage systems, but there were significant difference in moisture content, germination percentage, thousand-kernel weight and percentage of damage kernel changes. The paper bag was better than the bamboo bin in respect of all the storage parameters considered.

[Keywords] storage, rough rice, bamboo bin, paper bag, temperature, moisture, germination, insect infestation

I Introduction

Rough rice is essentially paddy that has been harvested, threshed and dried but not husked. There are different types of bamboo storage systems for paddy at farm level commonly used in Bangladesh and in other non-industrialized countries. Among these traditional bamboo storage systems, medium size of capacity around 300 kg, called “dool”, is common type of storage system used in Bangladesh. Thick paper bag of

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capacity 30 kg of rough rice is common type of storage system used by the Japanese farmers.

Temperature and moisture content are two important factors influencing the distribution and abundance of insects and fungi. When conditions are favorable for these pests, severe deterioration may result.

Bhatnagar reported a replicated study on the Punjab Agricultural University (PAU) steel bins, indigenous mud bins and polythene lined mud bins for storage of wheat grain for a year. Moisture content, germination, insect infestation and temperature were studied. The grain stored in mud bins displayed higher moisture level, higher incidence of infestation and lower germination percentage. Polythene lined mud bins and steel bins showed lower moisture level, lower infestation and higher germination percentage. The air tight steel bins were slightly better than the polythene lined mud bins in having lower incidence of infestation and a higher germination percentage.

Basnet and Jindal reported the changes of quality in terms of moisture content, bulk density, germination percentage, milling yield and breakage strength of stored paddy in a traditional bamboo bin and two ferrocement bins of conical and cylindrical shape, each of 0.5 ton capacity. The bamboo bin maintained an overall better quality of paddy during the four month storage period than did ferrocement bins.

Ahmed reported storage of wheat in dool (bamboo basket), dool with seeds dried at monthly interval, dool with 0.12 mm polythene bag inside, dool with seeds mixed with biskathali leaves, dool with coating of coalter, hessian bag, kerosene tin with air tight lid, polythene bag, and 0.12 mm thick polythene bag. Based on the viability retention capacity of seeds, the dool with 0.12 mm polythene inside, kerosene tin with air tight lid and 0.12 mm polythene bag were found to be efficient and the seeds maintained over 80% germination at the end of storage.

Bala et al reported a replicated study on storage of paddy in three types of traditional bamboo storage bins of different sizes. The storage capacity of each of the storage bins were 370, 930 and 1300 kg, respectively. They concluded that all these bins can be used for storage of seeds of paddy from harvesting to sowing season and the smallest capacity bin (370 kg) is the best among the three bins.

Few scientific data are available to demonstrate the success or otherwise of these traditional bamboo bin and modern paper bag storage systems and information on temperature, moisture content, germination percentage, percentage of damage kernel and mold growth and extent of spoilage is lacking. No comparative study has been reported on the quality of rough rice during storage in dool (bamboo basket), commonly used in Bangladesh, and thick paper bag, extensively used by the Japanese farmers. In Bangladesh, most of the time of the year, generally March to October, temperatures and relative humidities remain above 25°C and 75%, respectively. In Japan, generally June to August, temperatures and relative humidities remain above 25°C and 70%, respectively. So if a storage system shows a better performance than other in Japan then it is also expected that it will do the same in Bangladesh. The objective of this study is, therefore, to compare the quality of rough rice stored in dool and paper bag on the basis of changes of temperature, moisture content, germination percentage, percentage of damage kernel and thousand-kernel weight during storage.
II Materials and Methods

A cylindrical bamboo storage bin, called "dool" in Bangladesh, was constructed from split bamboo for experimental studies. Inside and outside surfaces of the dool were coated with mud and cow dung paste and dried in the sun light before storing rough rice. Dimensions of the dool was 1.0 m height and 0.8 m in diameter (Fig. 1(a)). A sketch of dool has shown in Fig. 1(b). The dool has a bottom as an integral part of it. Upper part of dool was covered with removal wooden plate. The dool was completely filled with rough rice with a constant capacity of 295 kg. Paper bag of capacity 30 kg of rough rice, extensively used by the Japanese farmers, was used for storing rough rice. Both the dool and paper bag were placed on raised platforms inside a room ventilated to the atmosphere. Sampling spear was also constructed to collect the grain samples from the storage systems.

Temperature, moisture content, germination percentage, thousand-kernel weight and percentage of damage kernel were measured at each bottom, middle and top layers of dool and then an average of each parameter was made from the three layers to compare with the same parameters of paper bag recorded for the same interval. But as the paper bag was small, the entire bag was considered as a single layer.

To monitor the temperature of the grain, copper constantan thermocouple probes were inserted at three positions in dool as shown in Fig. 1(a). Dimensions and positions of thermocouples for dool are shown in Fig. 1(a). They were set at depths 0.2 m, 0.5 m and 0.8 m from the surface of the grain bulk along the center of dool. Only one thermocouple was connected at the center of the paper bag. Thermocouple probes were connected through an interface of AD converter (green kit 77a model) then to personal computer for data collection. The temperature readings from the thermocouple probes were recorded for every 1 hour. Data were collected from November 22, 1994 to November 17, 1995 (360 days).

Sampling of the grain were carried out with manual spear which have to be pushed in to the grain mass. Sampling spear was pushed vertically in dool and paper bag. The spear has an inner and outer tubes both with slotted holes along one side. The inner tube can be rotated such that, after the spear has been pushed in the grain mass, the slots can be brought into alignment allowing grain to follow into the inner tube. About 10 g of sample is thus obtained each time from the depth penetrated by the spear.

Grain samples were collected from three layers (0.2 m, 0.5 m and 0.8 m from the surface of the grain bulk) of dool as shown in Fig. 1(a), by using sampling spear at an interval of 15 days. At each layer samples were collected from 2 locations at 0.2 m
radius from the center of the dool. Grains collected from two locations of the same layer were mixed together and were used to measure the moisture content, germination percentage, percentage of damage kernel and thousand-kernel weight. Each reading at each layer was replicated 3 times.

Samples of grains were also collected from different locations of paper bag at the same interval as dool and mixed together. Mixed samples were used to measure the same storage parameters as dool at each interval.

Moisture content (w.b.) was determined by oven drying at 135°C for 24 h. A hundred grains were randomly selected for measurement of thousand-kernel weight, germination percentage and percentage of damage kernel, respectively. A hundred randomly selected grains were sterilized, soaked with distilled water for 24 h, then placed on petridish laid with filter paper and placed into a germination chamber for 7 days maintained at constant temperature of 25°C. Filter paper was moist every day with fresh water to facilitate germination. The number of germinated seeds after 7 days was recorded as the germination percentage.

For measurement of thousand-kernel weight, a hundred randomly selected grains were weighed in a digital precision balance (0.01 g accuracy) at an interval of 15 days and then it was multiplied by 10. A hundred randomly selected grain were checked for damage kernel and percentage of damaged kernel were counted at an interval of 15 days. Percentage of damage kernel included the injured grains by rats, insects and threshing. Injured grains were checked by visual inspection. Appearance of a needle like hole on the kernel surface was treated as damaged by insects, kernels found broken during storage were counted as damaged by rates and kernels without or partly removed outer hulls were counted as injured by threshing. The rough rice grain was Japonica variety (Himenomai) and was collected from Maki Agricultural Farm near Agricultural faculty of Ehime university, Japan.

Statistical analysis was performed using the MICROSOFT software package. The normal test was selected for temperature data analysis as the number of observations was more than 30 and t-test was used for other data analysis as indicated by Rabin dra5). T-test was performed for moisture content, germination percentage, percentage of damage kernel and thousand-kernel weight and normal test was performed for temperature data analysis. The difference of each of these parameters between the two storage systems was tested.

III Results and Discussions

The temperature and moisture content of the stored grain in the bins varied with time and position because of changing weather conditions. Ambient temperature and relative humidity for the storage period starting from November 22, 1994 to November 17, 1995 are shown in Fig. 2. The ambient temperature and relative humidity decreased gradually at the beginning of storage and then increased gradually for a considerable period. The temperature remained over 30°C.

![Fig. 2 Ambient temperature and relative humidity changes during storage of rough rice](image-url)
for more than one month in the summer and then it gradually fell. The average relative humidity remained around 70% throughout the storage period.

1. Temperature changes during storage

Temperature changes in three layers of dool with storage period are shown in Fig. 3. Top layer of dool maintained the highest temperature among the layers particularly in hot summer and fluctuations of temperatures was also more because of, comparatively, easy ambient air movement in this layer. Average temperature changes in stored rough rice in dool and paper bag are shown in Fig. 4. Temperature in paper bag fluctuated more than in the dool. This was due to smaller size of the paper bag than the dool. In hot summer, paper bag maintained higher temperature than the dool.

Statistical analysis shows that there was no significant difference in temperature changes between the storage systems (Table 1). The highest temperature was 34.5°C in the paper bag.

After 205 days of storage starting from July 15, 1995, the temperature in the two storage systems were in the optimum range for insect infestation and it resulted in rapid fall of germination in dool but paper bag maintained the same germination percentage. However, there was a continuous persistence of high temperature both in dool and paper bag.

2. Moisture changes during storage

The grains had uniform moisture content of 15.7% (w. b.) before entering the storage. Moisture content changes in the three layers of dool during the storage period are shown in Fig. 5. Most of the time of storage, top layer maintained the lowest moist-

<table>
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<th>Table 1</th>
<th>Statistical analysis of one year data on storage parameters during storage of rough rice in dool and paper bag storage systems by normal test and t-test method (normal test is performed for the temperature data analysis only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage parameters</td>
<td>Difference between two means</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>0.52</td>
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<tr>
<td>Moisture content (% w.b.)</td>
<td>1.29*</td>
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<tr>
<td>Germination capacity (%)</td>
<td>16.04*</td>
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<td>Insect infestation (%)</td>
<td>9.13*</td>
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<td>Thousand-kernel weight (g)</td>
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*Significant (P < 0.05)
Moisture content among the layers of dool because of comparatively easy desorption of moisture from the grains of this layer to the ambient air. Average moisture content changes during storage followed similar patterns in both the storage systems (Fig. 6). Moisture content was almost gradually decreased throughout the storage period in both the storage systems. Changes in moisture content was mainly due to desorption of moisture to the ambient air. Paper bag maintained the lower moisture content throughout the storage period than the dool. The lowest moisture content recorded in the dool was 13.7% (w.b.) and it was 11.8% (w.b.) in paper bag.

There was significant difference of moisture content changes between the two storage systems (Table 1).

3. Germination percentage

The grain had uniform germination of 97% before entering the storage systems. Germination percentage of grain changes in three layers of dool during storage are shown in Fig. 7. Germination percentage, particularly in the bottom and middle layers of dool, was fallen as low as 8%, as indicated in Fig. 7. The main reason of reducing germination percentage of the grains in the top layer of dool was due to approximately 48% grain damaged by rats and 4% by insects at the end of the storage as shown in Fig 9 in the next section. But, yet, it maintained the highest germination percentage among the layers of dool as shown in Fig. 7. This indicated that the germination percentage of the unaffected grains (by rats and insects) in top layer of dool remained
unchanged throughout the storage period. The average germination percentage of rough rice stored in two storage systems is shown in Fig. 8. Almost equal germination percentage were observed in both the storage systems for first 195 days of storage while the storage temperature was less than 25°C. Average germination percentage of the grains in dool rapidly fell to 22% within a short period as indicated in Fig. 8 with the increase of ambient temperature. But the paper bag always maintained the germination of grains above 90%.

Statistical analysis shows that there was significant difference of germination percentage of grain between the two storage systems (Table 1).

4. Insect infestation and grain damage

The percentage of damaged kernel changes in the three layers of dool and the average percentage of damaged kernel changes in the two storage systems during the storage period are shown in Fig. 9 and Fig. 10, respectively. There was an infestation of argoumois grain moth (Storage cerealella Olivier) in both the storage systems. Rats also attacked the grains in the top layer of dool. The respiration rate of insect in stored grain increases with increase in temperature and the respiration of stored organisms usually doubles with a 10°C increase in temperature when the temperature increase is within their survival and development range. The percentage of damaged kernel by rats and insects was higher in the top layer and very low insect infestation was found in the middle and bottom layers of dool (Fig. 9). Insect infestation was negligible in paper bag, but the percentage of damaged kernel counted was mainly damaged by threshing. About 0-2% kernel were found injured by threshing.

There was significant difference in per-

![Fig. 9 Percentage of damage grain changes during storage of rough rice at bottom, middle and top layer of dool](image1)

![Fig. 10 Average percentage of damage grain changes during storage of rough rice in dool and paper bag storage systems](image2)

![Fig. 11 Thousand-kernel weight changes during storage of rough rice in dool and paper bag storage systems](image3)
grain. Fig. 11 shows the thousand-kernel weight of rough rice at 15% (w. b.) moisture content during storage in dool and paper bag. The paper bag maintained the same thousand-kernel weight throughout the storage period. But in dool, thousand-kernel weight was almost gradually decreasing throughout the storage period. This was simply due to more rats attack and insect infestation in the dool. There was significant difference in thousand-kernel weight between the two storage systems as indicated in Table 1.

IV Conclusion

An experiment was carried out to assess the quality of rough rice stored in bamboo bin (dooll) and paper bag on the basis of changes of temperature, moisture content, germination percentage, percentage of damage kernel and thousand-kernel weight during storage.

There was no significant difference in temperature changes between the two storage systems but the temperature in paper bag fluctuated more than the dool because of its smaller size.

Moisture content in the two storage systems fell gradually with storage period due to desorption of moisture to the ambient air. Paper bag maintained lower moisture content throughout the storage period than the dool.

Germination percentage of the stored grains in the dool rapidly fell with the increase of ambient temperature, particularly, in the bottom and middle layers because of comparatively low ambient air movement in these layers. Germination percentage of the grains in the top layer of dool also fell as low as 50% because of more insect infestation and rats attack in this layer. Germination percentage of the grains in the paper bag remained almost unaltered, above 90%, in 360 days storage.

Most of the cases paper bag maintained more thousand-kernel weight than the dool. There was significant difference in thousand-kernel weight between the two storage systems.

Percentage of damaged kernel was higher in top layer of dool than the middle and bottom layers. Almost negligible amount of kernel damaged was observed in paper bag. This indicates that paper bag has a high resistance to insects and rats, although the temperature was favorable for insect infestation in this storage system.

Dool, capacity around 300 kg, can be used for storage of rough rice for eating purposes only but not for seed purposes. Smaller size dool (capacity < 100 kg) seems to be an alternative for seeding purposes. Modern paper bag storage system of rough rice is far better than the traditional bamboo bin (dool) storage system in Japan.

References

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