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Effect Different Packaging Materials on Quality of Chickpea Grain During Storage

Jay V. Patel*, D. K. Antala and R. M. Satasiya

Department of Processing and Food Engineering, College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh, Gujarat, India (362001)

*Corresponding Author E-mail: jaypatelv333@gmail.com

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ABSTRACT

Freshly harvested and fully matured chickpea grains (cv. GJG-3) were cleaned, sorted, graded and dried up to 7.6 % (w.b.) moisture content for safe storage. The dried grains were packed in different packaging materials viz., jute bag (control), polyethylene lined jute bag, polypropylene (PP) woven laminated bag, high density polyethylene (HDPE) bag with vacuum, multilayer coextruded plastic bag with vacuum, polyethylene laminated aluminium foil bag with vacuum, perdue improve crop storage (PICS) bag with 5.0 kg sample size. All the bags were stored at room temperature (13.2 °C -38.5 °C, 18.8 -91.1 % RH) for twelve months in the laboratory. The quality parameters of the grain were analysed at two-month interval during storage. Moisture content of the grain was recorded maximum in jute bag and minimum was observed in polyethylene laminated aluminium foil bag during entire storage period. The weight loss (7.51 %) was found in chickpea grain stored only in jute bag at the end of twelve months of storage period. Minimum protein content in the grain was found in jute bag (15.32 %) at the end of storage period. The other packaging materials were found at par with each other for protein content of the grain during entire storage period. Minimum cooking time of the grain was observed in jute bag (47.25 min) and maximum cooking time was recorded in polyethylene laminated aluminium foil bag (74.67 min) on twelve months of storage. Hydration capacity (0.240 g/grain), hydration index (0.986), swelling capacity (0.248 ml/grain) and swelling index (1.446) was found maximum in PP woven laminated bag at the end of the storage. Hydration and swelling properties of the grain was found lower in vacuum packed materials.

Key words: *Chickpea grain, Packaging materials, Storage life, Quality evaluation.*

INTRODUCTION

The chickpea (*Cicer arietinum* L.) is one of the most important pulse crop cultivated throughout the world. India is the largest chickpea producing country accounting for 72% of the global chickpea production. In India, the area under chickpea cultivation was 95.4 lakh ha with an annual production of 90.8 lakh tons during the year 2016-17[3].

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It is a good source of carbohydrates, important vitamins, minerals, essential amino acids and nutritionally important unsaturated fatty acids. It is a major and cheap source of protein for millions of vegetarians in the developing countries. Chickpea is predominantly consumed in the form of whole grain, dhal, flour, sprouted grain, green or matured dry seeds and is used in the preparation of a variety of snacks, sweets and condiments[12].

Pulses are more difficult to store than cereals and suffer much greater damage from insects and microorganisms. The post-harvest losses of food grains are estimated to be 10 to 20% in India[8]. The pulse beetle and bruchids are mostly found during the storage of chickpea and reduces the market value of seed, germination percent and nutrition value which make chickpea unfit for marketing as well as human consumption[20]. Many synthetic insecticides have been found effective against this pest, but are hazardous and toxic, due to their residual effect in the food. Insect resistance to phosphine is a global issue now and control failures have been found in some countries. Methyl bromide has been identified as a major contributor to ozone depletion and is, therefore, being phased out completely[29]. 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[19]. Looking to the above facts, the present research work was undertaken to retain the quality and reduce post-harvest loss of the grain.

MATERIAL AND METHODS

The freshly harvest and uniformly matured desi chickpea grain (*GJG-3*) was procured from the Agricultural Research Station, Dhari, JAU, Junagadh. The grain was cleaned and graded by cleaner-cum-grader machine. The grain was then cleaned and sorted out manually to remove extraneous materials such as dust, dirt, stones, chaff, immature grains, insect infested and damaged grains. The chickpea grain was dried for 6 h in open yard for sun drying up to 7.6 % (w.b.) final moisture content for safe storage. The grains were packed in different packaging materials with 5.0 kg sample size. The jute bags, polyethylene lined jute bags and PP woven laminated bags were packed and sewed by portable stitching machine (Revo bag closer, Surat) 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 (700 mm Hg) in vacuum packaging machine (Packmech Engineers, Ahmedabad). All the bags were stored at the end of month of April, 2018 at room temperature (13.2-38.5 °C, 18.8 - 91.1 % RH) for twelve months on platform in the laboratory for rat control.

Details of treatments

Independent parameters

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

All the quality parameters of the grains were recorded during two-month of storage by standard methods. The environmental parameters such as temperature and relative humidity were recorded daily with using data logger at room conditions in the laboratory during storage. Moisture contents of the samples were determined by using hot air oven method as suggested by Sadasivam and Manickam[24]. 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-month interval as reported by Adams and Schulton[1]. Cooking time was recorded as the time when 90 % of the grain were soft enough to masticate[31]. Protein content of the grain was estimated as per the method suggested by Lowry et al.[17]. Hydration and swelling properties of the grains were determined using following equations as reported by Williams *et al.*[31].

$$\text{Hydration capacity, g/grain} = \frac{\text{Weight after soaking} - \text{Weight before soaking}}{\text{Number of grains}}$$

$$\text{Hydration index} = \frac{\text{Hydration capacity of grain}}{\text{Weight of one grain}}$$

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

$$\text{Swelling index} = \frac{\text{Swelling capacity of grains}}{\text{Volume of one grain}}$$

Statistical analysis was carried out by Completely Randomized Design with three replications. All the treatments were compared at 5% level of significance using the critical difference test.

RESULTS AND DISCUSSION

Environmental parameters

Maximum temperature (38.5 °C) was recorded in the month of May while minimum temperature (13.2 °C) was observed in the month of January. Maximum RH was recorded in the month of July (91.1 %) while minimum RH was found in the month of March (18.8 %).

Quality parameters of chickpea grains:

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. However, little variation was observed in other treatments. The increase in moisture content of the grain up to four months (up to August) of storage period might be due to hygroscopic nature of the grain and moisture exchange in a pervious material during high RH in monsoon season[11,18,23]. The moisture content of the grain deceased after four months of storage period for all the treatments. The maximum moisture content of the chickpea stored in JB, JBL and PPL was found 12.38 %, 10.39 %, and 10.12 %, respectively on four months of storage. Minimum moisture content was observed in ALPEV followed by MCPV, HDPEV and PICS *i.e.* vacuum packaging and triple layer PICS bags during entire storage. It might be attributed to their lesser permeability in plastic packaging materials as well as vacuum packaging[28]. The similar results for moisture content were also reported by Asha[5] in maize, Kurdikeri *et al*.[16] in maize and Shaw[26] in green gram during storage.

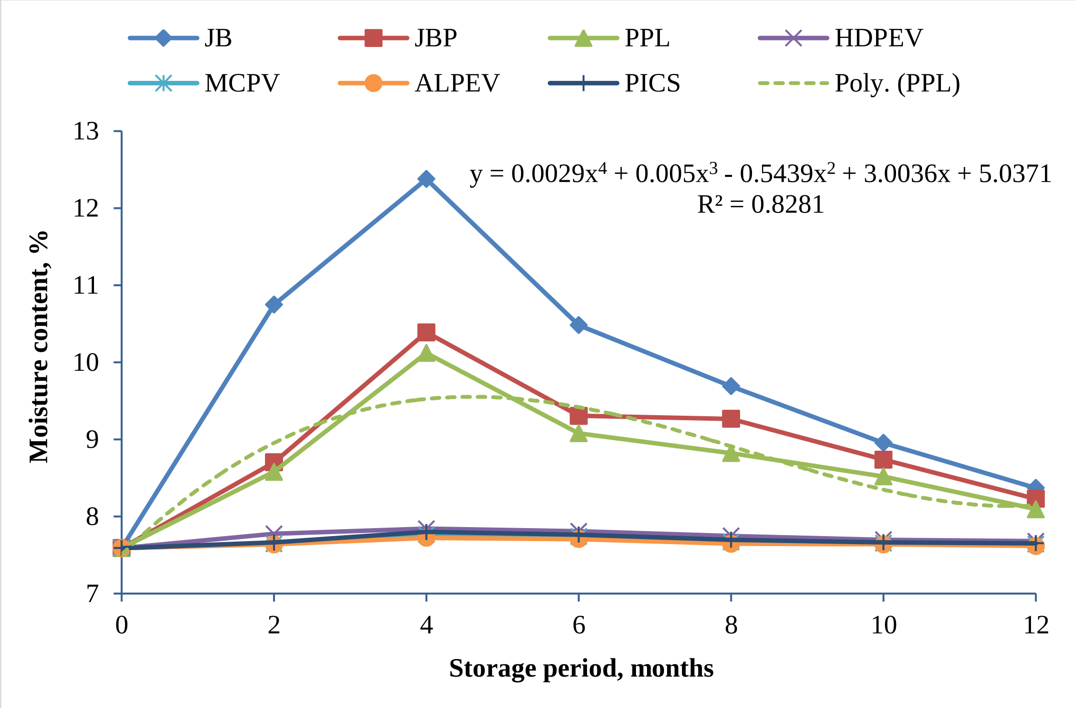

Fig. 1: Effect of different packaging materials on moisture content of chickpea grain

Weight loss

It is apparent from the Table 1 that weight loss in chickpea grain started only in JB from four months of storage and increased with increase in storage period. It might be due to insect infestation developed only in JB. The result presented in Table 1 shows that JB had significantly highest weight loss (7.51 %) at the end of storage period. However, JBP, PPL, HDPEV, MCPV, ALPEV and PICS had no weight loss during entire storage period due to pulse beetle restricted by packaging materials. These findings are fairly matched with Sudini *et al.*[27] in groundnut and Khare *et al.*[13] in chickpea during storage.

Table 1: Effect of different packaging materials on weight loss (%) of chickpea grain during storage

Treatment	Storage period, Months				
	4	6	8	10	12
JB	0.81* (0.16)	0.99* (0.48)	1.73* (2.49)	2.21* (4.39)	2.83* (7.51)
JBP	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)
PPL	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)
MCPV	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)
PICS	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)	0.71* (0.0)
S.Em. ±	0.019	0.016	0.022	0.039	0.017
C.D. at 5 %	0.056	0.049	0.066	0.120	0.050
C.V. %	4.43	3.78	4.44	7.4	2.82

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

Protein content

The effect of different packaging materials on protein content of chickpea grain was found non-significant up to eight months of storage period (Table 2).

Table 2: Effect of different packaging materials on protein content of chickpea grain

Treatment	Storage period, Months					
	2	4	6	8	10	12
JB	21.06	20.34	19.01	18.11	17.01	15.32
JBP	21.27	20.42	19.80	18.43	18.26	18.21
PPL	21.47	20.62	19.98	19.06	18.84	18.76
HDPEV	21.89	21.49	20.85	19.46	19.17	19.09
MCPV	21.68	20.82	20.39	19.32	19.07	18.98
ALPEV	21.52	20.73	20.32	19.12	18.92	18.84
PICS	21.35	20.54	19.87	18.71	18.54	18.45
S.Em.±	0.440	0.437	0.494	0.902	0.369	0.602
C.D. at 5 %	NS	NS	NS	NS	1.118	1.826
C.V. %	3.55	3.66	4.26	8.27	3.44	5.72

The initial protein content was recorded 22.39 % at the time of storage of chickpea grain. It is apparent from the Table 2 that protein content of the chickpea decreased with advancement of storage period. The reduction in the protein content 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 seeds[30]. Minimum protein content was recorded in JB (15.32 %) at the end of storage period. Maximum protein content was recorded in HDPEV (19.09 %) at the end of storage period. However, it was found at par with JBP, PPL, MCPV, ALPEV and PICS during entire storage period. It was also observed protein content of the grain was found higher in vacuum packed bags than other treatments. These results are in agreement with Chattah *et al*.[9] for wheat grain.

Cooking time

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[22].

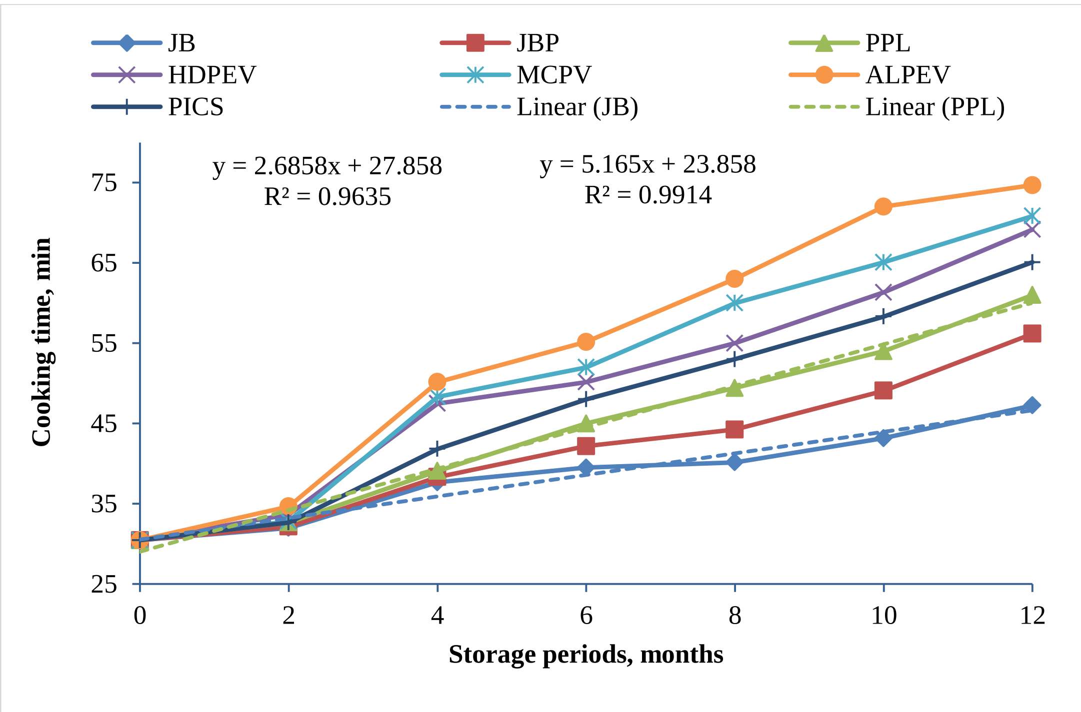

Fig. 2: Effect of different packaging materials on cooking time of chickpea grain

The effect of different packaging materials on cooking time of chickpea grain was found significant during entire storage period. JB resulted significantly lowest cooking time (47.25 min) followed by JBP and PPL at the end of storage period. However, significantly highest cooking time was found in vacuum packed packaging materials ALPEV (74.67 min) followed by MCPV and HDPEV bags on twelve months of storage. The similar findings for cooking time were also reported by Almeida *et al.*[2] for bean grains and Sethi *et al.*[25] for pigeon pea dhal and Ferreira *et al.*[10] for black bean during storage.

Hydration and swelling properties of chickpea grain

Hydration capacity

It is evident from the Fig. 3 that hydration capacity of the chickpea decreased with increase in storage period. The effect of different packaging materials on hydration capacity of the chickpea was found significant during entire storage period. PPL resulted significantly highest hydration capacity (0.240 g/grain) at the end of storage period. However, PPL was found at par with JBP and JB during entire storage period. ALPEV resulted significantly lowest hydration capacity (0.110 g/grain) and was found at par with MCPV during entire storage period.

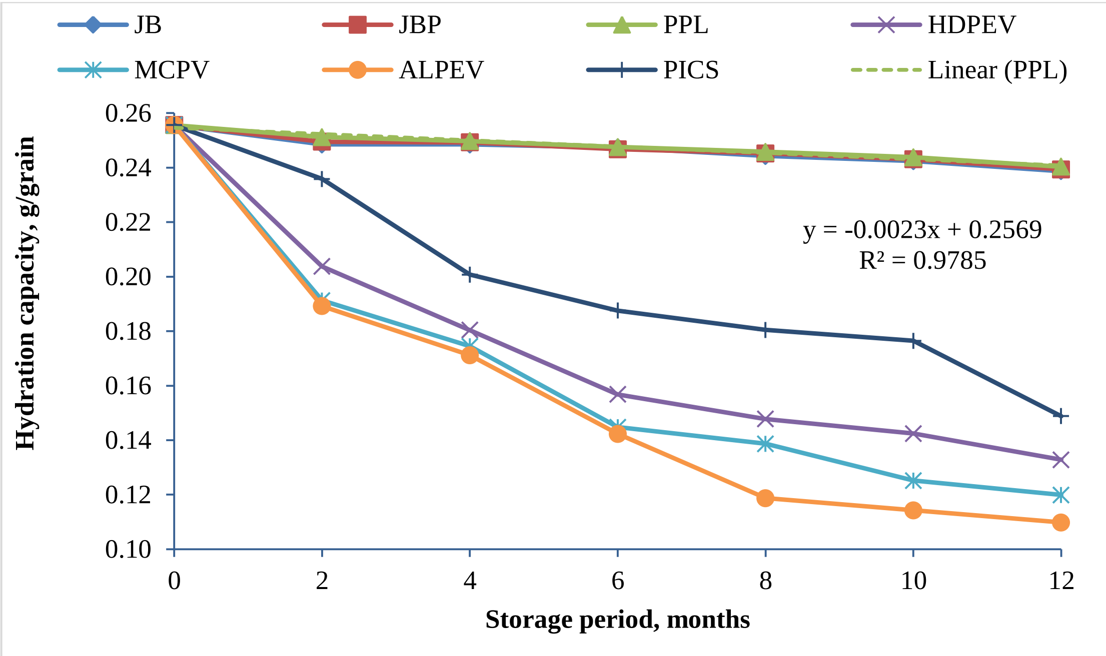

Fig. 3: Effect of different packaging materials on hydration capacity of chickpea grain

Hydration index

The effect of different packaging materials on hydration index of the chickpea was found significant during entire the storage period. From the Fig. 4, it can be observed that hydration index of chickpea grain declined with advancement of storage period. PPL resulted significantly highest hydration index (0.986) at the end of twelve month of storage period. However, JBP and JB was found at par with PPL during entire storage period. ALPEV resulted significantly lowest hydration index (0.457) at the end of storage and it was at par with MCPV during entire storage study.

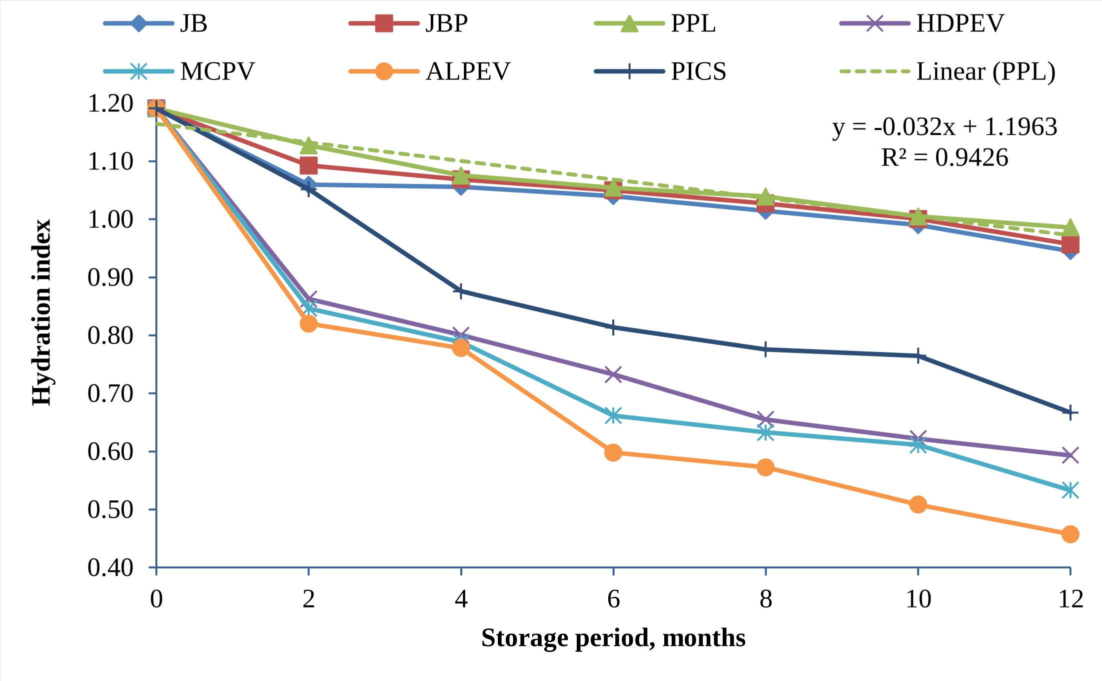

Fig. 4: Effect of different packaging materials on hydration index of chickpea grain

Swelling capacity

It is obvious from the Fig. 5 that swelling capacity of chickpea grain decreased with increase in storage period. The effect of different packaging materials on swelling capacity was found significant during entire storage period. PPL resulted significantly highest swelling capacity (0.248 ml/grain) at the end of storage period. However, JBP and JB were found at par with PPL during entire storage period. Swelling capacity of the grain was found minimum for ALPEV (0.117 ml/grain) and it was at par with MCPV throughout storage period.

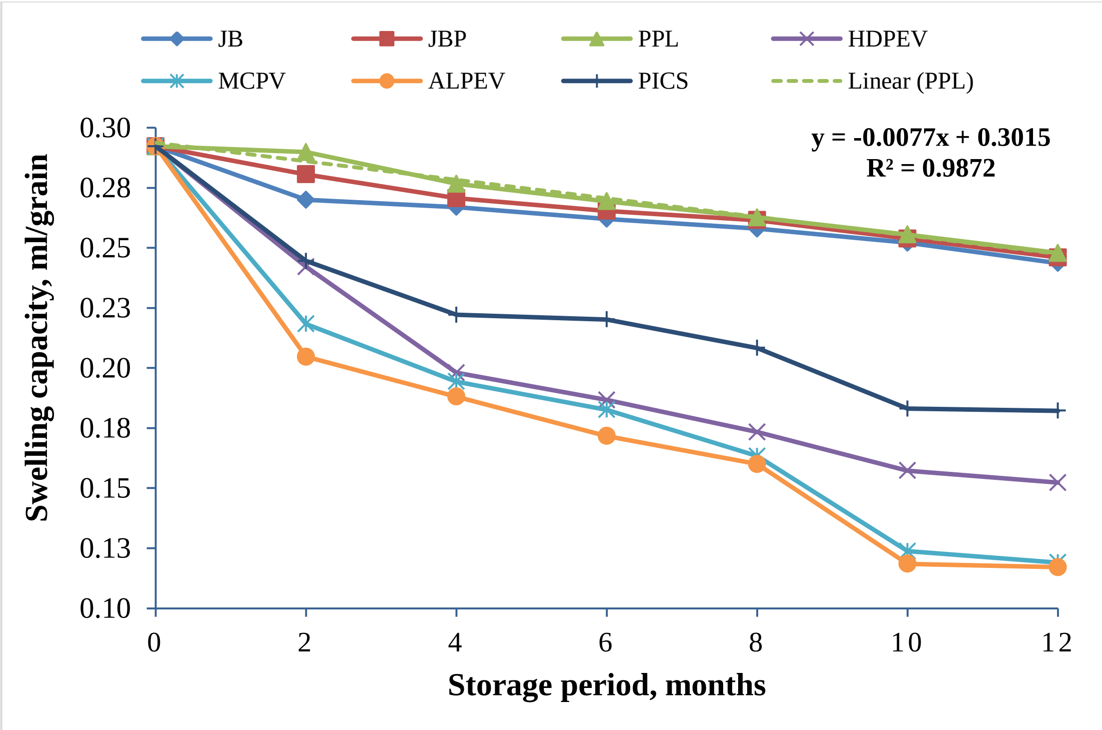

Fig. 5: Effect of different packaging materials on swelling capacity of chickpea grain

Swelling index

It can be observed from the Fig. 6 that the swelling index of chickpea grain decreased with advancement of storage period. PPL resulted significantly highest swelling index (1.446) at the end of storage period. However, JBP and JB was found at par with PPL during entire storage period. ALPEV resulted significantly lowest swelling index (0.667) at the end of storage and it was at par with MCPV during entire storage study. Hydration and swelling properties of the grain was found lower in vacuum packed packaging materials like ALPEV, MCPV and HDPEV bags than without vacuum packed packaging materials on twelve months of storage. Similar results for reducing in hydration and swelling properties in pulse during storage are also reported by Burr *et al.*,[7] Antunes and Sgarbrieri,[4] and Kon and Sanshuck,[15].

The results for reducing in hydration and swelling properties in chickpea grain with the storage period 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[6,14,21].

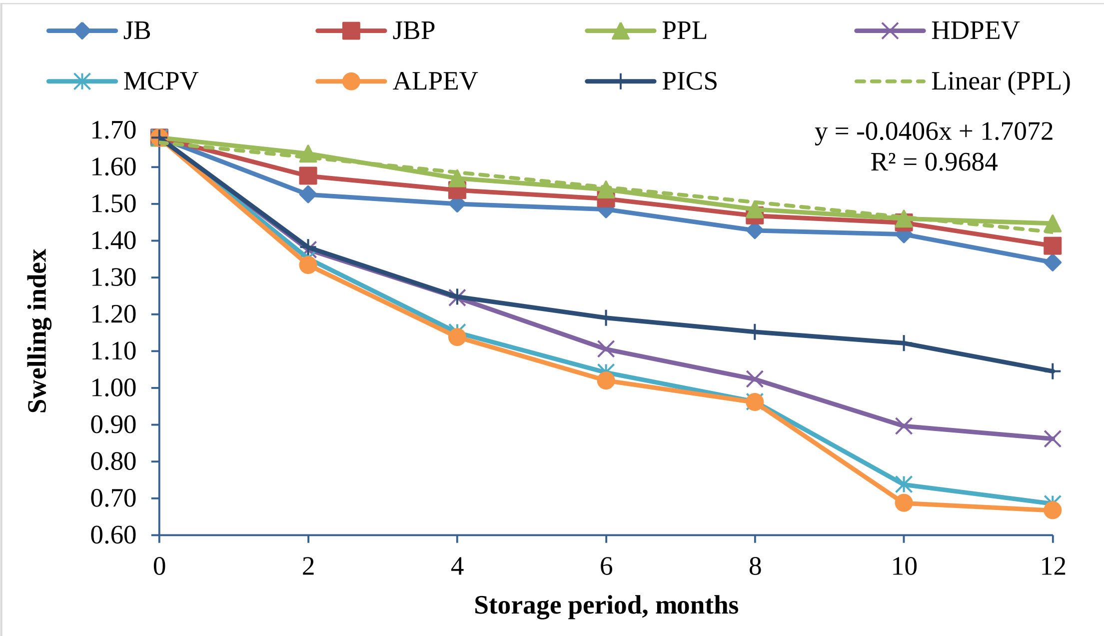

Fig. 6: Effect of different packaging materials on swelling index of chickpea grain

CONCLUSIONS

Vacuum packed materials viz., ALPEV, MCPV and HDPEV had minimum moisture content, weight loss as well as hydration and swelling properties and maximum cooking time of chickpea grain. Maximum moisture content and weight loss as well as minimum protein and cooking time of the grain was recorded in JB. Considering the overall aspects of the study, it may be concluded that PPL was observed to be best packaging material amongst all treatments having highest hydration and swelling properties, no weight loss and moderate moisture content, protein and cooking time.

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