ROLE OF EFFECTIVE PARAMETERS ON KINETICS AND MILLING QUALITY OF PADDY STORED IN DIFFERENT PACKAGING MATERIALS

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ABSTRACT

The present research was carried out to investigate the effect of different packing materials (LDPE bags, gunny bags, earthen bin and super grain bags) on grain moisture content, lightness and milling quality of paddy for 10 months of storage. Moisture content, lightness were recorded for 15days interval for first two months thereafter 30 days internal to till end of storage period. When the LDPE bags, gunny bags and earthen bin were used as the packing material, the moisture content lightness and milling quality were decreased as moisture increased from 10.07-12.67% (wb) which decreases the lightness (L) from 71.01 to 67.05. When seed was packed in metal and earthen bins the reduction in viability of seed with time of storage varied with the moisture content of seed at packing. When paddy stored in super grain bags with initial moisture content of 10.07% showed satisfactory temperature, moisture content and lightness throughout the storage period resulting in better milling quality than those packed in other packaging materials like LDPE bags, gunny bags and earthen bin with same moisture content.

Keywords: *LDPE bags, gunny bags super grain bag, milling quality, moisture content*

INTRODUCTION

Rice (*Oryzae sativa L.*) is the staple food accounting for about 93 percent of the total food produced, about 70% of average calorie intake and 35% of household expenditure. Rice production is the largest contributor to farm income, while related trade and commerce are important sources of rural non-farm income (*Ahmed*, 2001). Globally rice is cultivated in an area of 154 million hectares with an annual production of 640 million tonnes and average productivity of 3.9 tonnes/ha. Although rice is grown across several countries, more than 90percent is produced and consumed in Asia alone. It is the second most consumed cereal in the world and in India it ranks first. India is the second largest rice producer. In India during the period 2013-14 rice was cultivated in an area of 42 million hectares with a production of 106.65 million tonnes. The productivity in rice cultivation has increased from 2,131 kg per hectare in 2006-07 to 2,390 kg per hectare during 2014-15 (Department of Agriculture, Cooperation & Farmers Welfare, New Delhi, 2015-16). Although yield differentials within the country are significant, yield of rice in most of the states has been lower than that of Punjab. However, there has been significant improvement in the yield of rice in the recent years.

Seed storage can be a major problem in India since it is located in tropical and sub tropical regions, where the combination of high temperature and high relative humidity causes rapid deterioration of seed quality. The main purpose of seed storage is to secure the supply of good quality seed for planting program whenever needed. Hence, seeds must often be stored during the period from harvest to sowing. The storage time could be short-term (less than a year) or long-term (more than a year) (Perry, 1978). Nearly 30% of the seeds are lost during storage period due to insects, rodents and microorganisms. Generally, seeds harvested before or during monsoon season need to be dried and stored until the next planting season. For most of the period between harvest and planting periods, the relative humidity exceeds 75 per cent and temperature remains above 30°C, causing seed to deteriorate rapidly. Seeds absorb moisture from the ambient air when they are stored under humid environments and loose moisture when stored in low RH.

A safe storage system of food grains plays a vital role for ensuring food security especially for the people who are fully dependent on cultivation. Very limited study so far has been conducted in this flood prone area, particularly on loss evaluation of rice and the sustainable preventive measures for losses. Such a critical situation deserves a careful and effective investigation for addressing food security. The present study, therefore, will provide a framework to identify the problems and prospects of farmers. This study would also reveal a path of finding suitable locations for constructing storage techniques and management of storage system so that the people in rural areas would be able to store and protect their food grains based on their needs, emergency distribution, and price speculation. Keeping eye on the above discussion, the objectives of the study were to identify and suggest quality packaging material for increasing shelf life without affecting the quality of paddy.

Materials and methods

Material used were, paddy grain, moisture boxes, moisture meter (Make; John Deere Model No. SW08120), electronic balance, hot air woven, LDPE bag, gunny bag, earthen bin and super grain bag. To find the effect of varieties on storability of paddy, Rajendra Sweta variety of paddy was chosen for the study.




Fig1. LDPE bag Fig2. Gunny bag Fig3. Mud Bin Fig4. Super Grain Bag

A sample (200 kg) was collected from the directorate of seed and farm, Bihar Agricultural University, Sabour. The initial moisture content of the paddy was determined before it was taken to storage. It was observed that, the initial moisture content of the paddy was 10.07 percent (w.b.). Thereafter the grain was poured into the pre-disinfected 5 different types of bags (Fig. 1). LDPE and gunny bags were sealed properly while super grain bag was double locked with the help of zip. Paddy grains were also filled in earthen bin and covered properly. The ambient condition was 28.31 ±1 °C and 72±2% RH.

Measurement of Moisture Content

Hot air oven method was used to determine the initial moisture content of the selected paddy. A pre weighed paddy sample of 15 g was kept in a pre-dried and weighed moisture box in oven at 80 °C for 24 hours Ranganna (2002). The dried samples were cooled in desiccators to room temperature and then weighed using electronic balance and moisture content (w.b.) of sample which was expressed as g water/g dry matter was used for calculations.

The moisture content of sample was calculated by using following equation.

$$\text{Percent moisture content (db)} = \frac{W_1 - W_2}{W_2} \times 100$$

............................(i)

Where, W_1 = mass of original sample (g)

W_2 = mass of the sample after drying (g)

Assessment of weight loss

Paddy grain loss bioassay was conducted to determine the damage caused insects to paddy stored hermetically and to serve as basis for determining the effectiveness of hermetic double bagging technology. The Thousand grain mass (TGM) method described by Boxal (1986) was used to determine dry-weight loss. A sample of 1 kg of each maize variety was taken and sieved to remove all unwanted material and to obtain a working sample. A sub-sample of the working sample was used to determine the moisture content. The moisture content was determined three times and the mean value recorded. The remaining sample was accurately weighed and the number of grains counted. This was also repeated thrice. The TGM was calculated using the formula:

$$\text{TGM} = \frac{10W(100 - MC)}{N}$$

.... (ii)

Where, W = weight of sample N = number of grains in sample and MC=moisture content

This was done before storage and repeated five times monthly for six months for each maize variety stored in the three different bags. At the end of each month, the percentage weight loss was determined using the formula:

$$\text{Weight loss, \%} = \frac{(M_1 - M_2)}{M_1} \times 100 \quad \text{.......... (iii)}$$

Where M_1= The TGM of grain at the start of storage.

Mx=the TGM of grain at the time x (i.e. 1, 2 or 6 months).

Colour measurement

Colour is important to consumer as a mean of identification, as a method of judging quality and for its basic esthetic value and food is no exemption. The overall objective of colour of the food is to make it appealing and recognizable. The most common technique to assess the colour is colorimeter. There are several colour scales used in a Hunter Lab Colorimeter such as *L**, *a** and *b** which represented the surface colour. The colour values are obtained as *L** is the lightness coefficient, ranging from 0 (black) to 100 (white), *a** is purple-red (positive *a** value) and blue-green (negative *a** value). a* and *b**, that represents yellow (positive *b** value) or blue (negative *b** value) colour (McGuire, 1992).

Analysis of MC and L* Value Changes of Milled Rice

The general equation describing the quality loss in food during a period of time can be expressed as equation (4) as in

$$-\frac{dC}{dt} = kC^n$$

....................(iv)

Where *C* = a component concentration; t = time; namely the exposure time (weeks) at room temperature; -dC/dt = rate of change of a component concentration with the exposure time; *k* = a pseudo-rate constant; n = reaction order. If n = 0 (zero-order reaction), equation (4) collapse to equation (5).

$$-\frac{dC}{dt} = k$$

...................(v)

The integral of equation (5) yields equation (6).

$$C - C_o = k(t - t_o)$$

...............................(vi)

Where C_o is the concentration at time zero (t_o). Equation (6) indicates that there is a linear relation between concentration and time, where the rate constant is the slope of the straight line. If *n* = 1 (first-order reaction), equation (4) becomes equation (7).

$$-\frac{dC}{dt} = kC$$

.....................(vii)

and the integral of equation (7) yields equation (8).

$$ln = lnC_o - k(t - t_o)$$

...............................(viii)

A plot of the logarithm of the concentration versus time yields a straight line, where the rate constant is the absolute value of the slope of the straight line. In contrast to the zero-order reaction, the rate of a first-order reaction depends on the concentration of a reactant (Tamrin *et al*., 2015).

Rice milling and head rice recovery

The milling quality of rice may be defined as the ability of rice grain to stand milling and polishing without undue breakage so as to yield the greatest amount of total recovery and the highest proportion of head rice to broken. Milling yield of rough rice is the estimate of the quantity of head rice and total milled rice that can be produced from a unit of rough rice. Paddy samples were dehulled with locally available sheller. The sample was poured into the hopper. The output of the sheller was passed twice through the rollers to get effective shelling. The resulting brown rice was weighed. The brown rice was passed through polisher for 30 seconds. The milled rice sample was collected in a poly propylene bag of 200gauge thickness. The bag was self-sealing type which sealed properly immediately after receiving milled rice in it. The rice is allowed to cool before weighing. The weight of the total milled rice is recorded. While calculating head rice, the rice with length equal to full grain length or more than 3/4th of the full length grain was considered as head rice. Then the

HRR in percentage was calculated with the help of following formula. (Cruz and Khush, 2000)

$$HRR = \frac{\text{weight of head rice}}{\text{weight sample}} \times 100 \quad \text{.............(ix)}$$

Results and Discussion

Damage and weight losses

Grain damage includes scarification of the pericarp and of the periphery of the endosperm, eating out of the germ, partial or complete consumption (hollowing out) of the kernel (Duna, 2003). The damage and weight losses caused by the tunneling and feeding activities of adult insects were observed to have increased gradually in the jute and polypropylene bags as the storage period progressed while a reduction was rather experienced in the triple-layer hermetic bags. This observation confirms the findings of Murdock *et al*., Navarro *et al*., De Bruin, Villers *et al*. Donahaye *et al*. (2001) who all reported little or no damage to hermetically stored grain. Super grain bag did not favour one insect species over the other. In other words, hermetic bag used in controlling loss due to insects.

Kinetics of MC Changes

Sweta rice variety had length of 8.01 mm and width of 3.00 mm, whereas the initial *L** on the surface of rice kernel was 71.01±0.61. The MC and *L** of rice during stored in LDPE bag, gunny bag, earthen bin and super grain bag were presented in Figure 5 to 8. Kinetic studies were carried out to determine the kinetic orders and rate of changes for the MC changes of milled rice during storage in some types of plastic packaging at room temperatures. All results of the kinetics measurements were plotted as logarithms of the MC against the storage period. Graphs of MC against time were also plotted, and used in the evaluation of the kinetic order. Lines of best fit were drawn through each set of data, where appropriate. Logarithmic plot for MC produced reasonably straight lines, indicating that the increase of MC in rice kernel followed first-order kinetics to a fair approximation, as formulated in equation (4). The determination of the reaction order was carried out by evaluating both logarithmic and non-logarithmic plots of the MC of milled rice.

It can be observed from Fig. 5 to Fig. 8 that the MC of rice in all cases increased with the storage period at room temperature. The analysis of the MC rate was conducted on the first week to the eight week of storage period. The initial MC of rice before storage was 10.07±0.05 % at the average relative humidity of 72%. The rate changes of MC during storage in LDPE bag, gunny bag, earthen bin and super grain bag packaging were 6.5×10^{-3}, 5.5×10^{-3}; and 7.3×10^{-3} for 15 days interval for first two month and 30 days interval for rest of the storage period. Whereas the highest rate of MC changes was found in without packaging which was 9.1×10^{-3} 15 days and 8.2×10^{-3} for 30 days. The MC of rice was highly increased from 10.07±0.05 % (initial MC) to 12.67±0.24 % (first 15 days, and rest 30 days interval respectively) for the treatment without packaging, followed by LDPE bag, gunny bag, earthen bin and super grain bag packaging. Once the moisture achieved the equilibrium moisture content with the surrounding environment (first 15 days of storage), the MC was slowly inclined as shown in Fig. 5. On the other hand, the MC at the first 15 days of storage for super grain bag was unchanged therefore the MC increases during storage in the super grain bag was the slowest among the other treatments. This study was in line with the research carried by Muangkaeo *et al*., (2005) on the influence of packaging materials and storage time on seed viability and chemical component of paddy seed.

Kinetics of *L Changes**

Unlike the measurement of MC, the *L** on the paddy declined during storage in LDPE bags, gunny bags and earthen bin. The initial *L** value of paddy was 71±0.61, and this value declined for the entire sample stored in above packaging indicating the whiteness on rice kernel decreased. Many papers have reported on the changes of rice during storage. Most of the papers stated that storage had an effect on the physical and chemical of rice, including cooking quality, texture, volatile components, and color (Tulyathan and Leeharatanaluk, 2007; Keawpeng and K. Venkatachalam, 2015). Unfortunately, none of those mentioned in detail on the color changes on paddy during storage. It can be observed from Fig 5to Fig 7 that the lightness (L*) of paddy stored in LDPE bags, gunny bags, earthen bin decreases from of lightness (L*) from 71.01 to 68.94, 71.01 to 65.13 and 71.01 to 67.05 respectively. Analysis of the kinetic orders and rate of changes for the *L** value of paddy during storage showed that the rate of changes for *L** value followed the first-order kinetics for all of the packing materials. The rate of decreases for the *L** values of paddy packed in super grain bag were 9.3×10^{-3}, 7.7×10^{-3} and 8.1×10^{-3} for first 15 days, respectively. Whereas for paddy without packaging was 9.3×10^{-3} for 15 days and 8.4×10^{-3} for 30 days. The continuous decreases of *L** value was pronounced in gunny bag, LDPE and earthen bin respectively and it can be noted that there was a correlation between the MC increases and *L** value decreases. This result was in line with Tamrin *et al.* (2015) for Milled Rice during Storage in Plastic Packaging.

Variation in head rice recovery

The head rice recovery (HRR) changed in proportion with the change in moisture content and insect population. As insect population increased the HRR decreased. The weight loss of paddy increased with increase in moisture content till the 10 months of storage, thereafter started decreasing. The moisture content change was huge to affect the paddy (Chiappini *et al*, 2009). The effect of moisture content was prominent on head rice yield. The head rice yield changed with change in moisture content. The insect count increased with increase in moisture content but with a time lag of couple of months. There was direct relation of head rice yield, moisture content and insect population. The effect of insect population on HRR was such that as insect population increased the HRR decreased. The percentage weight loss of paddy increased with increase in moisture content. Similar results have been reported by Phillip and Meronuck, 2000. Fig. 4 shows the effects of super grain bag on parameters like moisture, lightness and milling quality of paddy. A very negligible increase in moisture content from 10.07 to 10.32(wb) was observed. The lightness was slightly decreased from 71.01 to 70.88. These changes were significant as compared to other packaging materials. Similar result was found by Divekar et al. 2015 for paddy under different condition.

Conclusions

The rate of MC and *L** changes of milled rice during storage in LDPE bag, gunny bag and earthen bin as well as milled rice without packaging followed the first-order kinetic. The rate of MC increases for paddy packed in LDPE bag, gunny bag and earthen bin were 6×10^{-3}; 5×10^{-3}; and 7×10^{-3} first 15 days, and rest 30 days interval, respectively. The *L** value of milled rice decreased during storage. The rate of *L** changes was in the ranges of 9.3×10^{-3}, 7.7×10^{-3} and 8.1×10^{-3} first 15 days, and 7.3-7.1×10^{-3} rest 30 days interval respectively. The moisture migration to and from the grain is not prevented by LDPE bag, gunny bag and earthen bin. This affected the quality parameters of paddy. The super grain bags could arrest the moisture transmission up to some extent which helps in restoring the milling quality parameters of paddy. The ample moisture migration and slight variation in lightness in super grain bags could retain the paddy quality than the other packing materials.

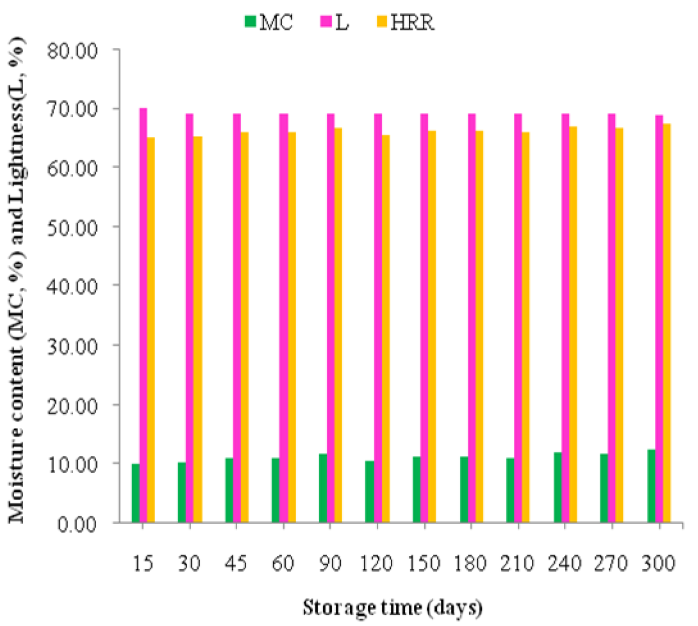

Fig. 5: Effect of moisture content on L and HRR of paddy stored in LDPE **bag**

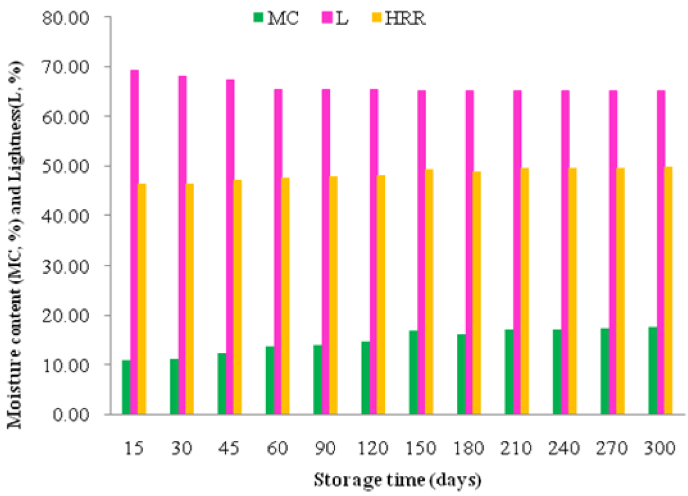

Fig. 6: Effect of moisture content on L and HRR of paddy stored in gunny bag

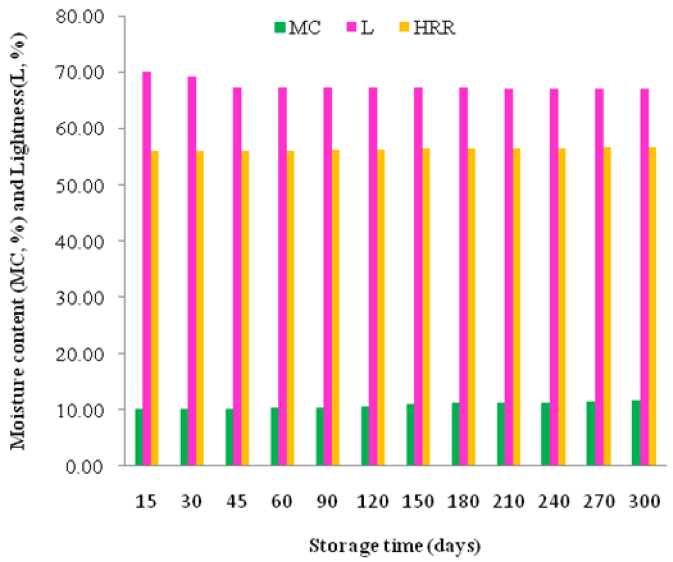

Fig. 7: Effect of moisture content on L and HRR of paddy stored in earthen bin

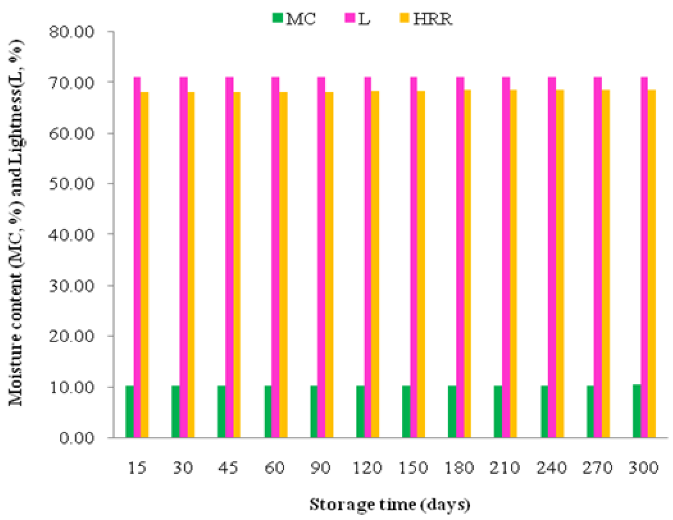

Fig. 8: Effect of moisture content on L and HRR of paddy stored in super grain bag

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