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Effect of packaging on storage behaviour of chickpea grain

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Abstract
The experiment was conducted to study the effect of packaging on storage behavior of chickpea grain during the 2018-19 and 2019-20. Initially, chickpea grains (cv. GJG-3) were cleaned shorted, graded and sun dried up to 7.51-7.71% (w.b.) for safe storage. There were seven type of packaging material were used *viz*. Jute bag (JB), Polyethylene lined jute bag (JBP), PP woven laminated bag (PPL), HDPE bag with vacuum (HDPEV), Multilayer Coextruded Plastic bag with Vacuum (MCPV), Polyethylene Laminated Aluminum foil bag with Vacuum (ALPEV), Perdue Improve Crop Storage bag (PICS).The storage was carried out for up to twelve months. The sample was taken every two month to study quality parameter. Maximum moisture content was recorded in jute bag followed by JBP and PPL. There was significant effect on packaging material of insect population, grain damage and weight loss for storage. Jute bag has highest insect population (268 numbers/500 g), grain damage (93.15%) and weight loss (16.91%) followed by JBP. However, there was no insect, damage and weight loss observed in rest of the treatments. Maximum protein content was recorded in HDPEV bag and it is at par with other packaging material except JB and JBP. Minimum cooking time observed in JB (46.17 min) while maximum (75 min) in ALPEV bag end the end of twelve month. Maximum swelling capacity (0.249 ml/grain) was found in PP woven laminated bag whereas it was found lower in vacuum packed bags. Maximum germination (91.0%) and seed vigour index (1128) was recorded in PP woven laminated bag followed by PICS bag. Seed qualities like germination and vigour index of the grain was found poor in vacuum packed bags, JB bags and JBP bags. The internal cost benefit ratio were ramined 1:16, 1:23, 1:18,1:20, 1:10 and 1:24 for JB, JBP, PPL, HDPEV, MCPV, ALPEV and PICS respectively over jute bag.

Keywords: Chickpea, storage, packaging material, quality parameters

Introduction
The chickpea (*Cicer arietinum* L.) is one of the most important pulse crop cultivated and used in diet in most of countries over the world. India produces tremendous amount of chickpea which is 72 percent of the chickpea production in the world. Area under the chickpea cultivation in India was 95.4 lakh ha and an annual production of 90.8 lakh tons during the year 2016-17 (Anon., 2017) [4]. Chickpea is a good source of carbohydrates and protein, and protein quality is considered to be better than other pulses. It is also a good source of important vitamins like riboflavin, niacin, thiamin, folate. Chickpea has several potential health benefits and it is good for human diseases such as type 2 diabetes, digestive diseases and some cancers. (Jukanti *et al.*, 2012) [21]. Chickpea seed contains 13% to 33% protein, 40% to 55% carbohydrate, and 4% to 10% oil (Stallknecht *et al*. 1995) [47].
Chickpea is commonly known as gram, channa, or chhola in the Indo-Pakistan subcontinent. Young plants and green pods are eaten like spinach. The green seeds are cooked as a vegetable, mature seeds are used as dry pulse, parched, boiled, fried, or in various dishes. Dhal is the split chickpea seed, without the coat, and is eaten cooked in a thick soup. The flour is used in many bakery products, sweets, and ceremonial dishes (Duke 1980) [9].
Grain storage plays an important role in preventing losses which are caused mainly due to insect pests, pathogens and rodents. Various synthetic pesticides have been used to protect stored grains from insect infestation, but its massive use can create so many detrimental effects on the environment and cause intoxication of non-targeting organisms. Certain insect pests have acquired resistance against most of the insecticides. To overcome the ill effects of synthetic pesticides, the best alternative is to going back for adopting Traditional Method for protecting the food grains and seeds from insect pest attack. (Prakash, 2016) [39].
Pulses are more difficult to store than cereals and suffer much greater damage from insect and microorganisms. This not only results in quantitative losses, but also in qualitative reduction of the nutritive value because of vitamin loss and deterioration of protein quality. The milling losses in insect-damaged grains are even higher as more breakage and powdering occur with

such grains. Pulses are susceptible to infestation, both in the field and during storage, by weevils, which are prolific, breed rapidly, and cause serious deterioration in the nutritive value of grain. At 30 degree Celsius and 70 percent relative humidity, some species of bruchids take only a few weeks to develop from egg to pupa. Higher humidity is conductive to more rapid proliferation of all species.

There are basically two traditional methods of storage, in bags and in bulk. Bags can be stored either in the open air or in warehouses; bulk grain is stored in bins or silos of various capacities. The choice between these methods and the degree of technological sophistication of the storage buildings depend on many technical, economic, and socio-cultural considerations. The traditional storage system used by small farmers is commonly seen in India (lal and verma 2007) [41].

Proper packaging and storage methods are essential for good storage stability for food grains. Traditionally, jute has been used for bulk packaging of food grains and pulses. Plastic materials *viz*., HDPE and PP woven sacks, multi-layer co-extruded film, triple-layer bags and aluminium foil are used very widely for food grain and seed storage due to the excellent barrier to moisture, air, odors and microorganisms. Polyethylene lining in jute bag or in PP woven bag are also useful to protect the products from moisture ingress. Vacuum packaging increases storage life of food products by inhibiting the growth of microorganisms and improves hygiene by reducing the danger of cross contamination (Meena *et al*., 2017) [30]. Looking to the above facts, the present research work was undertaken to reduce post-harvest loss and retain the quality of the grain.

Materials and Methods

Chickpea grains were stored for a period of 12 months and same experiment was carried out for two year to determine the effect of packing on storage behavior of grains. i.e. from April, 2018-19 to April, 2019-20 at Department of Renewable Energy Engineering, College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh. Desi chickpea grain (GJG-3) was procured from the Department of Seed Science and Technology JAU, Junagadh. After harvesting, cleaning and the grains were sorted out manually to remove foreign materials such as dust, dirt, stones, chaff, immature grains, insect infested and damaged grains. For safe storage of chickpea grains, 6 h in open yard for sun drying was carried out and the chickpea grains were dried up to 7.51-7.71% (w.b.) final moisture content. Freshly emerged ten pairs (male and female) of pulse beetle were released carefully in each treatment and packed in 5.0 kg sample size. All the bags were stored at room temperature (13.0-38.8°C, 20.7 - 91.3% RH) for twelve months on platform in the laboratory for rat control. The jute bags, polyethylene lined jute bags and PP woven laminated bags were packed and sewed by portable stitching machine after filling the grain. For PICS bags packaging, the grains were filled and sealed inner double layer HDPE bags and packed in outer PP bags and sewed by portable stitching machine. HDPE bags, multilayer coextruded plastic bags and polyethylene laminated aluminium foil bags were packed with vacuum (500 mm Hg) in vacuum packaging machine. Periodically samples of the grain were drawn from each treatment at an interval of two months from the top, middle and bottom portion of the package and thoroughly mixed for final sample. Infestation, losses and quality parameters of the grains were recorded during storage by standard methods. The environmental parameters were recorded daily at room conditions in the laboratory during storage.

Experimental variables

Independent variables

1. Jute bag (JB) (control)
2. Polyethylene lined jute bag (JBP)
3. PP woven laminated bag (PPL)
4. HDPE bag with vacuum (HDPEV)
5. Multilayer coextruded plastic bag with vacuum (MCPV)
6. Polyethylene laminated aluminium foil bag with vacuum (ALPEV)
7. Perdue improve crop storage bag (PICS)

Dependent variables

- Moisture content
- Insect population
- Grain damage
- Weight loss
- Protein content
- Cooking time
- Swelling capacity
- Germination & vigour index

Experimental design

No. of Replications: 3 (Three)
Statistical Design: Completely Randomized Design (CRD)

Observations

Observations were taken in every two month interval for the stored chickpea grains. The environmental parameters such as relative humidity and temperature were recorded by data logger over the platform, where chickpea grains were stored.

Moisture contents of the samples were determined by standard method suggested by Sadasivam and Manickam (1996) [43].

Insect population like pulse beetle and bruchid were observed by taking 500 g samples. The total number of adults obtained from each sample was counted and recorded.

Grain damage percentage was calculated by taking sample of 200 Nos. chickpea grains for counting damaged grains from the sample. The grain damage was determined using following formula.

$$\text{Grain damage } (\%) = \frac{\text{Number of damaged grains}}{\text{Number of grains in sample}} \times 100$$

The weight loss was calculated using weight of un-infested grains and weight of infested grains as well as number of un-infested grains and number of infested grains at two months interval as reported by Adams and Schulton (1978) [1].

$$\text{Weight loss } (\%) = \frac{(\text{UND}) - (\text{DNU})}{\text{U (ND+NU)}} \times 100$$

Where

U = Weight of un-infested grains (g)
NU = Number of un-infested grains
D = Weight of infested grains (g)
ND = Number of infested grains

Protein content of the chickpea grains were estimated by standard method as reported by Lowry *et al*., 1951 [26]

Cooking time of chickpea grain samples were cooked in a beaker on heating mortal having a ratio of the grain: distilled water as 1: 10. Full cooking time was recorded as the time when 90% of the grains were soft enough to masticate, as suggested by Williams *et al*., 1983 [38]. Protein content of the chickpea grains were estimated by standard method as reported by Lowry *et al*., 1951 [26].

Swelling capacity of the grains were calculated using following equations as reported by Williams *et al.*, (1983) [49].

$$Swelling\ capacity, ml/grain = \frac{\text{Volume after soaking} - \text{Volume before soaking}}{\text{Number of grains}} \times 100$$

Germination percentage for the chickpea grain was calculated by using the method given by International Seed Testing Association (ISTA, 1996) [15].

Seed vigour index was determined by using following formula, as reported by International Seed Testing Association (ISTA, 1996) [16].

$$Seed\ vigour\ index = Average\ seedling\ length\ (\text{root} + \text{shoot}), \text{cm} \times Germination\ \%$$

Results and Discussion

During the period of experiment maximum temperature was recorded as 38.5 °C in the month of May while minimum temperature was recorded as 13.2 °C in the month of January. Maximum RH was recorded as 91.1% in the month of July while minimum RH was found as 18.8%. In the month of March.

1. Moisture content

It is evident from the Fig. 1 that moisture content of the grain increased drastically for JB followed by JBL and PPL up to four months of storage period then decreased up to twelve month of storage. However, little variation was found in other treatments. The increase in moisture content of the grain might be due to hygroscopic nature of the grain and increase in RH during monsoon season (Harrington, 1972; Malarkodi, 1997; Roberts, 1986, Saidanaik and Chetti, 2017) [12, 27, 42, 44]. The maximum two year average moisture content of the chickpea stored in JB, JBL and PPL was found 12.80%, 10.41%, and 10.18%, respectively on four months of storage while minimum moisture content was observed in ALPEV (7.71%) followed by MCPV, HDPEV and PICS i.e. vacuum packaging and PICS bags during entire storage.

2. Insect population

The samples of 500 g of the grain were drawn from each treatment from the top, middle and bottom portion of the package. The insect population of pulse beetle (*Callosobruchus chinensis* L.) was only found in JB and JBP bags and increased drastically with increase of storage period for both years. The statically analysis of pooled data for the both year of insect population are presented in the Table 1. From the Table 1, it can be observed that the effect of different packaging materials on average insect population was found significant during entire storage period. JB resulted significantly highest average insect population (268 numbers/500 g) followed by JBP (94 numbers/500 g) at the end of twelve months of storage period. However, PPL, HDPEV, MCPV, ALPEV and PICS were found at par with each other i.e. zero infestation during entire storage period for both the year. It might be due to reduced pressure and resulting oxygen content interfered with insect movement, feeding and respiration (Adler *et al*., 2016) [2]. The increase in insect population in the JB and JBP might be due to higher moisture content and O_2 availability which enhanced insect population. (Monira *et al.*, 2012) [31]. The Table 1 also shows that effect of packaging material on insect population was found significant for both the year and pooled for entire storage period of time. The year and year on treatment effect was found non significant up to twelve months. These findings are also matched with Haile (2015) [11] in chickpea, Martin *et al.*, (2015) [28] in wheat and Patel *et al.*, (2018) [18] in chickpea grain.

3. Grain damage

Grain damage was only found in JB and JBP bags and increased with increase of storage period for both years. The statically analysis of pooled data for the both year of grain damage are presented in the Table 2. From the Table 2, it is apparent that the effect of different packaging materials on grain damage was found significant during entire storage period for both years and pooled. There was no any significant difference found on year and Year on packing material for grain damage percentage. JB resulted significantly average highest grain damage (93.15% g) followed by JBP (40.49%) at the end of twelve months of storage period. However, PPL, HDPEV, MCPV, ALPEV and PICS were found at par with each other i.e. zero grain damage during entire storage period of time for both the two year (Xiaoji Fu *et al.*, 2018) [50]. It might be due to their lesser permeability in plastic packaging materials as well as vacuum packaging (Sumathi, 2010). The increase in grain damage in the JB and JBP might be due to the higher insect infestation which damaged the grain during storage period. The similar results for moisture content were also reported by Asha (2012) [5] in maize, Kurdikeri *et al.*, (1995) [24] in maize and Shaw (1998) [46] in green gram during storage.

4. Weight loss

Weight loss was found only in JB and JBP bags and increased with increase of storage period time for both years. The statically analysis of pooled data for the both years and pooled of weight loss are presented in the Table 3. It can be observed from the Table 3 that the effect of different packaging materials on weight loss was found significant during entire storage period. From the Table 3, it can be seen that there was no any significant difference found year and year on packaging material for weight loss of chickpea grain. JB resulted significantly average highest weight loss (16.91% g) followed by JBP (9.98%) at the end of twelve months of storage period for both the year. It might be due to high infestation of insects and their damage. (Utono, 2013) [14]. However, PPL, HDPEV, MCPV, ALPEV and PICS were found at par with each other i.e. zero weight loss during entire storage period. It might be due to pulse beetle restricted by other packaging materials hence no weight loss was observed. More storage period leads more weight loss due to more insect infestation also reported by Sudini *et al*. 2015 [48] in groundnut, Khare *et al.* 1972 [22] in chickpea during storage and Yar *et al.*, 2017 [33] in wheat flour.

5. Protein content

The statically analysis of pooled data for the both year of protein content are presented in the Table 4. It is apparent from the Table 4 that protein content of the grain decreased with advancement of storage period. Khanna *et al*., 2017 [36] for Bengal gram. It might be attributed to oxidation of the amino acids, increase in the respiratory activity and moisture content as a result of deterioration process of the stored grains. The effect of different packaging materials on protein content of chickpea grain was found significant on ten and twelve months of storage period for both years and pooled. The pooled result of second, six and eight month of storage period was found significant effect of protein content on packaging material. There was no any significant difference found year and year on packaging material for entire storage period of time. The average maximum protein content (18.80%) was recorded in the grain for HDPEV packaging. However, it was found at par with PPL, MCPV, ALPEV and PICS during entire storage period. JB resulted significantly lowest protein content (13.78%) at the end of twelve months of storage period. These results are in agreement with Chattah *et al*. (2014) [7] for wheat grain and Patel *et al.*, (2018) [19] for storage of chickpea grain.

6. Cooking time

Effect of different packaging materials on average cooking time for both year of chickpea grain are shown in Fig 2. It can be observed from the Fig. 2 that cooking time of the chickpea grain increased with increase in storage period. It might be due to the susceptibility of chickpea grain to develop the hard to cook condition related to both seed coat tannin content and phytic acid level in the cotyledon. The effect of different packaging materials on cooking time of chickpea grain was found non-significant during second month of storage period only while rest significant for both years and pooled. JB resulted significantly lowest cooking time during entire storage period. However, significantly highest cooking time was found in ALPEV during entire storage period. PPL was found at par with PICS bag for cooking time. The average minimum cooking time for both year of the chickpea grain was observed in JB (46.17 min) at the end of storage period. The average Maximum cooking time for both year of the grain was recorded in vacuum packed packaging materials *i.e*., ALPEV (75.00 min) followed by MCPV and HDPEV bags on twelve months of storage. The similar results were also reported by Almeida *et al.* for bean grains, Sethi *et al.* for pigeon pea dhal and Ferreira *et al.* for black bean during storage. PPL (57.83 min) was found at par with PICS bag for cooking time.

7. Swelling capacity

The swelling capacity of different packaging material versus different storage period of time for both years is presented in Fig.3. It is clear from the Fig. 3 that swelling capacity of chickpea grain decreased with increase in storage period. It might be due to formation of structural change and harder texture of pulse grain during storage which rendered the cells resistant to water absorption. The effect of different packaging materials on swelling capacity was found significant during entire storage period of time for both the years and pooled. PPL resulted significantly highest swelling capacity (0.249 ml/grain) at the end of storage period. The similar results reported by Patel *et al*., (2018) [20]. Swelling capacity of the grain was found minimum for ALPEV (0.112 ml/grain) and it was at par with MCPV throughout storage period. It was moderated (0.187 ml/grain) for PICS bag at the end of storage period. It might be due to formation of structural change and harder texture of pulse grain, increase in electric conductivity and solute leaching during storage which rendered the cells resistant to water absorption (Bressani, 1993 and Kilmer *et al*., 1994, Nasar-Abbas *et al*., 2008) [6, 23, 35]

8. Germination

The Fig. 4 shows the germination percentage of different packing material for the different storage period. From the Fig. 4, it is obvious that germination of the grain diminished with advancement of storage period. There was no any significant effect on germination up to six month for both year and pooled but decline in germination percentage over the storage period irrespective of treatment was due to ageing effect leading to depletion of food reserves, seed deterioration, fluctuating temperature, relative humidity and grain moisture content as influenced by storage packaging materials, as reported by Bortey *et al.*, (2016) [13], Smiderle, *et al.* 2017 [37] for cowpea and Rai *et al.* 2011 for maize. PPL resulted significantly average highest germination (91.00%) followed by PICS (86.00%) at the end of storage period for both the year. PICS was found at par with HDPEV and MCPV at the end of twelve month of storage period. JB had significantly average lowest germination (59.50%) followed by JBP (68.50%) at the end of storage period for both year. It might be attributed to insect infestation, grain damage and low swelling capacity of the grain. The similar results were also reported by Mookherjee *et al.*, (1970) [32] in chickpea, and Jagtap (2006) [17] in sorghum. Superior germination quality was found for PP bag and PICS bag while it was very poor for jute bag.

9. Seed vigour index

The Fig. 5 shows the Seed vigour index of different packaging material for the different storage period of time. From the Fig. 5 it can be seen Seed vigour index declined with increase in storage period irrespective of packaging materials. It might be due to changes in free radical scavenging enzymes, increase in free radical production, degradation of protein, increase in amino acid pool for reduction in vigour and viability during ageing. There was significant effect of packaging material vigour index for entire storage of both years and pooled except the second month. Significantly average highest seed vigour index was recorded in chickpea grain stored in PPL (1128) followed by PICS (1031) at the end of storage period for both the years. Seed vigour index for HDPEV was found at par with MCPV and ALPEV. Minimum seed vigour index was recorded in JB (580) at the end of twelve months of storage. Seed quality of the grain was found lower in vacuum packaging materials like ALPEV, MCPV and HDPEV bags than without vacuum packed bags on twelve months of storage. It might be due to anaerobic respiration within the package and low swelling properties of the grain. The results of Seed vigour index are matches with Chormule *et al.*, (2015) [8] in chickpea, Meena *et al.*, (2017) [29] in cotton and Naguib *et al.*, (2011) [34] in wheat.

Economic of Chickpea grain storage

The cost economic analysis were carried out for different packaging material of chickpea storage for two year. The annual cost for 25 kg storage were found Rs. 3.75, 6.25, 8.00, 10.00, 9.00, 17.50 and 7.50 for JB, JBP, PPL, HDPEV, MCPV, ALPEV and PICS respectively. There was least heathy pod (6.85%) found was JB and followed by JBP (59.51%). Howevr, There was no any damged found in rest of the treatments. The net gain of chikpeas grain storage over jute bag was determined Rs. 526.40 for JBP while rest of the treatment was found Rs. 931.60. The internal cost benefit ratio over jute bag were ramined 1:16, 1:23, 1:18,1:20, 1:10 and 1:24 for JB, JBP, PPL, HDPEV, MCPV, ALPEV and PICS respectively.

Table 1: Effect of different packaging materials on insect population (number/500g) of chickpea grain during storage

Treatment	Storage Period, Months																	
	2			4			6			8			10			12		
	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled
JB	1.95* (3.3)	2.04* (3.7)	2.00* (3.5)	2.86* (7.7)	3.18* (9.7)	3.02* (8.7)	5.04* (25)	5.43* (29)	5.23* (27)	9.70* (93.67)	10.26* (105)	9.98* (99.34)	12.70* (161)	13.13* (172)	12.92* (166.5)	16.20*(262)	16.52* (272.7)	16.36* (267.35)
JBP	1.77* (2.7)	1.68 (2.3)	1.73 (2.5)	2.48* (5.7)	2.54* (6)	2.51* (5.85)	3.39* (11)	3.69* (13.3)	3.54* (12.15)	2.60* (20.33)	5.34* (30.67)	5.17* (25.5)	5.92* (34.67)	6.41* (64.33)	6.17* (49.5)	8.56* (73)	8.97* (115)	8.77* (94)
PPL	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)
HDPEV	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)
MCPV	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)
ALPEV	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)
PICS	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)
S.Em.±	0.04	0.05	0.03	0.03	0.08	0.04	0.09	0.13	0.08	0.09	0.14	0.09	0.14	0.11	0.09	0.11	0.19	0.11
C.D. at 5%	0.14	0.15	0.10	0.10	0.25	0.13	0.28	0.41	0.24	0.27	0.44	0.25	0.44	0.32	0.26	0.35	0.58	0.32
C.V.%	8.05	8.07	8.06	4.65	10.7	8.41	9.37	12.8	11.3	6.02	9.15	7.81	7.86	5.55	6.76	4.89	8.01	6.68
Y																		
S.Em.±			0.02			0.02			0.04			0.05			0.05			0.06
C.D. at 5%			NS			NS			NS			NS			NS			NS
Y×T																		
S.Em.±			0.05			0.06			0.12			0.12			0.13			0.16
C.D. at 5%			NS			NS			NS			NS			NS			NS

* Data subjected to square root transformation
Figures in parentheses are original values

Table 2: Effect of different packaging materials on grain damage (%) of chickpea grain during storage

Treatment	Storage Period, Months																	
	2			4			6			8			10			12		
	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled
JB	4.87* (0.22)	9.66* (2.33)	9.03* (1.28)	12.69* (4.3)	13.97* (5.33)	13.33* (4.82)	22.38* (14)	24.18* (16.33)	23.28* (15.17)	39.13* (39.3)	39.70* (46)	39.41* (42.65)	62.21* (77.7)	63.91* (84)	63.06* (80.85)	73.66* (91.3)	74.01* (95)	73.84* (93.15)
JBP	4.45* (0.10)	7.72* (1.33)	7.3* (0.72)	8.41* (1.7)	8.41* (2)	8.41* (1.85)	14.74*(6)	16.52* (7.67)	15.63* (6.84)	19.21* (10.3)	21.27* (14.33)	20.24* (12.32)	23.30* (15.2)	26.90* (21.33)	25.10* (18.27)	37.95* (37.3)	41.64* (43.67)	39.79* (40.49)
PPL	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)
HDPEV	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)
MCPV	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)
ALPEV	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)
PICS	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)
S.Em.±	0.26	0.34	0.21	0.31	0.30	0.22	0.31	0.63	0.35	0.41	0.65	0.38	0.69	0.85	0.55	0.90	1.05	0.69
C.D. at 5%	0.79	1.02	0.61	0.93	0.91	0.62	0.94	1.90	1.01	1.24	1.98	1.11	2.09	2.59	1.59	2.72	3.19	2.00
C.V.%	8.82	10.80	9.92	9.03	8.56	8.79	6.55	12.47	10.14	6.29	9.72	8.24	7.89	9.31	8.67	8.23	9.37	8.84
Y																		
S.Em.±			0.11			0.12			0.19			0.21			0.29			0.37
C.D. at 5%			NS			NS			NS			NS			NS			NS
Y×T																		
S.Em.±			0.30			0.30			0.49			0.54			0.78			0.98
C.D. at 5%			NS			NS			NS			NS			NS			NS

* Data subjected to Arcsin transformation
Figures in parentheses are original values

Table 3: Effect of different packaging materials on weight loss (%) of chickpea

Treatment	Storage Period, Months																	
	2			4			6			8			10			12		
	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled
JB	4.87* (0.22)	4.79* (0.20)	4.83* (0.21)	5.71* (0.49)	5.76* (0.51)	5.73* (0.50)	10.40* (2.76)	10.67* (2.94)	10.54* (2.85)	16.89* (7.94)	17.06* (8.41)	16.98* (8.18)	17.43* (8.48)	18.10* (12.98)	17.76* (10.73)	22.81* (14.54)	23.80* (19.82)	23.31* (16.91)
JBP	4.45* (0.10)	4.50* (0.12)	4.48* (0.11)	4.73* (0.18)	5.09* (0.29)	4.91* (0.24)	6.63* (0.84)	7.09* (1.03)	6.86* (0.94)	8.73* (1.81)	9.01* (2.98)	8.87* (2.40)	11.02*(3.17)	11.37* (7.34)	11.20* (5.26)	14.90* (6.12)	15.43* (13.84)	15.17* (9.98)
PPL	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)
HDPEV	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)
MCPV	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)
ALPEV	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*	4.06*

	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
PICS	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)	4.06* (0.0)
S.Em.±	0.04	0.04	0.03	0.06	0.15	0.08	0.09	0.17	0.10	0.10	0.06	0.06	0.22	0.17	0.14	0.24	0.07	0.13
C.D. at 5%	0.12	0.13	0.08	0.17	0.45	0.23	0.28	0.52	0.28	0.30	0.19	0.17	0.68	0.53	0.41	0.74	0.21	0.37
C.V.%	1.59	1.71	1.65	2.19	5.74	4.37	3.02	5.51	4.47	2.63	1.66	2.19	5.58	4.24	4.94	5.10	1.43	3.70
Y																		
S.Em.±			0.02			0.04			0.05			0.03			0.08			0.07
C.D. at 5%			NS			NS			NS			NS			NS			0.20
Y×T																		
S.Em.±			0.04			0.11			0.14			0.08			0.20			0.18
C.D. at 5%			NS			NS			NS			NS			NS			NS

* Data subjected to Arcsin transformation
Figures in parentheses are original values

Table 4: Effect of different packaging materials on protein content (%) of chickpea grain during storage

Treatment	Storage Period, Months																	
	2			4			6			8			10			12		
	2019	**2020**	**pooled**	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**
JB	20.98	20.76	20.87	20.42	20.21	20.31	18.86	18.51	18.69	17.95	18.23	18.09	16.88	16.50	16.69	14.02	13.54	13.78
JBP	21.11	20.88	20.99	20.56	20.44	20.50	19.59	19.45	19.52	18.32	18.54	18.43	17.53	17.32	17.42	16.82	16.48	16.65
PPL	21.25	21.14	21.19	20.78	20.72	20.75	19.97	19.97	19.97	18.94	18.85	18.90	18.57	18.42	18.50	18.56	18.40	18.48
HDPEV	21.57	21.57	21.57	21.14	21.08	21.11	20.83	20.48	20.65	19.31	19.21	19.26	19.13	18.99	19.06	18.96	18.63	18.80
MCPV	21.41	21.53	21.47	21.06	20.98	21.02	20.49	20.28	20.39	19.13	19.07	19.10	18.95	18.85	18.90	18.70	18.44	18.57
ALPEV	21.35	21.13	21.24	20.96	20.96	20.96	20.18	20.50	20.34	19.08	18.95	19.02	18.82	18.46	18.64	18.60	18.36	18.48
PICS	21.16	21.08	21.12	20.67	20.84	20.75	19.81	19.66	19.74	18.63	18.61	18.62	18.39	18.36	18.38	18.32	18.23	18.28
S.Em.±	0.14	0.19	0.12	0.24	0.32	0.20	0.46	0.43	0.32	0.35	0.24	0.21	0.35	0.33	0.24	0.26	0.26	0.18
C.D. at 5%	NS	NS	0.34	NS	NS	NS	NS	NS	0.91	NS	NS	0.61	1.05	1.01	0.70	0.80	0.78	0.53
C.V.%	1.17	1.52	1.36	1.99	2.71	2.38	4.00	3.77	3.89	3.21	2.17	2.74	3.29	3.19	3.24	2.58	2.56	2.57
Y																		
S.Em.±			0.06			0.11			0.17			0.11			0.13			0.10
C.D. at 5%			NS			NS			NS			NS			NS			NS
Y×T																		
S.Em.±			0.17			0.29			0.45			0.30			0.34			0.26
C.D. at 5%			NS			NS			NS			NS			NS			NS

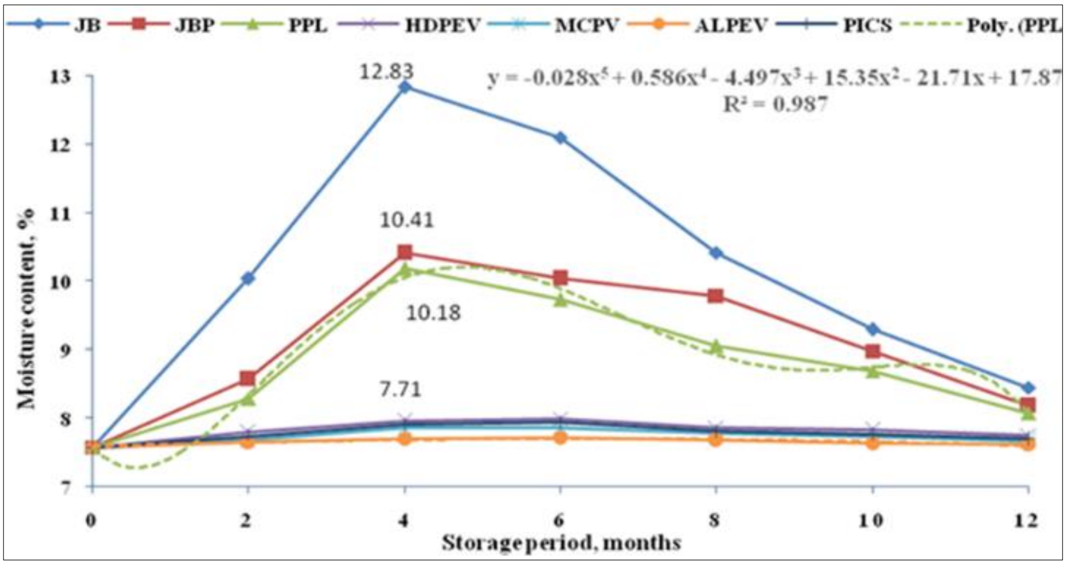

Fig 1: Effect of different packaging materials on moisture content of chickpea grain

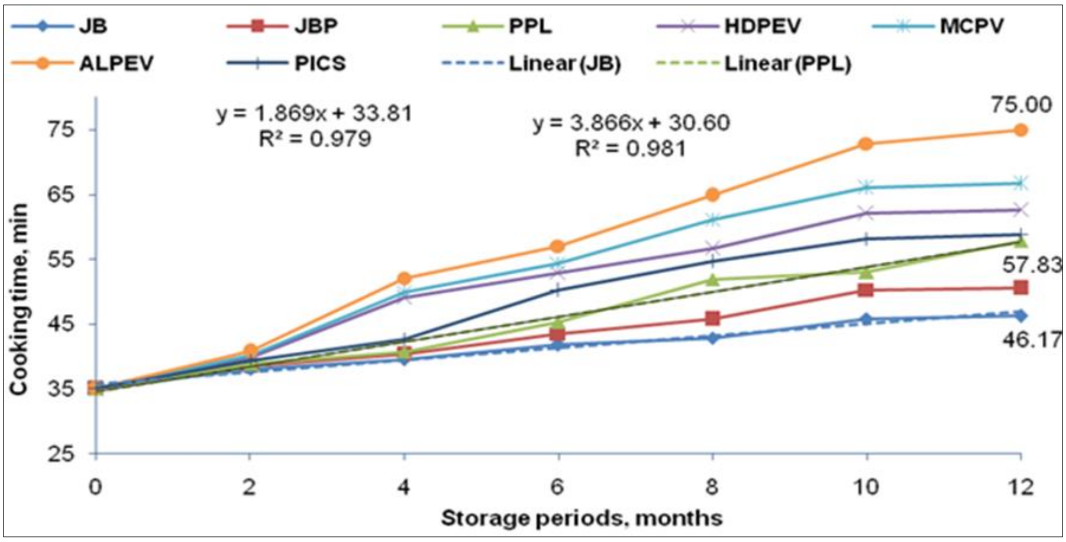

Fig 2: Effect of different packaging materials on cooking time of chickpea grain

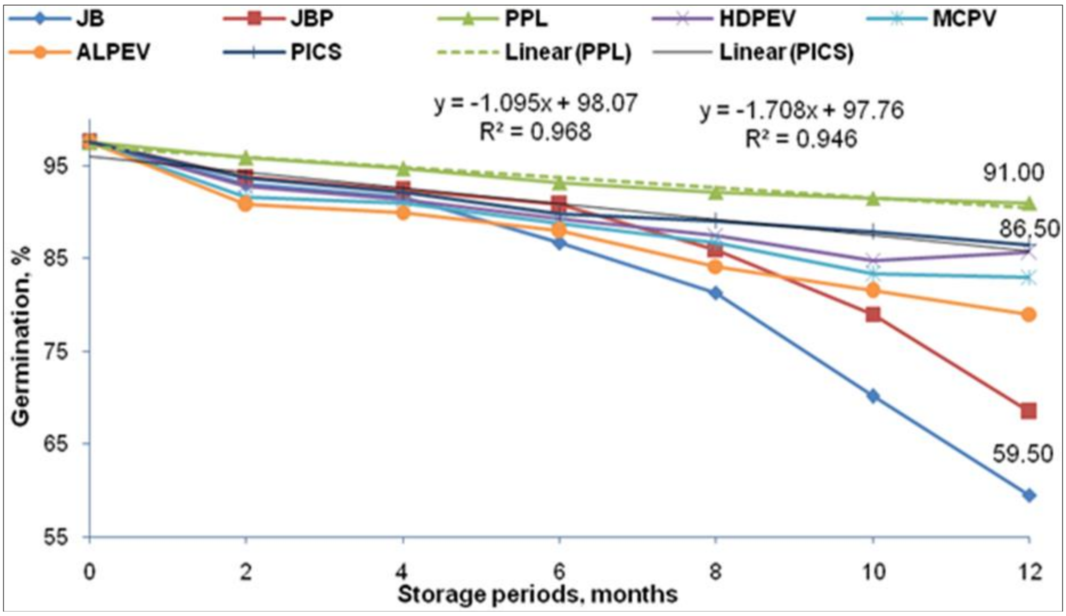

Fig 3: Effect of different packaging materials on germination of chickpea grain

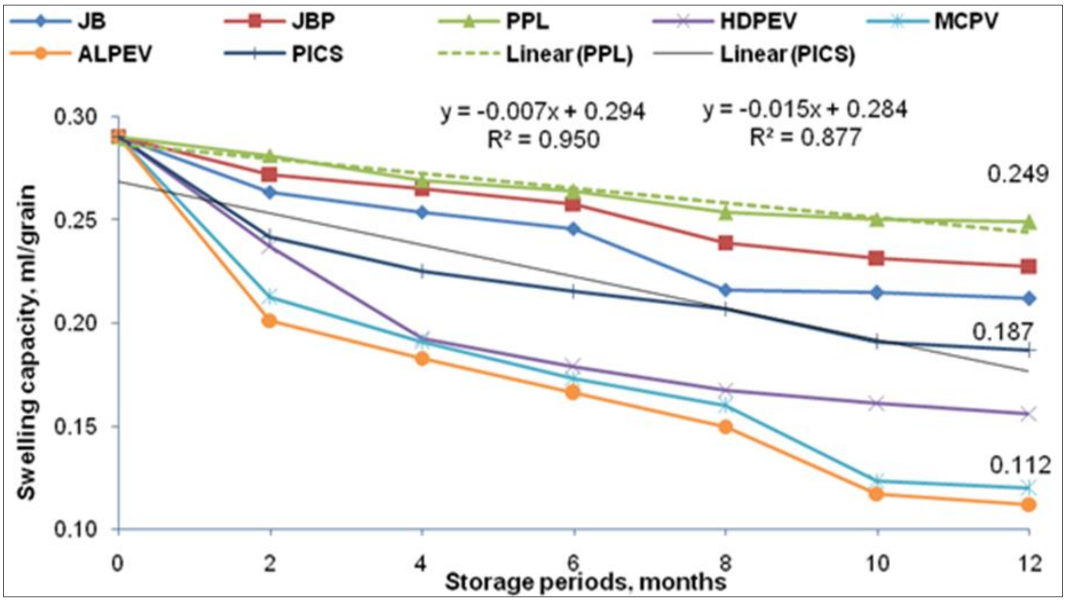

Fig 4: Effect of different packaging materials on swelling capacity of chickpea grain

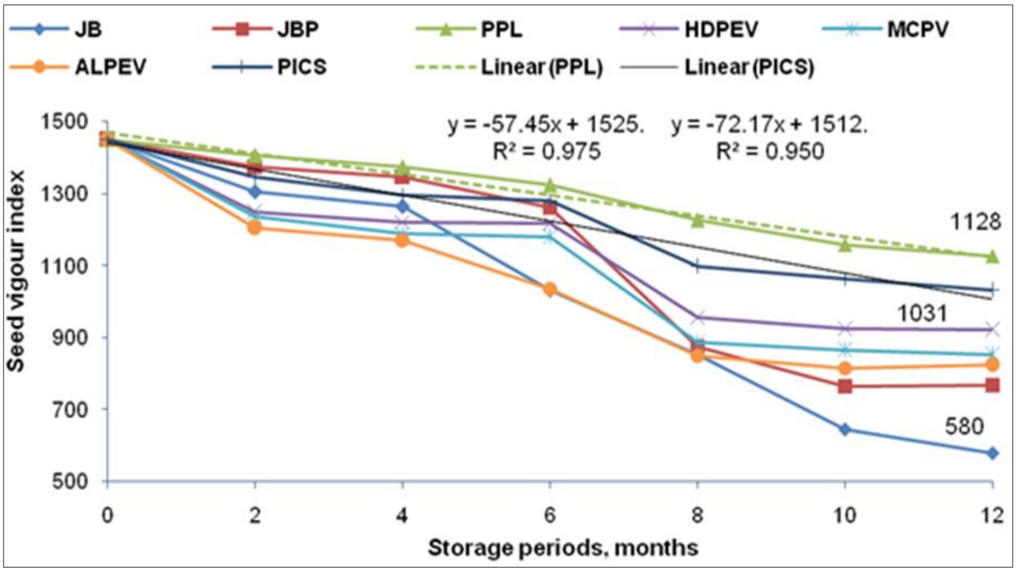

Fig 5: Effect of different packaging materials on seed vigour index of chickpea grain

Conclusions

The pooled of insect population (268 numbers/500 g), grain damage (93.15%) and weight loss (16.91%) was found maximum in chickpea grain stored in jute bag followed by polyethylene lined jute bag at the end of twelve months of storage period. They were not found in other bags during entire storage period. Two year average maximum moisture content (12.80%) of the grain was recorded in jute bag followed by polyethylene lined jute bag on four months (September) of storage period then it decreased with increase of storage period. However, little variation was observed in other treatments. Minimum moisture content was observed in polyethylene laminated aluminum foil bag during entire storage period. Two year average maximum protein content in the grain was recorded in HDPE bag (18.80%) and it was at par with other packaging materials except jute bag and polyethylene lined jute bag. Minimum protein content in the grain was found in jute bag (13.78%) and polyethylene lined jute bag (16.65%). at the end of storage period. Two year average minimum cooking time of the grain was observed in jute bag (46.17 min) and maximum cooking time was recorded in vacuum packed materials i.e., polyethylene laminated aluminium foil bag (75.0 min) followed by multilayer coextruded plastic bag (66.67 min) on twelve months of storage. Maximum swelling capacity (0.249 ml/grain) was found in PP woven laminated bag whereas it was found lower in vacuum packed bags. Maximum germination (91.0%) and seed vigour index (1128) was recorded in PP woven laminated bag followed by PICS bag. Seed qualities like germination and vigour index of the grain was found poor in vacuum packed bags, JB bags and JBP bags. Considering the overall aspects of the study, it may be concluded that PP woven laminated bag and PICS bag were observed to be best packaging material amongst all treatments for chickpea grain storage up to twelve months. The net of 25 kg gain of chikpeas grain storage over jute bag was determined Rs. 526.40 for JBP while rest of the treatment was found Rs. 931.60. The internal cost benefit ratio over jute bag were found 1:16, 1:23, 1:18, 1:20, 1:10 and 1:24 for JBP, PPL, HDPEV, MCPV, ALPEV and PICS respectively.

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