Indian Journal of Agricultural Sciences **95** (12): 1566–1570, December 2025/Short Communication
https://doi.org/10.56093/ijas.v95i12.147234

Vacuum packaging: A promising technology for safe storage of green gram (*Vigna radiata*) seeds

VIJAYSINGH THAKUR[1]*, NAWALAGATTI C M[1], CHETTI M B[1], HILLI J S[1] and R V PATIL[1]

University of Agricultural Sciences, Dharwad, Karnataka 580 005, India

Received: 08 January 2024; Accepted: 28 November 2025

Keywords: Ambient storage, Bruchids, Cold storage, Conventional packaging, Green gram, Vacuum packaging

In the agricultural sector, the year-round demand for commodities necessitates effective storage solutions to address seasonal variations in production. Preserving excess produce during peak seasons is crucial for meeting market demands during off-seasons. Thus, it is fundamental to ensure a steady supply of quality seeds to farmers for cultivating healthy crops and satisfying consumer needs (Wright and Cafiero 2011). Seed deterioration is inevitable, but its rate can be controlled through proper temperature and humidity management during storage (Adetumbi *et al.* 2009). In India, inadequate storage facilities and a lack of post-harvest pulse management knowledge contribute to significant post-harvest losses, reaching up to 25–30% (https://farmer.gov.in/imagedefault/prospects_2017.pdf). Globally, post-harvest losses, receiving less than 5% of research funding, pose a critical challenge (Kitinoja *et al.* 2011).

Short-duration pulse crops, like green gram (*Vigna radiata*) require prolonged storage to ensure year-round availability. Successful storage involves protection from pests, prevention of mold contamination and maintenance of viability and nutritional properties. Pulse storage is particularly challenging due to their high protein content, making them more susceptible to damage from storage pests (Lal and Verma 2007). Bruchids (*Callosobruchus* spp.) pose a serious threat to pulses both in the field and during storage, causing substantial economic losses (Srinivasan *et al.* 2008). Traditionally, synthetic pesticides like carbon disulfide, phosphine and methyl bromide were employed, but their environmental and food safety concerns have led to criticism (Williamson *et al.* 2008).

Alternative measures include biopesticides derived from plant extracts, such as soybean and neem oil, hot pepper powder, custard apple extracts and banana plant juice, which have shown efficacy against bruchids (Swella and Mushobozy 2007). Despite their advantages, botanicals have limitations, including higher application rates and potential environmental impact on non-target organisms (Rozman 2015). Given the drawbacks of both organic and inorganic chemicals for storage, there is a growing need for chemical-free alternatives. With this context, research has been undertaken to explore chemical-free storage options, experimenting with various packaging and storage conditions.

Experimental location: An experiment on seed storage was conducted for a period of 18 months from November 2019 to May 2021 at the University of Agricultural Sciences, Dharwad (15.49º N, 74.99º E; at an elevation of 750 m amsl), Karnataka. Average temperature (ºC) and relative humidity (%) data for the ambient storage facility were recorded using an anemometer/psychrometer during the initial 15 days of every other month (Fig 1). Meanwhile, the cold storage maintained a temperature of 5–7ºC with a relative humidity of 60 ± 2% throughout the entire storage period.

Experimental setup and treatments: Healthy green gram seeds (BGS-9), freshly harvested from farmers' field, underwent sun-drying before being packed in various materials such as cloth bags, gunny bags, HDPE bags and vacuum packed bags (wherein air is extracted and the pack is hermetically sealed). Each packing method (cloth, gunny, HDPE) involved packing 3 kg of seeds (Fig. 2), in two storage conditions. For vacuum packaging, 1 kg of seed was packed in 9 bags in two storage conditions, with no stacking to expose all bags to environmental conditions. The polythene bag specifications for vacuum packaging are detailed in Table 1. The vacuum packaging machine used was an OLPACK 501/V, manufactured by INTERPRISE–BRUSSELS S.A., BRUXTAINER DIVISION, Belgium.

Methodology: Initial measurements were taken for germination (%) and moisture content (%) (ISTA 2013) before packing. Subsequently, every 15th day of every alternate month, representative samples were collected from all treatments and the aforementioned parameters were documented for a duration of 18 months. The significance of

[1]University of Agricultural Sciences, Dharwad, Karnataka.
*Corresponding author email: vijay7607@gmail.com

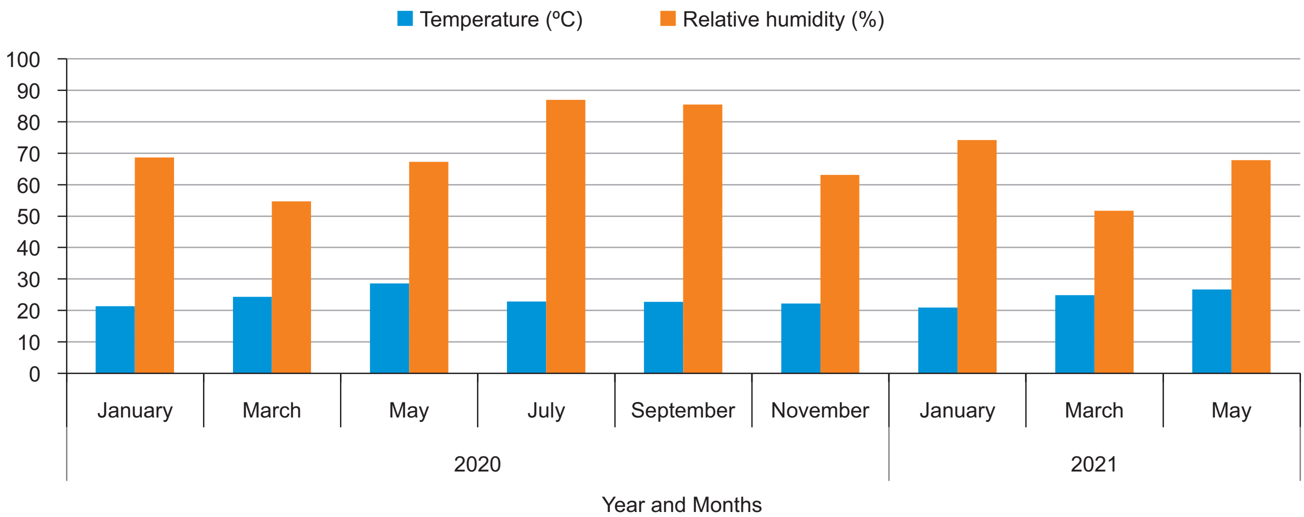

Fig. 1 Average temperature and relative humidity of storehouse of ambient condition.

Table 1 Characteristics of the LDPE bag employed for vacuum packaging

	Unit	Results	Tested as per guidelines of
Thickness (microns)	Microns	149.40	IS: 2508
Water vapour transmission rate	$g/m^2/24$ h at 38°C and 90.0% Relative humidity	0.95	ASTM F 1249
Oxygen transmission rate	$cc/(m^2 \times day \times atm)$	0.91	ASTM D 1434-15

Fig. 2 Different packagings used for storage of green gram seeds under ambient and cold conditions.

various variables was tested using a completely randomised design (CRD) and the results are presented in tabular format. The experimental data were analysed statistically by following the suitable design outlined by Panse and Sukhatme (1967).

Germination: In the current investigation, no significant differences were found in germination between treatments after a two-month storage period (Table 2). However, as the storage duration progressed, bruchid infestation occurred under ambient conditions for all packagings, except for vacuum packed bags in the ambient storage and all packaging materials in the cold storage. This infestation in ambient conditions was attributed to the permeable nature of packaging, allowing bruchids to penetrate and proliferate. Similar findings on insect infestation in permeable packaging was reported by Thakur and Dhiman (2016).

Due to bruchid infestation, a significant reduction in germination occurred due to larvae's internal feeding behaviour. Accordingly, packages with bruchid infestation were discarded and observations discontinued. Swamy *et al.* (2018) also reported decreased germination due to bruchid infestation. In cold storage conditions, there was no insect infestation, but over time, there was a decline in viability and vigour in all seeds in permeable packaging due to ageing. The ageing of seeds is influenced by temperature, oxygen and moisture. While temperature and moisture are effectively controlled in cold storage, it is the presence of oxygen that significantly contributes to seed deterioration in this environment. High oxygen content in permeable packaging accelerate seed deterioration by depleting protective antioxidants. A correlation between the antioxidant system and seed ageing has been noted by Demirkaya *et al.* (2010). The investigation's results align with Silva *et al.* (2018) findings in rice, showing a slower rate of seed deterioration in cold conditions.

In vacuum packed seeds, notably, the rate of seed deterioration was observed in both ambient and cold conditions. The modified atmospheric condition within the vacuum packed bags, coupled with higher thickness and lower water vapour and oxygen transmission rates of the polythene bag (Table 1) contributed to this effect. Low oxygen concentration in the package minimised oxidation, resulting in less deterioration compared to other

Table 2 Influence of packaging and storage conditions on germination (%) at different time intervals of storage in green gram seeds

Treatments		Before storage	Storage period (months)								
			2	4	6	8	10	12	14	16	18
Ambient storage	T_1, Cloth bag	97.0 (80.0)	95.3 (77.5)	*	*	*	*	*	*	*	*
	T_2, Gunny bag	97.0 (80.0)	94.8 (76.8)	*	*	*	*	*	*	*	*
	T_3, HDPE bag	97.0 (80.0)	95.3 (77.5)	*	*	*	*	*	*	*	*
	T_4, Vacuum packed bag	97.0 (80.0)	97.0 (80.0)	96.5 (79.2)	96.3 (78.9)	96.0 (78.5)	95.3 (77.5)	95.0 (77.1)	94 (75.8)	93.3 (75.0)	92.0 (73.6)
Cold storage	T_5, Cloth bag	97.0 (80.0)	96.3 (78.9)	94.3 (76.2)	92.3 (73.9)	87.7 (69.5)	85.8 (67.9)	81.0 (64.2)	78.2 (62.2)	74.2 (59.5)	71.0 (57.4)
	T_6, Gunny bag	97.0 (80.0)	95.8 (78.2)	93.5 (75.2)	92.5 (74.1)	88.5 (70.2)	85.5 (67.6)	82.5 (65.3)	77.7 (61.8)	74.7 (59.8)	71.7 (57.9)
	T_7, HDPE bag	97.0 (80.0)	95.5 (77.8)	94.0 (75.8)	91.8 (73.4)	88.0 (69.7)	85.3 (67.5)	81.7 (64.7)	78.7 (62.5)	73.2 (58.8)	71.2 (57.5)
	T_8, Vacuum packed bag	97.0 (80.0)	97.0 (80.0)	96.8 (79.7)	96.8 (79.7)	96.2 (78.8)	95.3 (77.5)	95.2 (77.3)	94.7 (76.7)	94.0 (75.8)	93.2 (74.9)
	SEM±	---	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.6
	CD (p=0.01)	---	1.8	1.8	2.3	2.0	2.3	2.1	2.4	2.2	2.6

Figures in parenthesis are Arcsine values. *Observations in cloth, gunny and HDPE bag treatments have been stopped due to bruchids infestation after four-months of storage period. As per central Seed Certification Board, Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, the minimum seed germination for green gram is 75%.

packaging materials. In cold conditions, vacuum packed seeds outperformed those in ambient conditions due to the temperature difference, a key factor determining the rate of deterioration. Similar reports on maintaining seed viability for extended periods through vacuum packaging were made by Meena *et al.* (2017) and Wang *et al.* (2018).

Besides temperature, the primary contributors to seed deterioration are oxygen and moisture content. Ensuring the control of these factors, particularly through vacuum packaging, significantly influence seed longevity. The positive impact of vacuum storage on prolonging seed viability has been documented in sweet corn seeds (Chiu *et al.* 2003). Consistent findings on preserving seed viability for an extended duration through vacuum packaging have also been reported by Meena *et al.* (2017) and Wang *et al.* (2018).

Moisture content: In the present investigation, notable fluctuations in seed moisture content (Table 3) were observed in cloth, gunny and HDPE bags under ambient conditions, in contrast to the more stable conditions in cold storage. Green gram seeds exhibited moisture absorption during periods of high relative humidity, followed by moisture loss during low humidity periods (Fig. 1). The varying moisture content was attributed to surrounding environmental conditions and the hygroscopic nature of the seeds. Similar findings were reported by Shankar *et al.* (2018).

Similarly, when seeds were stored in permeable packaging materials (cloth, gunny and HDPE bags) in cold conditions, initial moisture absorption occurred but thereafter, no significant change in moisture content was noted. This stability resulted from the consistent storage conditions prevailing throughout the storage period. Comparable results of initial moisture increase when stored in permeable packaging materials and kept under humidity conditions similar to cold storage were reported by Ali *et al.* (2014) and Bakhtavar *et al.* (2019).

Seeds exhibited hygroscopic properties, absorbing and releasing moisture depending on environmental conditions. However, this hygroscopic behaviour is noticeable primarily when seeds were stored in permeable packaging materials such as cloth, gunny and HDPE bags. In contrast, impermeable packaging materials like vacuum packed bags, characterised by a very low water vapour transmission rate (0.95 $g/m^2/24$ h at 30ºC and 90.0% RH), oxygen transmission rate [0.91 cc/ ($m^2 \times day \times atm$)] and higher thickness (149.40 microns), resulting in minimal fluctuations in seed moisture content throughout the storage period, irrespective of cold or ambient conditions. Studies by Deepa *et al.* (2013) and Meena *et al.* (2017) consistently reported minimal variations in seed moisture content when vacuum packed.

Above all these, an attempt was made to check the survivability and reproducibility of bruchids with healthy seeds. To investigate this, 1 kg of non-infested healthy seeds of green gram were vacuum packed along with 50 live adults with their eggs (Fig. 3). After one week, when they were opened, none of the eggs were hatched and not a single bruchid was alive as seeds were compactly packed in a reduced oxygen level (hypoxia). It has been well explained

Table 3 Influence of packaging and storage conditions on moisture content (%) at different time intervals of storage in green gram seeds

Treatments		Before storage	Storage period (months)								
			2	4	6	8	10	12	14	16	18
Ambient storage	T_1, Cloth bag	8.40	9.85	*	*	*	*	*	*	*	*
	T_2, Gunny bag	8.40	9.83	*	*	*	*	*	*	*	*
	T_3, HDPE bag	8.40	9.90	*	*	*	*	*	*	*	*
	T_4, Vacuum packed bag	8.40	8.45	8.48	8.42	8.55	8.40	8.38	8.53	8.48	8.48
Cold storage	T_5, Cloth bag	8.40	9.20	9.23	9.27	9.20	9.25	9.23	9.20	9.30	9.20
	T_6, Gunny bag	8.40	9.20	9.28	9.25	9.30	9.25	9.25	9.23	9.28	9.35
	T_7, HDPE bag	8.40	9.18	9.33	9.37	9.28	9.20	9.28	9.33	9.35	9.38
	T_8, Vacuum packed bag	8.40	8.40	8.45	8.45	8.49	8.52	8.45	8.43	8.45	8.48
	SEM±	---	0.04	0.06	0.06	0.06	0.07	0.04	0.06	0.05	0.06
	CD (p=0.05)	---	0.14	0.25	0.26	0.28	0.30	0.20	0.26	0.22	0.26

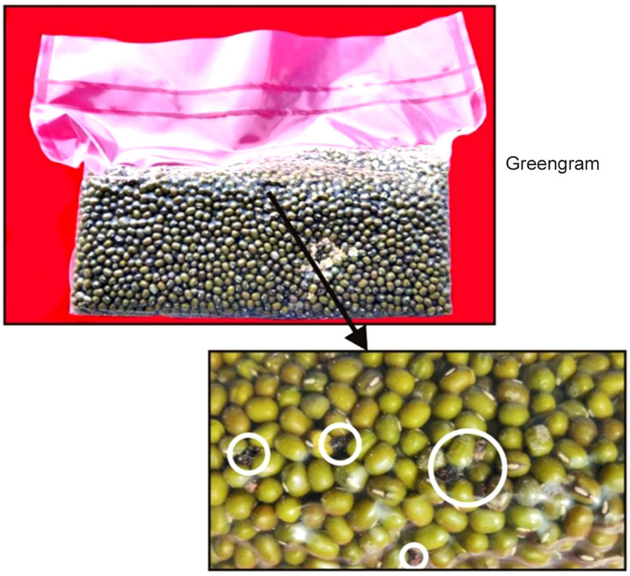

Fig. 3 Vacuum packaging of green gram seeds along with eggs and living adult of bruchids.

by Murdock *et al.* (2012), that blocking the supply of oxygen will prevent the main supply of water for *Callosobruchus maculatus*. This leads to inactivity, cessation of population growth, desiccation and eventual death of *C. maculatus*. In vacuum packed conditions, prime reason for the cessation of the bruchid population is hypoxia and bruchids cannot move within packaging material due to its compactness.

SUMMARY

Storage investigations were carried out for 18 months from 15 November 2019, to 15 May 2021 at the University of Agricultural Sciences, Dharwad, Karnataka to assess the impact of cloth, gunny, high-density polythene (HDPE) and vacuum-packed bags under ambient and cold conditions on the seed health of green gram. The rate of seed deterioration (<5%) was lower in vacuum packed bags due to the specific characteristics of the packaging materials, including higher thickness and lower oxygen and water vapour transmission rates, in both conditions. In contrast, cloth, gunny and HDPE bags exhibited a higher rate of seed deterioration (>26%), even in cold storage, owing to their permeable nature. Conclusively, the present study affirms that vacuum packaging emerges as the superior and promising technology when contrasted with numerous traditional packaging methods, ensuring the secure storage of green gram seeds in a natural, chemical-free environment. Consequently, not only does it contribute to the prolonged maintenance of seed health, but it also effectively eliminates any environmental threats.

REFERENCES

Abdul-Baki A A and Anderson J D. 1973. Vigour determination in soybean by multiple criteria. *Crop Science* **13**: 630–33.

Adetumbi J A, Odiyi A C, Olakojo S A and Adebisi M A. 2009. Effect of storage environments and storage materials on drying and germination of maize seed. *Electronic Journal of Environment Agricultural Food Chemistry* **8**(11): 1140–49.

Ali M R, Rahman M M and Ahammad K U. 2014. Effect of relative humidity, initial seed moisture content and storage container on soybean seed quality. *Bangladesh Journal of Agricultural Research* **39**(3): 461–69.

ASTM F1249-20. *Standard Test Method for Water Vapour Transmission Rate through Plastic Film and Sheeting Using a Modulated Infrared Sensor.* ASTM International. https://store.astm.org/f1249-20.html

ASTM D 1434-15. *Gas Permeability of Plastic Film and Sheeting.* ASTM International.

Bakhtavar M A, Afzal I and Basra S M A. 2019. Moisture adsorption isotherms and quality of seeds stored in conventional packaging materials and hermetic super bag. *PLoS ONE* **14**(2): 1–11.

Chiu K Y, Chen C L and Sung J M. 2003. Partial vacuum storage improves the longevity of primed sh-2 sweet corn seeds. *Scientia Horticulturae* **98**: 99–111.

Deepa G T, Chetti M B, Khetagoudar M C and Adavirao G M. 2013. Influence of vacuum packaging on seed quality and mineral contents in chilli (*Capsicum annuum* L.). *Journal of Food Science and Technology* **50**: 153–58.

Demirkaya M, Dietz K J and Sivritepe H O. 2010. Changes in antioxidant enzymes during ageing of onion seeds. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* **38**(1): 49–52.

IS 2508. *Polyethylene Films and Sheets–Specification*, 3rd edn.

Bureau of Indian Standards, New Delhi. https://mkp.gem.gov.in/catalog_data/catalog_support_document/buyer_documents/996716/54/78/703/CatalogAttrs/DrawingDocument/2023/11/17/is_2508_2016_2023-11-17-10-38-37_1cb68c913615e736bc75d9c89d648292.pdf

ISTA. 2013. International rules of seed testing. *Seed Science and Technology* **27**: 25–30.

Kitinoja L, Saran S, Roy S K and Kader A A. 2011. Postharvest technology for developing countries: Challenges and opportunities in research, outreach and advocacy. *Journal of the Science of Food and Agriculture* **91**(4): 597–603.

Lal R R and Verma P. 2007. *Technical Bulletin-Post Harvest Management of Pulses*. ICAR-Indian Institute of Pulses Research, Kanpur.

Meena M K, Chetti M B and Nawalagatti C M. 2017. Seed quality behaviour of soybean as influenced by different packaging materials and storage conditions. *Legume Research* **40**(6): 1113–18.

Murdock L L, Margam V, Baoua I, Balfe S and Shade R E. 2012. Death by desiccation: Effects of hermetic storage on cowpea bruchids. *Journal of Stored Products Research* **49**: 166–70.

Panse V G and Sukhatme P V. 1967. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi,

Rozman V. 2015. Control of stored products pests by natural products. *(In) Integrated Protection of Stored Products*, *Bulletin no. 111*, pp. 295–99. International Organisation for Biological and Integrated Control, West Palaearctic Regional Section, Zurich, Switzerland.

Shankar S V, Pandiarajanb T and Ganapathy S. 2018. Biochemical changes of black gram grains during hermetic storage. *Research Journal of Chemical and Environmental Sciences* **6**(6): 15–21.

Silva A S, Schmid L P, Mielezrski F and Pavan B E. 2018. Physiological quality of rice seeds stored in different environments and packages. *Journal of Experimental Agriculture International* **23**(2): 1–9.

Srinivasan T, Durairaj C and Vinothkumar B. 2008. Damage potential of bruchids in different edible legumes and interspecific competition between two species of *Callosobruchu*s spp. (Bruchidae: Coleoptera). *Madras Agricultural Journal* **95**(7–12): 400–06.

Swamy S V S G, Wesley B J, Raja D S and Vishnuvardhan S. 2018. Feasibility of sand layer technique for small scale storage of pulses seed. *Journal of Entomology and Zoology Studies* **6**(6): 428–31.

Swella G B and Mushobozy D M K. 2007. Evaluation of the efficacy of protectants against cowpea bruchids (*Callosobruchus maculatus* (F.) on cowpea seeds. *Plant Protection Science* **43**: 68–72.

Thakur S and Dhiman K C. 2016. Effect of seed coating with synthetic polymer and additives on storability of soybean seeds under mid hill condition of Himachal Pradesh. *Himachal Journal of Agricultural Research* **42**(1): 22–28.

Wang W, He A, Peng S, Huang J, Cui K and Nie L. 2018. The Effect of storage condition and duration on the deterioration of primed rice seeds. *Frontiers in Plant Science* **19**: 1–17.

Williamson S, Ball A and Pretty J. 2008. Trends in pesticide use and drivers for safer pest management in four African countries. *Crop Protection* **27**: 1327–34.

Wright B and Cafiero C. 2011. Grain reserves and food security in the Middle East and North Africa. *Global Food Security* **3**: 61–76.