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Comparative evaluation of different packaging materials for chickpea dhal quality over storage

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ABSTRACT

Chickpea (*Cicer arietinum L.*) is the premier leguminous crop cultivated in India, but it experiences lower yields due to biotic and abiotic stresses, particularly insect pest infestations during storage. The major post-harvest loss is due to inappropriate choice of packaging material. So, the present study aims to investigate suitable packaging material for storing Kabuli chickpea splits (cv. JG11). Processed chickpea splits were stored for 8 months in five different packaging materials viz., High Density Polyethylene (HDPE), Jute bags (JB), Low Density Polyethylene (LDPE), Biaxially Oriented Polypropylene (BoPP), and Polyethylene Terephthalate (PET) containers at ambient temperatures of 19-37 °C and relative humidity of 23-92%. During 8 months of storage, chickpea seed health quality parameters such as moisture content (%), protein content (%), mass loss (%), insect species, uric acid (mg/100g) and microbial load (CFU/g) were assessed for every two months. The moisture content (%w.b) of stored chickpea in different packaging materials ranged from 8.73 to 9.95%. The moisture content increased up to 4 months of storage period, then followed a decreasing trend in all the packaging materials. The protein content decreased in all packaging materials over the storage period. Mass loss by insects was not detected in chickpea samples stored in PET and BoPP material throughout the storage period. Insects namely *Callosobruchus chinensis, Tribolium castaneum, Rhyzopertha dominica* were observed in chickpea stored in JB and LDPE after 2 months of storage. But infestation was observed after 6 months of storage in HDPE. Due to more infestation, chickpea uric acid levels ranged from 7.84 to 1661.15 mg/100g during the storage period. Cooking time recorded was less than 24 min for all the chickpea samples stored in different packaging materials. Chickpea stored in JB significantly recorded highest bacterial count (4.88×10^6 CFU/g) and fungal count (3.99×10^3 CFU/g) followed by LDPE and HDPE. Whereas, in HDPE bacterial and fungal only was found after 6 months of storage (1.55×10^6 CFU/g) and (1.51×10^3 CFU/g). It was observed that PET storage container performed better in retaining the quality parameters during the storage amongst all the packaging materials for stored chickpea grain storage upto 240 days of storage due to the creation of hermetic conditions inside.

Keywords: *BoPP, LDPE, Chickpea, HDPE, Jute, Microbial load, PET, Protein content and Uric acid*

Chickpea (*Cicer arietinum* L.), one of the earliest domesticated legumes of the Fabaceae family, is an important pulse crop grown on about 10.91 million hectares in India, with an annual production of 12.26 million tonnes (Directorate of Economics & Statistics, ministry of Agriculture & Farmers Welfare, 2023). Commonly known as garbanzo bean, Bengal gram, or channa, chickpea is nutritionally rich, providing 18–24 g protein, 39–54 g carbohydrates, 7–12 g fibre, and essential minerals per 100 g. Two major types exist: Desi (small, dark, high in protein and fibre, with low glycaemic index) and Kabuli (large, light-coloured seeds with smoother coat) Despite its nutritional benefits, chickpea is prone to storage pests, particularly *Callosobruchus chinensis* (pulse beetle), a major cause of seed damage and economic loss in pulses (Babu *et al*., 2020).

Proper packaging is critical for minimizing post-harvest losses. While traditional jute bags are widely used, they are prone to insect infestation and moisture absorption (Satasiya *et al*., 2021). Modern packaging materials such as HDPE, LDPE, BoPP, and PET provide better barriers against moisture, oxygen, and microorganisms (Yewle *et al*., 2022), but have limitations in biodegradability and handling. Spoilage caused by insects, microorganisms, and chemical changes remains a major contributor to food loss in pulses, highlighting the importance of selecting suitable storage methods (FAO, 2019)

The present study was undertaken to evaluate the influence of different packaging materials (HDPE, LDPE, BoPP, PET, and jute) on quality parameters of stored split chickpea (*dhal*) under ambient conditions. Parameters assessed at two-month intervals over eight months included moisture content, protein content, insect infestation, mass loss, cooking time, uric acid, and microbial load.

MATERIAL AND METHODS

A seed storage experiment was conducted under ambient storage conditions at Post Harvest Technology Centre, Bapatla, Andhra Pradesh, India for 8 months. During the period of experiment temperature and relative humidity was recorded with data logger (HW4-Rotronics, China).

Experimental setup

Freshly harvested kabuli chickpea (cv. JG11) were used supplied by farmer's producer organization (FPO). The chickpeas originated from Kandukur, Prakasham, Andhra Pradesh harvested late December. The dried chickpeas which are clean, sound, free from insect, fungal infestation were stored at (8-10 % w.b.) until the day of use. Five different packaging materials were used in this study (HDPE, LDPE, BoPP, PET, Jute bag) respectively were procured from local market, Bapatla, Andhra Pradesh and the packing material shall be of food grade quality. After cleaning, the grains were milled in mini dall mill (S6265, Osaw Industries Pvt. Ltd., India). Each package shall contain milled and decorticated chickpea splits of weight approximately 1 kg chickpeas of the same type and of the same grade designation. If chickpeas are presented in bags, the bags shall also be free of pests and contaminants. Each package shall be securely closed and sealed illustrated in Fig.1. LDPE and HDPE sealed with hand sealing machine (Sepack, India). The Jute bags and BoPP were sealed by portable sewing machine (Revo-Da, India).

Observations recorded

Before storage, seed health quality parameters such as moisture content (%), protein content (%), mass loss (%), insect species, cooking time, uric acid (mg/100g) and microbial load (CFU/g) were recorded. The seed health quality parameters of packed chickpea samples were assessed for every two months during the storage period of 8 months.

Determination of moisture content

The moisture content of chickpea samples was evaluated according to Htwe *et al*., 2018. Weighed about 5 grams of the sample into a dish that has been dried and tared before putting it in an oven set to 103 to 105°C for 24 hours with the lid on. In the desiccators, the samples were allowed to cool. To determine the moisture content of the chickpea samples, the weight of the container with its cover was measured after it had cooled. The moisture content were determined by wet basis and were calculated by using Eq. (1).

Fig. 1. Chickpea dhal stored in different packaging materials (a) BoPP (b) HDPE (c) LDPE (d) PET and (e) Jute bag

Moisture (% w. b.) = $\frac{(W1-W2)}{W1-W} \times 100$ (1)

Where,
W1 = Weight of the dish with the material before drying (g)
W2 = Weight of the dish with the material after drying (g)
W = Weight of the empty dish (g)

Insect pest species identification

A brass impact test sieves (mesh sizes: 3.35 mm, 3.0 mm and 2.0 mm) in diameter perforations was used to weigh 100 g in each packaging material sample to extract all insects from stored chickpea grains (Perzada *et al.*, 2022). The insect species identification were observed under high resolution magnifying lens (RI-89-01–Magnascope, India).

Weevilled and germ eaten grain counting method

To calculate the percentage of mass loss, randomly selected 100 grains from the representative sample. Next, counted the number of weevilled and germ-eaten grains that were separated from the sample mass loss was calculated using Eq. (2) (Pragnya *et al*., 2018).

Mass loss (%) = $\frac{(W+G)-100}{S(W1+G1)} \times 100$ (2)

Where,
W = Percentage by number of weevilled grains
G = Percentage by number of germ-eaten grains
W1 =Mass of W grains (g)
G1 = Mass of G grains (g)
S = Mass of 100 healthy grains

Protein content

The measurement of protein content in 0.1 mL of sample mix and 0.1 mL of 2 N NaOH was followed by hydrolysis in a boiling water bath for 10 minutes at 100°C (Rizvi *et al*., 2022). One milliliter of recently mixed complex-forming reagent was added after the hydrolysate was cooled to room temperature. After allowing the solution to stand at room temperature for ten minutes, used a vortex mixer to add 0.1 mL of Folin-Ciocalteu reagent. Allowed the mixture to stand at room temperature for 30–60 min (do not exceed 60 min). To determine the protein concentration, measured the absorbance at 650 nm using a (Rayleigh, UV-9200 Spectrophotometer, Beijing).The Protein analysis was determined by using Eq. (3).

$$\text{Protein (\%)} = \frac{\text{OD of Test}}{\text{OD of standard}} X$$

$$\frac{\text{Concentration of standard}}{\text{Volume of Test}} X100 \quad (3)$$

Cooking Time

Finished cooking process time was determined by using paralles glass plate method (Akinoso & Oladeji, 2017) Using this approach, chickpea samples were taken at regular intervals during cooking and squashed between two small glass plates. The sample was deemed cooked when there was no longer any visible core. Initially, a trial experiment was conducted to determine an estimated cooking time. Samples of the boiling chickpea were then pressed between two tiny glass plates and checked every five minutes. The time between evaluations was shortened to three minutes as the cooking period came to an end. This process was carried out repeatedly until the seed core showed no signs of white hue. With a stopwatch, the amount of time spent cooking was tracked.

Determination of uric acid

A 50 g sample was finely grounded and approximately 10 g of powder was suspended in 200 mL of water. The suspension was allowed to stand for two hours, blended for ten minutes in a blender, and then centrifuged for ten minutes at approximately 2000 rpm. To the extract, 10 mL of standard sulphuric acid solution was added to precipitate the proteins. The solution was stirred, allowed to stand for five minutes, and then filtered. An aliquot of the filtrate containing 0.15–0.3 mg of uric acid per 10 mL was transferred into a 50 mL volumetric flask. To this, 5 mL of ammonium thiosulfate solution (ATS) and 1 mL of Benedict's uric acid reagent were added, and the volume was made up with distilled water. The resulting solution was gently shaken, and its optical density (OD1) was recorded using a spectrophotometer with a 520 nm filter. Similarly, in a 50 mL flask, 10 mL of standard uric acid solution (0.2 mg uric acid), 5 mL of ammonium thiosulfate, and 1 mL of Benedict's uric acid reagent were added. After five minutes, the solution was diluted to the mark, and the color intensity was measured at 520 nm (OD2) using Eq. (4) (Vishwakarma et al., 2021).

$$\text{Uric acid (mg/g)} = \frac{(OD1 - OD2) \times 10 \times 2}{\text{Weight of sample,g}} \qquad (4)$$

Microbial analysis

To ensure commercial sterility, microbial analysis was done. Microbial analysis evaluation of chickpea samples stored in various packing materials for bacterial and fungal burdens was performed after every two months during storage. The usual plate count approach was employed to assess the microbial population using Martin Rose Bengal Agar (MRBA) media for fungi and Plate Count Agar (PCA) media for bacteria. To make water blanks, dissolved 1 g of the powdered sample in 10 mL of sterile distilled water. For the purpose of counting the total amount of bacteria and fungi, one milliliter of a 10^{-6} and 10^{-3} dilution was utilized, respectively. In each Petri dish, 100 microliters of various samples were diluted before 20–25 milliliters of medium were added. Bacteria and fungi have been counted in colonies between 48 and 72 h (Yewle *et al*., 2020). The number of CFU/gm samples was calculated by applying the following Eq. (5).

$$n_c = \frac{Nm \times Df}{Ws} \qquad (5)$$

Where,

n_c = the number of colony-forming units (CFU's) per gram of the sample,

n_m = the mean number of CFU's,

d_f = the dilution factor and

w_s = the weight of the sample

Statistical analysis

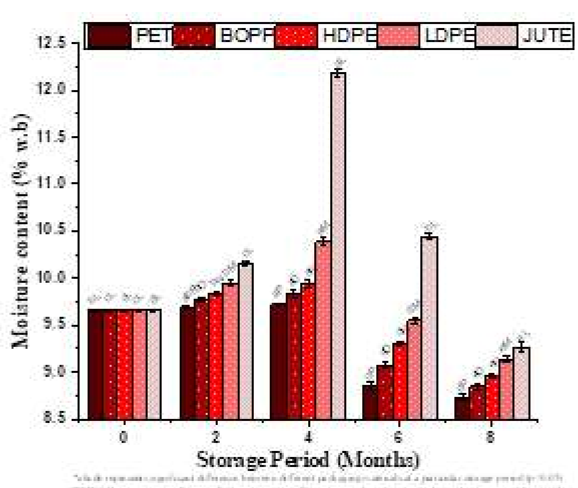
Seed health quality characteristic of chickpea was replicated three times and is shown as (mean ± standard deviation). Using IBM Statistical Package for Social Sciences software, an analysis of variance (ANOVA) and Duncan multiple range test at $p < 0.05$ were used to determine the significant difference between the mean samples.

RESULTS AND DISCUSSIONS

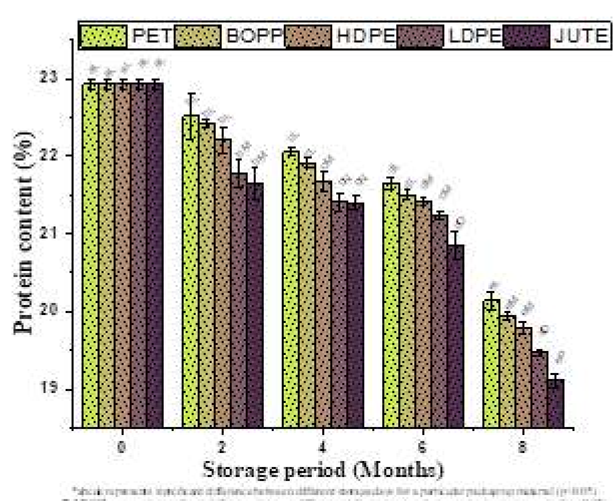
During the period of experiment maximum temperature was recorded as 39.5 °C in the month of May while minimum temperature was recorded as 23.6 °C in the month of January. Maximum RH was recorded as 90.7 % in the month of July while minimum RH was found as 22.3 %.

Moisture content

Before storage, the moisture content of stored chickpea dhal in different packaging material showed non-significant differences from each other. The initial moisture content of fresh chickpea was found to be 9.66 (% w.b). The moisture content (% w.b.) of chickpea in different packaging material varied as follows: PET (8.73-9.66%), BoPP (8.85-9.66%), HDPE (8.96-9.66%), LDPE (9.14-9.66%), and Jute bag (9.27-9.66%) respectively. The escalation in moisture content of samples stored in different packaging materials may be the result of water being released during respiration. It is illustrated from the Fig. 2 (a) that moisture content was increased over four months in all the packaging material. There was a significant ($P < 0.05$) change between moisture content of samples stored in packaging material during storage



(a) Moisture Content



(b) Protein content

Fig. 2. Effect of different packaging materials on moisture content and protein content of chickpea

period. The maximum average moisture content of the chickpea samples stored in Jute bag, HDPE, LDPE, BoPP and PET was found to be 12.18%, 10.38%, 9.95%, 9.84% and 9.72 % respectively after four months of storage while minimum moisture content was lower than the initial moisture content noticed in PET (8.73%) followed by BoPP (8.85%), HDPE (8.96%), LDPE (9.14%) and Jute bag (9.27%) after eight months of storage period. There was a slight significant change $p<(0.05)$ in moisture content for samples stored in PET between (0 & 2 months, 2 & 4 months). Similar results were reported by Thakur & Nawalagatti, (2021) in black chickpea grain stored in cloth, gunny, and HDPE bag increased up to two months then decreased up to fourth month then again increased up to sixth month of storage; Htwe *et al*., 2018 in chickpea grain stored in tin bins, bamboo baskets and woven plastic bags up to 9 months of storage; Kalsa, 2021 in chickpea grain stored in Supper Grain Pro bag (SGB), Perdue improved crop storage bag (PICS), Polypropylene bag (PPB), and Polypropylene bag lining with polyethylene sheet inside (PPBPE) were assessed up to one year.

Insect Infestation

The samples stored in different packaging materials of 500 g each were drawn from the top, middle and bottom portion from all the stored packaging material. Three insect pests i.e. *Callosobruchus chinensis (L.), Tribolium castaneum (H.) and Rhizopertha dominica* (F.) were observed in stored chickpea during storage period. The insect population of (*Callosobruchus chinensis* L., *Tribolium castaneum* H., *Rhizopertha dominica* F.) was only found in Jute bags and LDPE bags. As the storage prolongs pulse pests increased drastically with increase of storage period. The statically analysis of insect population are presented in the Table 1. Jute bag resulted significantly highest insect population (Callosobruchus chinensis-170, Tribolium castaneum-19 and Rhizopertha dominica-16) followed by LDPE (Callosobruchus chinensis-19, Tribolium castaneum-9 and Rhizopertha dominica-3) at the end of eight months of storage period. It might be decreased pressure and the consequent oxygen content that interfered with the inhalation, intake, and mobility of the insects (Schroeder *et al*., 2018). However, in HDPE only callosobruchus chinensis was observed during entire storage period. Higher moisture content and O_2 availability may have contributed to the increase in insect population in the Jute bag and LDPE (Dubey *et al*., 2024). There is no infestation in PET and BoPP throughout the cycle. These results are also consistent with the research conducted on chickpea grain by Kronenberg, (2022); (P. Chaithanya *et al*., 2024); (Hanif *et al*., 2023).

Protein content

A minimal significant decrease in protein content was observed during the study period in all the packaging materials shown in Figure 2 (b). The average maximum protein content 20.14% was recorded in sample stored in PET at the end of storage period. Jute bag resulted significantly lowest protein content 19.11% after eight months of storage period. Protein content in the chickpea samples stored in different packaging materials was found to be significant. The effect of packaging material during storage period in PET, BoPP & HDPE (2 & 4 months-except HDPE), LDPE & Jute (2 & 4

Table 1 Effect of packaging material on Insect infestation

Months	PET	BoPP	HDPE		LDPE		JUTE	
2	-	-	-	-	C.C	Live 1	C.C	Live 5
4	-	-	-	-	C.C	Live 5	C.C	Live 9
							T.C	Live 5
							R.D	Live 1
6	-	-	C.C	Live 3	C.C	Live 9	C.C	Live 37
					T.C	Live 2	T.C	Live 8
					R.D	Live 1	R.D	Live 4
8	-	-	C.C	Live 6	C.C	Live 19	C.C	Live 170
					T.C	Live 9	T.C	Live 19
					R.D	Live 3	R.D	Live 16

months), were found to be non- significant ($p<0.05$).Weevils that mostly consume the endosperm diminish protein levels, although insects may target the grain's germ, lowering a sizable amount of the grain's protein and vitamin content (Demis & Yenewa, 2022). The protein content of chickpea decreased as the infestation levels increased (Allali *et al*., 2020). These findings are fairly matched with Patel, (2018) in chickpea stored in JB, JBP, PPL, HDPEV, MCPV, ALPEV and PICS for twelve months of storage, whereas contradictory results with (Raleng *et al*., 2014) in deoiled sesame cake stored in LDPE and Aluminium foil for a period of 75 days.

Mass loss

Mass loss can be inferred from the Fig. 3 (a). Mass loss in HDPE, LDPE and Jute bag ranged from 2.42 to 13.70 %. However, during the initial 4 months of storage period mass loss in HDPE was not observed. Jute bag resulted the highest mass loss 13.70% followed by LDPE 11.87% and HDPE 5.92% after 8 months of storage period. The decreasing order of mass loss in stored packaging materials HDPE> LDPE >Jute bags. Mass loss in the chickpea samples stored in HDPE, LDPE and Jute bag was significantly differ with respect to time, the effect of packaging material during storage period was found to be significant ($p<0.05$). Physiological mass loss due to which it slowed down the metabolic activities like respiration and transpiration (Marichamy *et al*., 2020). Similar trend was found with (Chauhan *et al*., 2021) in chickpea grain in which mass loss increased as the storage period prolongs stored in JB, JBP but no mass loss was observed in PPL, HDPEV, MCPV, ALPEV and PICS, (Pragnya et al., 2018) in dehusked foxtail millet stored in PE, PP and PET for a period of six months.

Cooking time

Cooking generally promotes palatability and digestibility through the inactivation of antinutritional elements such as hemagglutinins and digestive enzyme inhibitors, the leaching of polyphenolics, and the gelatinization of starch (Wood, 2017). Cooking time of chickpea stored in different packaging materials ranged from 21.43-23.31 min as shown in Table. 2. Jute bag resulted significantly highest cooking time during storage period. However, lowest cooking time was observed in PET during storage period. As the levels of uric acid increased, increase in the cooking time was observed over 8 months of storage period by which insect count also drastically increased. Cooking time for stored chickpea samples in all the packaging materials was found to be non-significant. The effect of packaging material stored in PET & BoPP (2, 6, 8 months) during storage period was found to be non- significant ($p<0.05$). Results are in agreement with Satasiya *et al*., (2021) in chickpea stored in Jute bag recorded the lowest cooking time during twelve month of storage, Sethi, (2014) where cooking time was increased as the storage period increased in HDPE for a period of 10 months.

Uric acid

One of the main by-products of insect protein digestion is uric acid, in which anti-nutritional factors phytic acid and trypsin inhibitors increased with the increase in levels of infestation of Bengal gram (Devi *et al*., 2019). Uric acid can be figured out from Fig 3 (b). Uric acid in HDPE, LDPE and Jute bag ranged from 23.54 to 1661.15 (mg/100g). However, during

Table 2. Effect of packaging material on Cooking time of chickpea

Months	PET	BoPP	HDPE	LDPE	JUTE
0	21.43 ± 0.01^{eL}	21.43 ± 0.01^{eL}	21.43 ± 0.01^{eL}	21.43 ± 0.01^{eL}	21.43 ± 0.01^{eL}
2	23.00 ± 0.01^{dO}	22.56 ± 0.02^{dM}	22.52 ± 0.01^{dM}	21.48 ± 0.01^{dL}	21.46 ± 0.01^{dL}
4	23.08 ± 0.01^{cP}	23.00 ± 0.01^{cO}	22.56 ± 0.01^{cN}	21.54 ± 0.01^{cM}	21.52 ± 0.01^{cL}
6	23.15 ± 0.02^{bO}	23.08 ± 0.01^{bN}	23.00 ± 0.01^{bM}	21.58 ± 0.01^{bL}	21.56 ± 0.01^{bL}
8	23.31 ± 0.01^{aO}	23.15 ± 0.02^{aN}	23.08 ± 0.01^{aM}	22.03 ± 0.01^{aL}	22.01 ± 0.01^{aL}

*LMNOP indicates significant difference between different packaging materials at a particular storage period ($p<0.05$). *abcde indicates significant difference between different storage days for a particular packaging material ($p<0.05$).

Table 3. Effect of packaging material on bacterial and fungal count

	Fungal (CFU/g)				
Months	**PET**	**BoPP**	**HDPE**	**LDPE**	**JUTE**
2	-	-	-	2.01×10^3	2.36×10^3
4	-	-	-	2.71×10^3	2.84×10^3
6	-	-	1.37×10^3	3.11×10^3	3.49×10^3
8	-	-	1.51×10^3	3.54×10^3	3.99×10^3
	Bacterial (CFU/g)				
2	-	-	-	2.43×10^6	2.89×10^6
4	-	-	-	2.88×10^6	2.97×10^6
6	-	-	1.49×10^6	3.61×10^6	3.77×10^6
8	-	-	1.55×10^6	4.06×10^6	4.88×10^6

the initial 4 months of storage period uric acid in HDPE was not observed. Jute bag resulted the highest uric acid 1661.15 followed by LDPE 243.33 and HDPE 47.09 (mg/100g) after eight months of storage period. Due to more infestation chick pea even after cooking due to the presence of insect excreta and body parts, legumes becomes unhygienic, uric acid levels may enhanced and should not be consumed even after processing (Amoah *et al*., 2023). The order of packaging materials in reducing the uric acid was: HDPE> LDPE >Jute bags. Uric acid in the chickpea samples stored in HDPE, LDPE and Jute bag was significantly differ with respect to time, the effect of packaging material during storage period was found to be significant ($p<0.05$). These findings are fairly matched with (Devi *et al*., 2019) in chickpea grain in which insect infestation and uric acid are directly proportional to each other upto 90 days of storage in air tight sealed containers.

Microbial load

The processed and stored chickpea dhal was analysed for their commercial sterility. Chickpea is often attacked by fungi during pre and post-harvest stages, significantly affecting its productivity, also some species can be potential mycotoxin producers that can lead to serious threats to human health (Ramirez *et al*., 2018). The fungal and bacterial growth in chickpea splits stored in different packaging materials shown in Table 3 was found maximum in jute bags (3.99×10^3 & 4.88×10^6) followed by LDPE (3.54×10^3 & 4.06x 106) and HDPE (1.51×10^3 & 1.55×10^6) after eight months of storage. However, no microbial activity was found in PET and BoPP throughout the storage period as there is no insect inhabitation and uric acid. This may be attributed due to when moisture is present in a confined environment, spoilage bacteria can grow rapidly and form small colonies. These colonies cause chickpea

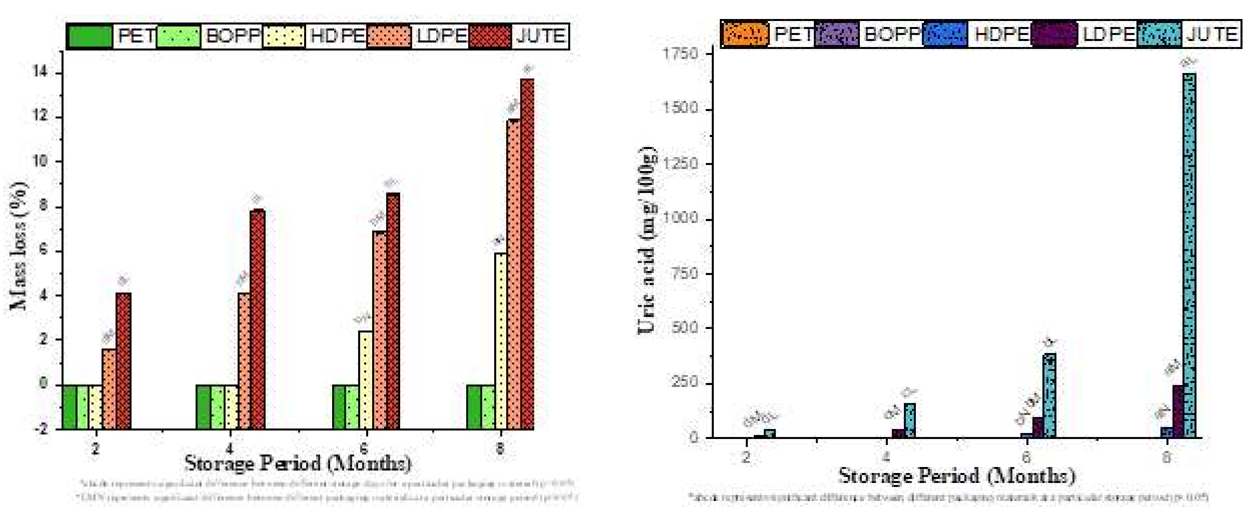


Fig. 3 Effect of different packaging materials on (a) mass loss and (b)uric acid of chickpea

dhal to quickly decay and become inedible (Dhakal, 2023). These results confirm the findings of (R. Yeole et al., 2018) during storage of green gram stored in hermetic bag, 300 PP bag, 200 PP bag, White plastic bag and gunny bag. These results are also consistent with (Harika *et al*., 2024) in dehulled splits of blackgram, pigeon pea and chickpea grain stored in GrainPro bag (>78ì), aluminium pouch (75 ì), woven polymer bag, low density polyethylene (LDPE) bag (>75ì), high density polyethylene (HDPE) bag (>75ì), polythene lined jute bag and polyethylene terephthalate (PET) jar up to 90 days of storage.

CONCLUSION

On the basis of results obtained it can be concluded that as the infestation increased cooking time, uric acid, mass loss, fungal and bacterial growth can be increased whereas, protein content of dhal decreased throughout the storage period. The maximum average moisture content of the chickpea samples stored in Jute bag, HDPE, LDPE, BoPP and PET was found to be 12.18%, 10.38%, 9.95%, 9.84% and 9.72 % respectively after four months of storage while minimum moisture content was lower than the initial moisture content noticed in PET (8.73%) followed by BoPP (8.85%), HDPE (8.96%), LDPE (9.14%) and Jute bag (9.27%) after eight months of storage period. The fungal and bacterial growth in chickpea splits stored in different packaging materials was found maximum in jute bags (3.99 x 10^3 & 4.88 x 10^6) followed by LDPE (3.54 x 10^3 & 4.06x 106) and HDPE (1.51 x 10^3 & 1.55 x 10^6) after eight months of storage. Uric acid in HDPE, LDPE and Jute bag ranged from 23.54 to 1661.15 (mg/100g). However, during the initial 4 months of storage period uric acid in HDPE was not observed. Jute bag resulted the highest uric acid 1661.15 followed by LDPE 243.33 and HDPE 47.09 (mg/100g) after eight months of storage period. Jute bag resulted significantly highest cooking time during storage period. However, lowest cooking time was observed in PET during storage period. As the levels of uric acid increased, increase in the cooking time was observed over 8 months of storage period by which insect count also drastically increased. The average maximum protein content 20.14% was recorded in sample stored in PET at the end of storage period. Jute bag resulted significantly lowest protein content 19.11% after eight months of storage period. Jute bag resulted significantly highest insect population (*Callosobruchus chinensis*-170, *Tribolium castaneum*-19 and Rhizopertha dominica-16) followed by LDPE (*Callosobruchus chinensis*-19, *Tribolium castaneum*-9 and *Rhizopertha dominica*-3) at the end of eight months of storage period. However, in mass loss during the initial 4 months of storage periodn HDPE was not observed. Jute bag resulted the highest mass loss 13.70% followed by LDPE 11.87% and HDPE 5.92% after 8 months of storage period. The decreasing order of mass loss in stored packaging materials HDPE> LDPE >Jute bags. The results of the current study lead to the recommendations that PET and BoPP bags can be recommended for use by seed producers to safely store chickpea seeds for up to 8 months as the best packaging materials amongst all having no insect population, and no microbial load, no uric acid formation, no mass loss due to insects and moderate moisture content of chickpea seed for 8 months of storage period. Therefore, based on the cost of the packaging material, PET container can be preferred over BoPP for storing chickpea to preserve the quality and reduce the post-harvest losses of chickpea.

Credit authorship certificate

S. Mohammod Jeelani: Conceptualization, Investigation, Data curation, Writing – original draft.
V. Vasudeva Rao: Methodology, Software, Investigation, Writing - review & editing.
D. Sandeep Raja: Validation, Formal analysis, Resources, Data curation.
S.V.S Gopala swamy: Formal analysis, Writing - review & editing.
L. Edukondalu: Methodology, Writing - review & editing.

Data Availability Statement

Data available on request from the authors.

Conflict of Interest

The authors declare that they have no conflict of interest.

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