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Vacuum Packaging Technology: A Novel Approach for Extending Storability of Various Crop Seeds

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INTRODUCTION

Quality seed is the foundation of successful crop production. Maintaining seed viability, germination, vigour and physical quality from harvest until the next planting season is essential for obtaining uniform crop establishment and higher productivity. During storage, seeds gradually deteriorate due to exposure to oxygen, moisture, high temperature, insects, fungi and other environmental factors. The rate of deterioration depends on seed moisture content, storage temperature, relative humidity, storage duration, crop species and initial seed quality (Copeland and McDonald, 2001; Justice and Bass, 1978).

Vacuum packaging is an effective and promising technology for extending the storability of crop seeds. In this technology, air is removed from the package before sealing, thereby reducing the amount of oxygen surrounding the seeds. Reduced oxygen availability helps minimize oxidative deterioration and suppresses the development of several aerobic microorganisms and storage pests. When properly dried seeds are packed in suitable high-barrier packaging materials, vacuum packaging helps maintain seed viability, germination and vigour for a longer period. (Meena et al., 2020; Meena et al., 2024b). The technology has applications in cereals, millets, pulses, oilseeds, vegetable seeds, spices and other dry agricultural products. It can be adopted by farmers, seed producers, Farmer Producer Organizations (FPOs), Self-Help Groups (SHGs), traders and seed-processing enterprises.

Why Vacuum Packaging of Crop Seeds?

Farmers commonly store seeds in gunny, cloth or ordinary polythene bags, which may provide limited protection against atmospheric moisture, oxygen, insects and microorganisms. Under warm and humid storage conditions, seed quality may deteriorate rapidly.

Studies by Meena et al. (2017) on groundnut and Meena et al. (2023, 2024a) on soybean highlight the importance of packaging materials and storage conditions in maintaining seed quality. Vacuum packaging offers an effective approach to seed preservation by removing air from the package before sealing, thereby reducing oxygen exposure and limiting moisture exchange. Its potential for extending the storability and quality of crop seeds and agricultural produce has also been discussed by Meena et al. (2020).

The major benefits of vacuum packaging include reducing oxidative deterioration, moisture absorption, insect infestation and storage-pest damage; suppressing aerobic microorganisms; maintaining seed viability, germination and vigour; reducing rancidity in oil-rich seeds; extending storage life; minimizing post-harvest losses; and improving storage-space utilization. However, its effectiveness depends on the initial seed quality, moisture content, packaging material, sealing quality and storage temperature. Therefore, seeds should be properly dried to a safe moisture level appropriate for the crop and packed in suitable, high-barrier packaging materials under appropriate storage conditions.

Table 1: Vacuum Packaging of various crop seeds

Crop group	Examples	Major benefit
Cereals and millets	Rice, wheat, maize, sorghum, ragi, bajra and foxtail millet	Helps maintain viability and reduces storage deterioration
Pulses	Chickpea, lentil, soybean and red gram	Protects against storage insects and quality deterioration
Oilseeds	Groundnut, sunflower, safflower and sesame	Reduces oxidation and insect infestation and enhance seed viability
Vegetable dry seeds	Tomato, chilli, brinjal, onion	Helps maintain germination and seed vigour
Fibre crops	Cotton	Helps preserve seed quality during storage
Spices	Cumin, coriander, fenugreek,chilli and turmeric	Helps maintain quality and reduce deterioration
Dry agricultural products	Dry chilli and other dry products	Protects against pathogen, insects and contamination

Steps for Vacuum Packaging

1. Insert the packaging bag into the “bag shaper” of a suitable size and fold the flaps correctly at the bottom of the bag.



2. The “bag shaper” with bag placed inside a suitable sized container or mould in to which fill the seeds, shake it and level the seeds in container manually.



3. The “bag shaper” was then removed and the flaps on top of the bag were folded, making sure that no creases formed which might compromise correct sealing.



4. Place the container on the roller way of the machine, then adjust the height of the roller way depending on the height of the bag and the bag was then conveyed into the vacuum chamber.





5. Close the vacuum chamber following which the stages of operation were automatic and at the end of the work cycle, air will be readmitted inside the chamber and open automatically. Remove the vacuum-packed bag out of the machine.



Cereals and Milletes



Pulse Crop Seeds



Oil Crop Seeds



Spices and Dry Fruits **Spice Powders**






Value added Products





Paneer **Basan Laddu and Coconut Laddu** **Namkeen**

Vacuum packaging of various Agricultural and Horticultural crop seeds
at Vacuum Packaging Laboratory, UAS, Raichur

Advantages of vacuum packaging

1. Maintains seed viability**:** Reduced exposure to oxygen and moisture helps slow deterioration and maintain germination potential.
2. Preserves seed vigour: Properly stored seeds retain better physiological quality and produce healthier seedlings.
3. Reduces insect infestation**:** Reduced oxygen availability and sealed packaging can help suppress several storage pests.
4. Minimizes fungal and microbial growth: Properly dried seeds in sealed packages are less exposed to external contamination and aerobic microorganisms.
5. Reduces oxidation: This is particularly beneficial for oil-rich seeds such as groundnut, sunflower, safflower and sesame.
6. Extends storage life: Vacuum packaging can help maintain seed quality for longer periods when combined with suitable storage conditions.
7. Reduces post-harvest losses: Better protection during storage reduces deterioration and wastage.
8. Suitable for different users: The technology can be adopted by individual farmers, SHGs, FPOs, seed producers and commercial seed enterprises.

Key points for successful vacuum packaging

1. Use good-quality, properly dried seed.
2. Select a suitable high-barrier multilayer vacuum pouch.
3. Ensure that the pouch is free from dust and seed particles at the sealing area.
4. Maintain proper vacuum and sealing conditions.
5. Inspect the package for leakage after sealing.

6. Store the packages in a clean, dry and preferably cool location.
7. Avoid puncturing, cutting or rough handling of vacuum-packed bags.
8. For long-term storage, combine vacuum packaging with appropriate temperature and relative humidity conditions.

Commercial benefits

Vacuum packaging has considerable potential as a practical and commercially viable technology for preserving seed quality. Compared with conventional packaging, it provides better protection against oxygen, moisture, insects and external contamination. Vacuum packaging can extend the viability and quality more than 5-6 years and by this technology we can replace the cold storage gowdan for the agriculture seed supply chain.

- The technology can benefit farmers, seed producers, traders, FPOs, SHGs, seed-processing units and agricultural enterprises. Preservation of seed viability and vigour can result in better germination and crop establishment during the following season.
- For commercial seed enterprises, maintaining quality during storage can reduce storage losses and improve the marketability of seed lots. For farmers and farmer groups, vacuum packaging provides an opportunity to store quality seed safely and reduce dependence on repeated purchase of planting material.
- The technology can also support decentralized seed storage and small-scale enterprises because machines of suitable capacity can be used according to the quantity of seed being handled.

Target beneficiaries

The major beneficiaries of vacuum packaging technology are:

- Farmers – for safe storage of seed for the next crop season.
- Seed producers – for maintaining seed viability and vigour.
- Farmer Producer Organizations (FPOs) – for collective seed processing and storage.
- Self-Help Groups (SHGs) – for establishing small-scale packaging enterprises.
- Seed-processing industries – for maintaining the quality of processed seed.
- Agricultural institutions and universities – for research and long-term seed storage.
- Traders and agri-entrepreneurs – for reducing storage losses and improving product quality.

Training and demonstration programmes on acuum Packaging and Storage of Major Agricultural Crop Seeds through Vacuum Packaging Laboratory, UAS, Raichur









Limitations and precautions

Despite its advantages, vacuum packaging requires proper handling and management.

- Poor-quality packaging material may lose its vacuum during storage.
- Seeds with excessive moisture should not be vacuum packaged for long-term storage.
- Proper sealing equipment and trained operation are required.
- Punctures or cuts in the pouch can cause loss of vacuum.
- Rough transportation and handling should be avoided.
- Seeds should have good initial quality before packaging.
- Vacuum packaging should be combined with appropriate storage temperature and humidity for long-term preservation.
- Packaging material should be selected according to crop, seed quantity and storage duration.

CONCLUSION

Vacuum packaging is a simple, efficient and promising technology for extending the storability of various crop seeds. By reducing exposure to oxygen and atmospheric moisture and providing protection against insects and microorganisms, it helps slow down seed deterioration and maintain germination, viability and vigour.

The technology is particularly useful for cereals, millets, pulses, oilseeds, vegetable seeds and other dry agricultural products. Its success depends on the use of good-quality seed, appropriate moisture content, suitable high-barrier packaging material, proper vacuum sealing and suitable storage conditions.

Adoption of vacuum packaging by farmers, FPOs, SHGs, seed producers and agri-entrepreneurs can reduce post-harvest losses, improve seed storage efficiency and ensure the availability of quality seed for the next planting season. Thus, vacuum packaging represents a practical and commercially feasible approach for improving seed preservation and supporting sustainable agricultural production.

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