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Effect of storage duration on moisture uptake of green gram stored in hermetic and other bags

Asha Kumari and Mukesh Shrivastava

Abstract
Green gram (*Vigna radiate*) grains were procured from local market, cleaned and graded by two screen cleaner-cum-grader. Storage study was conducted by storing large sized green gram grains in 4 types of bags (jute, plastic, polythene, hermetic) without and with treatment (Aluminium phosphide tablets) at 3 different initial moisture contents (12.34, 14.07, 16.04 % w.b.). Total 21 such bags having different treatment combinations were kept in laboratory for 33 weeks. Daily observation of ambient temperature and relative humidity was taken throughout the study period. Weekly observations of moisture content were recorded for 27 (jute bags) to 33 weeks (hermetic bags). It was observed that moisture content goes on increasing with advancement of storage duration across all 21 experimental combinations. The overall variation range for moisture content was 12.34 – 25.67% w.b. Variation was more in case of untreated samples as compared to treated samples. Hermetic bags stored green gram was found better with minimum moisture uptake even after 33 weeks of storage duration. Statistical analysis through UNIANOVA revealed that initial moisture content emerged as most significant independent variable to affect moisture content. The interaction of trt*imc significantly affected moisture uptake (moisture content). Hence the hermetic bag could be recommended for storing green gram safely for longer duration without affecting its quality.

Keywords: green gram, hermetic bag, jute bag, plastic bag, polythene bag, treated, untreated, storage duration, moisture content, UNIANOVA

Introduction
Agriculture is the backbone of Indian economy contributing 13.7% of its total GDP and employing around 55% of the total working population in India. Around 65% of India's population is dependent upon agriculture and allied sectors. Various cereals (wheat, rice etc.), pulses (pigeon pea, gram etc.) and oilseeds (groundnut, soybean) are produced largely in India. India is the world's largest producer and consumer of pulses accounting about 27% of the total production and about 30% of total consumption in world. Total production of pulses in India during the year 2013-14 was 18.5 million tons. In the year 2015-16, the pulse production in Bihar has been estimated as 7.35 *lakh* tons, out of which green gram shared 1.558 *lakh* tons.
Post-harvest Food Loss (PHL) is defined as measurable qualitative and quantitative food loss along the supply chain, starting at the time of harvest till its consumption or other end uses. Post harvest losses are due to poor production practices, poor post harvest management practices, lack of grading at farm level, poor packaging, poor transportation, multiple handling, and poor marketing system. Reduction of pre-harvest, harvest and post-harvest losses is indeed a complementary means of increasing the food availability. Storage losses are due to high moisture content of the stored material, the storage condition (high relative humidity), erratic climatic condition, absence of primary processing (cleaning and grading) at farm level and lack of storage facility at production catchment. The storage loss in commercial storage of food grains is around 3 to 5% when storage was done for 8 months (Krishnamurthy, 1975) [1].
A method considered for the prevention of storage losses in airtight storage bags termed as 'airtight storage' or 'hermetic storage' bags. Hermetic storage systems strive to eliminate all exchange of gases between the inside and the outside of a grain storage container/bag. If the gas exchange is low enough, living organisms such as insects within the container/bag will deplete oxygen and produce carbon dioxide until they die or become inactive due to the low oxygen. Hermetic storage bags is a safe, cost-effective storage method that controls insect infestations in addition to preserving the quality of grains, while allowing for pesticide-free, short-term and long-term qualitative and quantitative seed preservation, without refrigeration, maintaining seed vigor and pest control. Storage at low temperature (4°C) ensures greater safety margins between insect development time and break of dormancy, although hermetic storage, even at ambient temperatures, naturally eliminates insect development altogether.

Hermetic storage is capable of maintaining relative humidity that preserves seed moisture and prevents mold growth. Hermetic bags need to be validated for its effectiveness in hermetic storage of food grains under Bihar conditions. In response to requests by farmers, traders and private seed companies to determine the effectiveness of hermetic bags for storage of cereals/pulses, a comparative study on storage behavior of green gram different storage bags was made to assess the qualitative and quantitative loss and to validate the advantages of hermetic bags in green gram storage over the conventional storage bags used in the region.

Materials and Methods

Sample preparation and treatment

Fresh and healthy green gram pulse grains were procured from local farmer at Ratwara village of Muzaffarpur district in Bihar. Cleaning and grading of grains was done in two screen seed cleaner-cum-grader using top screen of 4.0 mm and bottom screen of 2.5 mm round holes. Total 210 kg cleaned and graded green gram grains of 2.64 mm Ø size with moisture content of 12.05 % w.b. were available for storage study. Grains were weighed on a digital platform type balance (WENSER) having 150 kg capacity and 0.01 kg sensitivity.

The fumigant (Aluminium Phosphide) popularly known as sulphas was used for the chemical treatment whose molecular formula is AlF, molecular weight is 57.955 $gm.mole^{-1}$ and density is 2.85 $gm.cm^{-3}$. Half sulphas tablet weighing 0.93 g kept inside a piece of muslin cloth was placed in the centre of the bag and bag-mouth was closed by tightly twisting the free portion and then tying it by plastic rope.

Experimental variables

Independent variables

1. Type of storage bags : 4 types [Jute (JUT), Plastic (PLS), Polythene (PLY), Hermetic (HER)]
2. Initial moisture content (IMC) % w. b. : 3 levels [IMC1-12.32 %, IMC2-14.04%, IMC3-16.04% w.b.]
3. Treatment : 2 levels [Treated chemically (T), Untreated (UT)]
4. Storage duration (weeks) : 28 to 34 levels [Jute bags – 0 to 27 weeks, Plastic bags 0 to 29 weeks, Polythene bags 0 to 31 weeks, Hermetic bags 0 to 33 weeks]

Dependent variables

- Water activity
- Grain moisture content, % w.b.

Observations

- Ambient temperature ^{o}C (Daily)
- Ambient R.H., % (Daily)

Experimental design

Factorial - 4 types of bags × 2 types of treatment × 3 levels of IMC = 24 Combinations

But the Hermetic bags were used to store samples without any treatment only, so the total combination reduced to 21 as detailed below:

- 3 JUT bags – T – with IMC_1, IMC_2, IMC_3
- 3 PLY bags – T – with IMC_1, IMC_2, IMC_3
- 3 PLS bags – T – with IMC_1, IMC_2, IMC_3
- 3 JUT bags – UT – with IMC_1, IMC_2, IMC_3
- 3 PLY bags – UT – with IMC_1, IMC_2, IMC_3
- 3 PLS bags – UT – with IMC_1, IMC_2, IMC_3
- 3 HER bags – UT – with IMC_1, IMC_2, IMC_3

Experimental methodology

After determining moisture content of cleaned and graded lot of green gram grains as 12.05% w.b., the whole lot was subdivided in three sub-lots. Required amount of water was added in two sub-lots which were left for tempering for 24 hours to adjust the moisture within the grain heap for getting two more desired levels of moisture contents. The initial moisture content of all three lots was determined again which were found as 12.34%, 14.07%, 16.04%w.b. Then green gram grains were stored in 21 bags as per experimental design. The size of hermetic/polythene bag was 112×61 cm, and of jute/plastic was 83×55 cm (having capacity of 50 kg each). For treatment of samples, half tablet (0.93g) of sulphas tied in a small piece of muslin cloth was kept in stored grains. The mouth of each bag was tied with the help of plastic rope after evacuating air above the stored grains out of the bag. For observations, samples were drawn from each bag randomly every week. Observations were continued for 27-33 weeks for different bags depending upon the condition of resultant grains.

The moisture content of sample was determined by standard hot air oven method. The samples were dried in hot air oven at 105±2^{o}C for 24 hours. The moisture content of sample was determined in accordance with AOAC method (Anonymous, 1990) using following formula

$$MC = \frac{W_m}{W_m + W_d} \times 100$$

MC = Moisture content, % w.b.

W_m =Weight of the moisture evaporated, g

W_d = Weight of dried sample, g

The ambient temperature and relative humidity were recorded by portable digital temperature/relative humidity meter (ZEAL, 0.1^{o}C, 0.1%). Observations were taken on daily basis during entire period of experimental storage in near vicinity of storage bags.

Results & Discussion

The summarized overall variation in moisture content with minimum and maximum values under each experimental combination have been presented in Table 1. It reveals that the moisture content of the grain was initially in the range of 12.34 to 16.04 % for three initial moisture contents (IMC) which went up in the range of 15.62 to 25.67 % after 33 weeks of storage. The highest moisture content value was observed as 25.67 % for the experimental combination of JUT/UT/IMC3. The moisture content of untreated Green gram grains in the jute bag was increased from 12.32 to 25.67 % across all IMCs after 27 weeks of storage. Similarly moisture content of treated Green gram grains in the jute bag was increased from 12.32 to 25.00 % across all IMCs after 27 weeks of storage. The moisture content of untreated Green gram grains in hermetic (HER) bag was increased from 12.32 to 22.50 % across all IMCs after 33 weeks of storage. The

hermetic bags performed better allowing minimum moisture uptake as compared to other types of bags. The elevation in moisture content with storage period may be due to increase in water activity owing due to variation in temperature and relative humidity during storage period. These results are in line with results of previous researchers – Mutungi *et al*. (2014) [2], Kumari *et al*. (2015) [3], Freitas *et al*. (2015) and Kumar *et al*. (2016) [5] for other grains.

Table 1: Summarized overall variation in moisture content for all experimental combinations

Treatment Combination	Max.Value (week no)	Min.Value (week no)
JUT/T/IMC1	18.27 (27)	12.34 (0)
JUT/UT/IMC1	19.95 (27)	12.34 (0)
PLS/T/IMC1	17.38 (29)	12.34 (0)
PLS/UT/IMC1	17.80 (29)	12.34 (0)
PLY/T/IMC1	16.32 (31)	12.34 (0)
PLY/UT/IMC1	16.82 (31)	12.34 (0)
HER/UT/IMC1	15.62 (33)	12.34 (0)
JUT/T/IMC2	21.00 (27)	14.07 (0)
JUT/UT/IMC2	21.50 (27)	14.07 (0)
PLS/T/IMC2	20.00 (29)	14.07 (0)
PLS/UT/IMC2	20.50 (29)	14.07 (0)
PLY/T/IMC2	19.00 (31)	14.07 (0)
PLY/UT/IMC2	19.56 (31)	14.07 (0)
HER/UT/IMC2	18.36 (33)	14.07 (0)
JUT/T/IMC3	25.00 (27)	16.04 (0)
JUT/UT/IMC3	25.67 (27)	16.04 (0)
PLS/T/IMC3	24.00 (29)	16.04 (0)
PLS/UT/IMC3	24.78 (29)	16.04 (0)
PLY/T/IMC3	23.12 (31)	16.04 (0)
PLY/UT/IMC3	23.54 (31)	16.04 (0)
HER/UT/IMC3	22.50 (33)	16.04 (0)

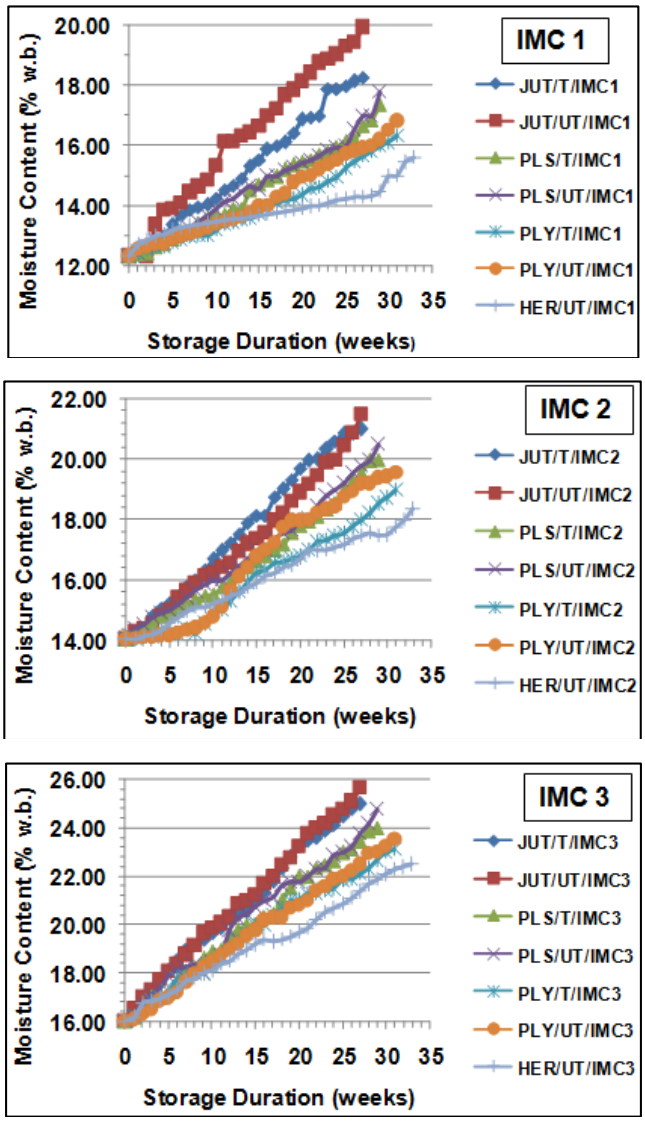

Fig 1: Variation in moisture content with storage duration for different bags and treatment at three different initial moisture contents

Moisture content had a general increasing trend across all experimental combinations with advancement of storage duration (Fig. 1). This may be due to increase in ambient relative humidity and dampness created by the heat of respiration of the grain. Untreated Green gram grains stored in hermetic (HER) bags had lowest moisture contents at all IMCs as compared to polythene (PLY) bags, plastic (PLS) bags and jute (JUT) bags in that order. Similarly treated grains behaved in the same manner across all combinations. The moisture uptake was lower at IMC1 as compared to IMC3 at all experimental combinations.

Table 2: UNIANOVA for effect of independent variables on moisture content

Source	Type III Sum of Squares	df	Mean Square	F	Sig. <0.05%
Corrected Model	5645.513[a]	629	8.975	197.534	.000
Intercept	368139.193	1	368139.193	8.102E6	.000
Bags	30.067	3	10.022	220.577	.000
Trt	1.891	1	1.891	41.612	.000
Imc	3601.861	2	1800.930	3.964E4	.000
Week	524.171	33	15.884	349.581	.000
bags * trt	29.005	2	14.503	319.182	.000
bags * imc	305.536	6	50.923	1.121E3	.000
bags * week	67.827	87	.780	17.158	.000
trt * imc	166.822	2	83.411	1.836E3	.000
trt * week	42.086	31	1.358	29.879	.000
imc * week	14.101	62	.227	5.006	.000
bags * trt * imc	244.501	4	61.125	1.345E3	.000
bags * trt * week	48.935	56	.874	19.232	.000
bags * imc * week	13.063	166	.079	1.732	.000
trt * imc * week	15.896	62	.256	5.643	.000
bags * trt * imc * week	10.885	112	.097	2.139	.000
Error	58.887	1296	.045		
Total	420145.104	1926			
Corrected Total	5704.399	1925			
a. R Squared = .990 (Adjusted R Squared = .985)					

Table 2 shows UNIANOVA for main factors effect and their interaction effect on moisture content for the entire experiment. It reveals that all main variables individually and their interaction had a significant effect on moisture content. The imc having highest F-value affected moisture content the most, followed by weeks, bags, and trt. Interaction of trt*imc was the most important interaction affecting moisture content the most.

Conclusion

Moisture uptake (Moisture content) had a general increasing trend across all experimental combinations with advancement of storage duration. This may be due to increase in ambient relative humidity and dampness created by the heat of respiration of the grain. Untreated Green gram grains stored in hermetic (HER) bags had lowest moisture contents at all IMCs as compared to polythene (PLY) bags, plastic (PLS) bags and jute (JUT) bags in that order. Similarly treated grains behaved in the same manner across all combinations. The moisture uptake was lower at IMC1 as compared to IMC3 at all experimental combinations. The hermetic bags performed better allowing minimum moisture uptake as compared to other types of bags. Hence the hermetic bags could be recommended for storing green gram safely for longer duration without affecting its quality.

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