

Effect of packaging materials and storage conditions on seed biochemical parameters during storage in onion seed (*Allium cepa* L.)

Abstract

A lab experiment was conducted from April 2021 to September 2022 at NSP, Seed unit, UAS, Dharwad. The seed biochemical parameters, such as α -amylase activity and catalase activity, were evaluated at bimonthly intervals, and the experimental design followed was a Factorial completely randomized design (FCRD) with three replications and two factors, namely storage conditions such as ambient and cold storage and storage containers (cloth bag, high-density polythene bag (HDPE), polythene bag (700 gauge), aluminum laminated bag, vacuum packed bag), the results revealed that the treatment with vacuum packed bag stored in cold storage gave good results at the end of 18 months of storage period *i.e.*, α -amylase activity (2.00 μ .mol/min/mg) and catalase activity (1.35 mmol/min/g) respectively compared to other seeds stored in different packaging materials that are stored in ambient and cold storage conditions.

Keywords: Vacuum-packed bag, ambient storage, cold storage, α -amylase activity, catalase activity

1. Introduction

Onion (*Allium cepa* L.) is one of the most significant vegetables grown from bulbous plants and a member of the Amaryllidaceae family. It holds a significant place in the world due to its widespread cultivation and high demand for its consumption. The seed possesses the highest vigor at the time of physiological maturity and gradually decreases as the storage period increases (Goel *et al.*, 2003). Biochemical deterioration was mostly observed during seed aging, where high temperature and humidity conditions are normally affected. Many hypotheses have been proposed regarding causes of seed aging, such as lipid peroxidation mediated by free radicals, inactivation of enzymes or decrease in proteins, disintegration of cell membranes, and genetic damage (McDonald, 1999; Murthy *et al.*, 2002; Priestley, 1986; Smith and Berjak, 1995; Walters, 1998). One of the most crucial hypotheses suggested for the causes of seed aging is the degradation and inactivation of enzymes caused by alterations in their macromolecular structures. (McDonald, 2004; Bailly, 2004; Basra and Malik, 1994; Kalpana and Rao, 1993; Goel *et al.*, 2003; Lehner *et al.*, 2008;).

The initial quality of seeds, moisture level, relative humidity (RH %), and storage conditions have a considerable influence on seed storage. However, if the seeds are stored in controlled conditions, it is suitable for maintenance of the seed quality for a longer duration. Over the long storage period, especially in natural environments under tropical and subtropical areas, seed deterioration will be higher.

Seed vigor and viability may decrease because of deterioration processes, as this process is unavoidable and irreversible. It causes an increase in free radicals content and the lengthening of their chain, changes to the structure of proteins, the depletion of food reserves, an increase in fat acidity, changes in the activity of enzymes, damage to the membrane, chromosomal aberrations, and finally an increase in the rate of seed respiration. Usually, as seed moisture levels and storage space temperatures rise, the degree of degradation increases. Moist seeds and higher storage temperatures harm seeds. (Ellis *et al.*, 1981).

2. Material and methods

At the NSP, Seed unit, UAS, Dharwad, a lab experiment was conducted from April 2021 to September 2022. The seed biochemical parameters such as α -amylase activity and catalase activity were assessed, and the experiment design used was Factorial Completely Randomised Design (FCRD) with 3 replications and 2 factors, namely storage conditions such as ambient and cold storage and storage containers such as cloth bags, high-density polythene bags (HDPE), polythene bags, aluminum laminated bags and vacuum packed bags. The seeds were stored for 18 months. Arka Kalyan variety was used for the study. The seed is purchased from the University of Horticultural Sciences, Bagalkot. Every two months, readings were taken.

2.1 Estimation of α -amylase activity

Procedure:

- In each test tube, 0.25 ml of starch solution, 0.5 ml of buffer, and 0.25 ml of the enzyme were added. The same amounts of buffer, starch, and enzyme were added to all test tubes for each seed sample. To maintain a blank solution, 0.5 ml of buffer and 0.5 ml of starch were added to a separate test tube. All test tubes, including the blank, were incubated at room temperature for 15 minutes. After incubation, 0.5 ml of DNSA solution was added to each test tube, and they were placed in boiling water for 5 minutes to stop the reaction. The test tubes were then allowed to cool before the volume was made up to 10 ml with distilled

water. The concentration was determined by recording the absorbance at 560 nm, and enzyme activity was calculated using the given formula. The results were expressed in μg of maltose released per minute per 1 ml of enzyme source. (Sadasivam and Manickam, 1996).

- **α -amylase activity** =
$$\frac{\text{Maltose concentration released by enzyme source (in } \mu\text{g)}}{\text{Incubation period (15 minutes)}} \times 4$$

2.2 Catalase activity

Catalase activity was determined spectrophotometrically with the method proposed by Beers and Sizer in 1952.

Procedure

Ten onion seedlings three days old were homogenized in pestle and mortar by adding potassium phosphate buffer (100 mM, pH 7.8) amended with EDTA solution (3 mM). The homogenate was centrifuged at 12,000 rpm for 10 minutes. This was done twice. This supernatant was taken for catalase assay.

The reaction mixture in the test cuvette containing 2.98 ml of 0.051 % substrate (hydrogen peroxide) in 50 mM, pH 7.0 phosphate buffer was read against a control cuvette containing 2.98 ml H_2O_2 free phosphate buffer, 50 mM, pH 7 (substrate blank was used because the enzyme extract observed strongly at 240 nm). This procedure was standardized using pure catalase enzyme from Bovine liver (procured from Sigma Aldrich India) according to the method of Beers and Sizer (1952).

Note: The blank was prepared freshly for each assay.

The enzyme activity was calculated using the molar extinction coefficient of H_2O_2 (33.6 M/cm) and expressed as mmol/min/g.

The activity of catalase was calculated by using the following formula,

$$\text{U/ml/gFW} = \frac{\Delta A \times 1,000 \times \text{reaction volume (ml)}}{33.43 \times \text{Time (min)} \times \text{Volume of enzyme (ml)}}$$

Where,

ΔA = Change in the absorbance 240 nm in time t.

33.43 = Molar absorption or extinction coefficient of hydrogen peroxide at 240
nm

3. Results and discussion

There was a significant effect of storage containers and duration under ambient and cold temperatures on α amylase activity (μ . mol/min/mg) and catalase activity (mmol/min/g) in the enzyme activity of onion var. Arka Kalyan (Table 1 and 2).

3.1 α -amylase

The results of α - amylase as influenced by storage conditions, packaging materials, and their interactions during the storage period are given in Table 1. As the storage period progressed, the reduction in α - amylase activity increased from 2.55 in 2nd month to 1.66 μ . mol/min/mg at the end of the 18th month of the storage period was found irrespective of storage conditions and packaging materials. α -amylase activity was influenced by factors like the storage condition in which it is stored and the packaging material in which it is packed. There was a decrease in α - amylase activity from the 2nd month to the 18th month, influenced by different factors.

Storage conditions (S)

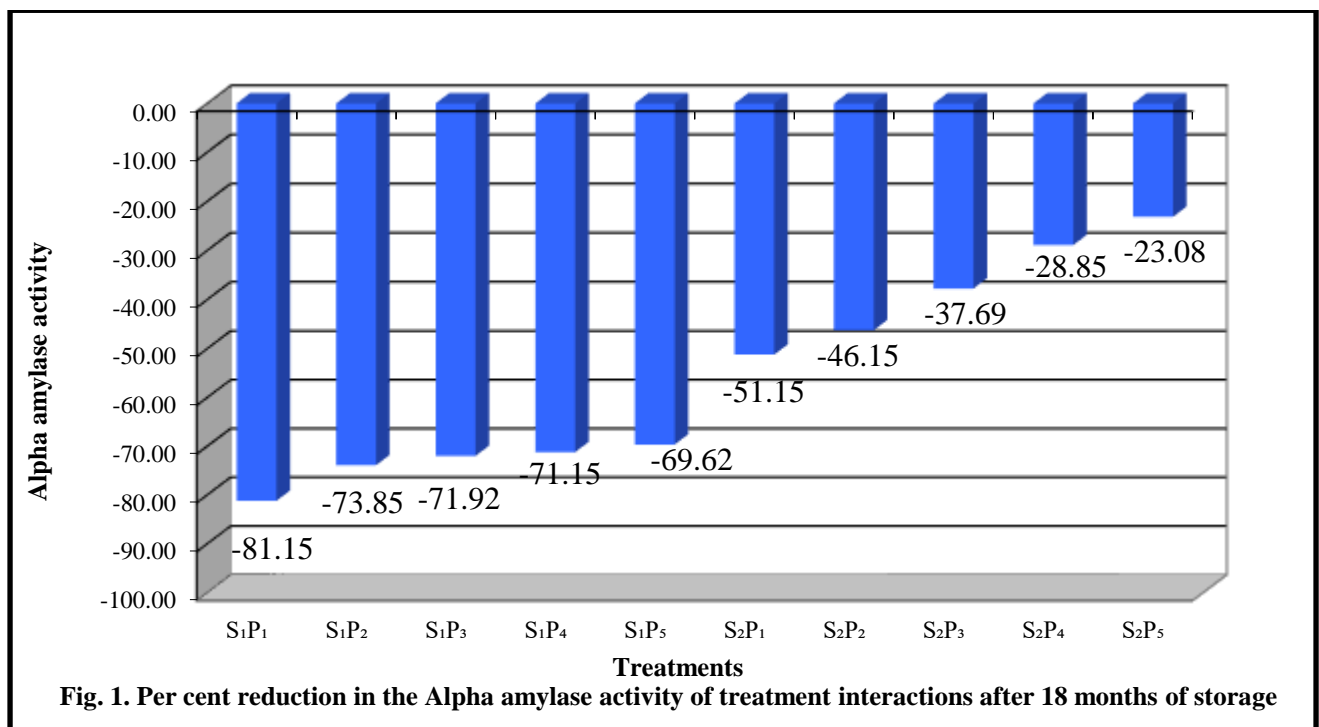
Regardless of initial storage conditions and their packaging material, higher mean α -amylase activity was noticed in cold storage compared to ambient storage throughout the storage period (18 months). The mean α -amylase activity decreased from 2.54 to 0.68 u.mol/min/mg and from 2.55 to 1.62 μ . mol/min/mg in ambient storage and cold storage, respectively.

Packaging material (P)

Among all the packaging materials, lower mean α -amylase activity was noticed in cloth bags, followed by HDPE bags, polythene bags, aluminum laminated pouches, and vacuum-packed bags. Mean α -amylase activity decreased from 2.50 to 0.88 μ . mol/min/mg in a cloth bag and from 2.59 to 1.39 μ . mol/min/mg in vacuum-packed bags through the storage period.

Interaction (S x P)

The interaction effect of storage conditions and packaging material on mean α -amylase was found to be significant throughout the storage period. Among all the treatment combinations, S₂P₅ reported significantly the highest α -amylase activity of 2.00 u.mol/min/mg at the end of the storage period. S₁P₁ recorded significantly the lowest α -amylase activity of 0.49 u.mol/min/mg at the end of the 18-month storage period. There was an 81 percent decrease in amylase activity in S₁P₁ followed by S₁P₂ (73.85%) decrease, and a 23.08 percent decrease was seen in S₂P₅. α -amylase activity content decreased as the storage progressed. The highest decrease was seen in treatment S₁P₁ (81.15 %), followed by S₁P₂ (73.85 %), and the lowest decrease was seen in S₂P₅ (23.08 %). (Fig.1 and 2).



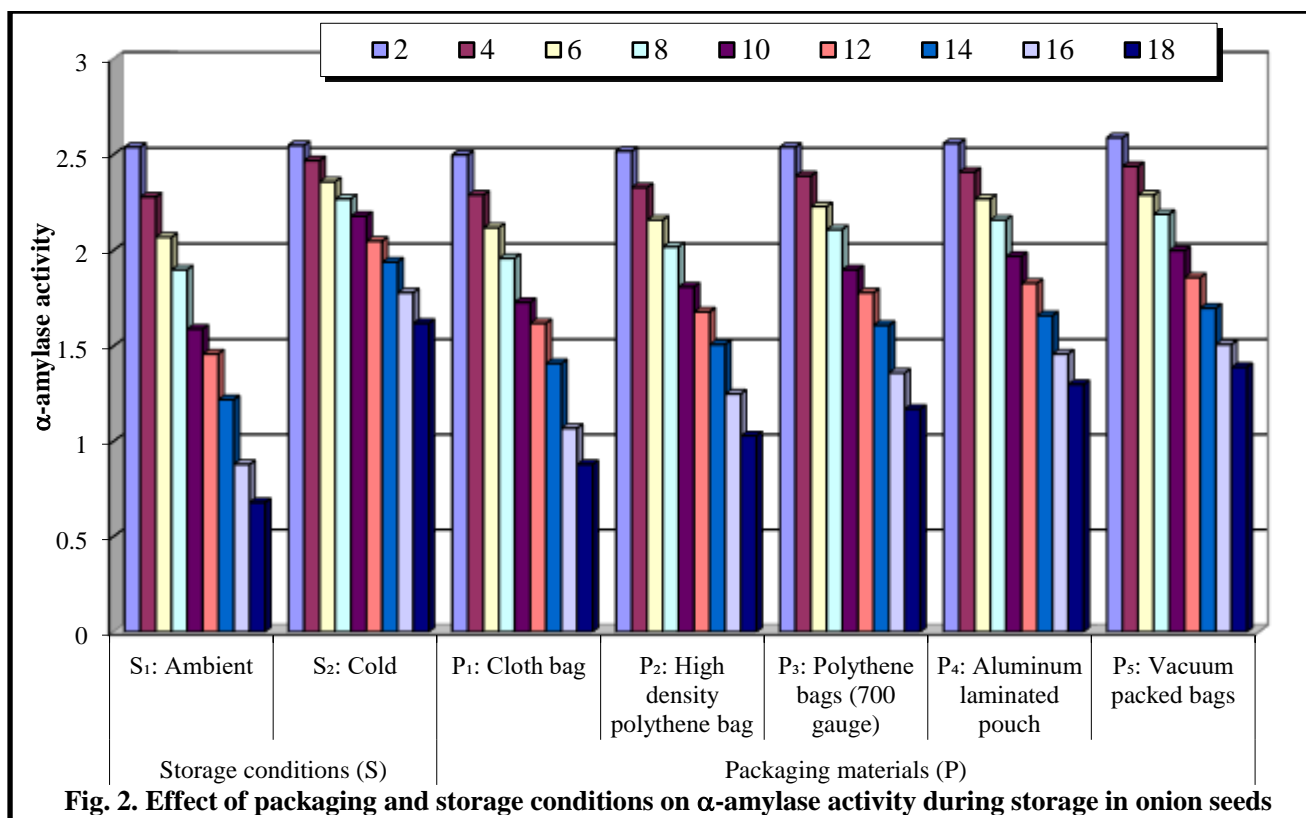


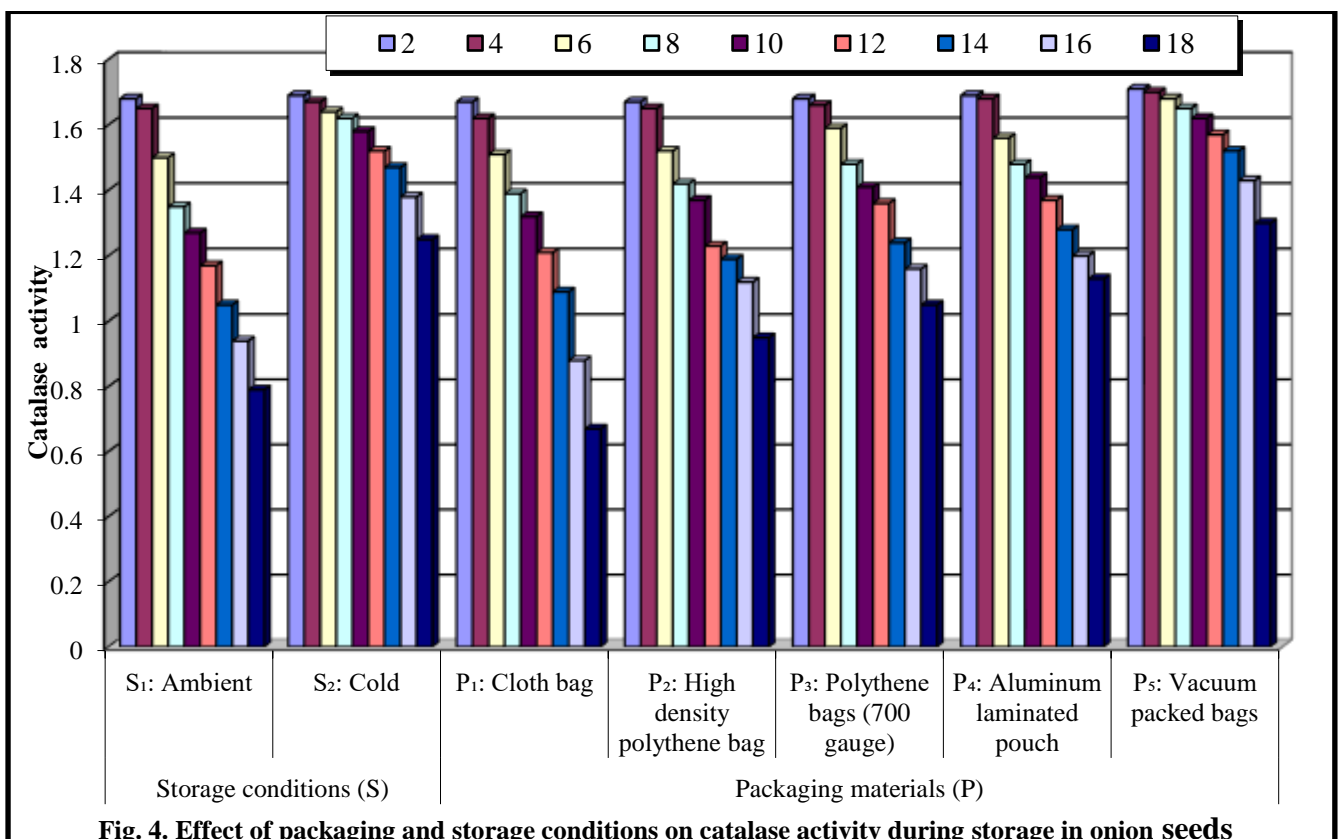
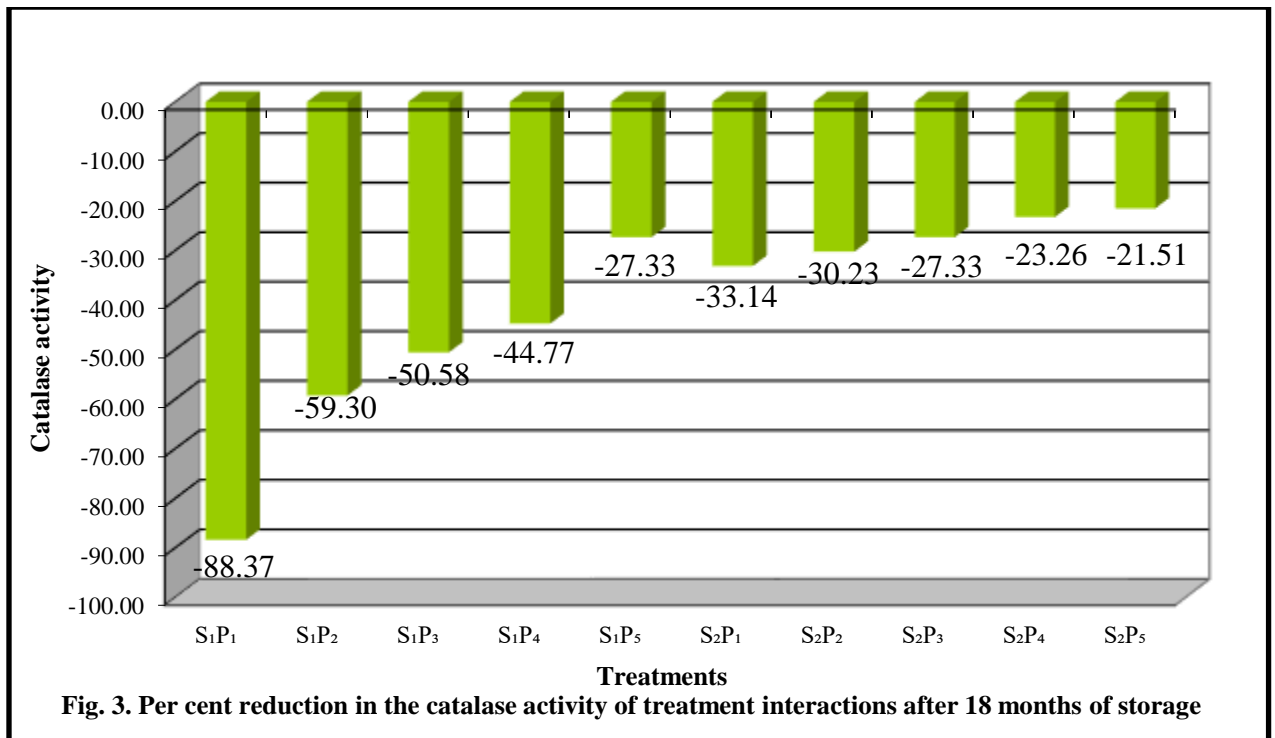
Fig. 2. Effect of packaging and storage conditions on α -amylase activity during storage in onion seeds

3.2 Catalase activity

The results of catalase activity, as influenced by storage conditions, packaging materials, and their interactions during the storage period, are given in Table 2. As the storage period progressed, there was a reduction in catalase activity from 1.69 at the 2nd to 1.02 mmol/min/g at the end of the 18th month of the storage period, irrespective of storage conditions and packaging materials. Catalase activity was influenced by factors like the storage condition in which it is stored and the packaging material in which it is packed. Different factors influenced a decrease in catalase activity from the 2nd month to the 18th month.

Storage conditions (S)

Regardless of initial storage conditions and their packaging material, higher mean catalase activity was noticed in cold storage compared to ambient storage throughout the storage period (18 months). The decrease in mean catalase activity was from 1.68 to 0.79 mmol/min/g and from 1.69 to 1.25 mmol/min/g in ambient storage and cold storage, respectively. (Fig.3 and 4).



Packaging material (P)

Among all the packaging materials, lower mean catalase activity was noticed in cloth bags, followed by HDPE bags, polythene bags, aluminum laminated pouches, and vacuum-

packed bags. Mean catalase activity decreased from 1.67 to 0.67 mmol/min/g in cloth bags and from 1.71 to 1.30 mmol/min/g in vacuum-packed bags through the storage period.

Interaction (S x P)

The interaction effect of storage conditions and packaging material on mean catalase activity was found to be significant throughout the storage period. Among all the treatment combinations, S₂P₅ reported the highest catalase activity, 1.35 mmol/min/g, at the end of the storage period. S₁P₁ recorded significantly lowest catalase activity of 0.20 mmol/min/g at the end of the 18-month storage period. There was an 88.37 percent decrease in catalase activity in S₁P₁, followed by S₁P₂ (59.30%) decrease, and a 21.51 percent decrease was seen in S₂P₅. Catalase activity content decreased as the storage progressed. The highest decrease was seen in treatment S₁P₁ (88.37 %) then, followed by S₁P₂ (59.30 %), and the lowest decrease was seen in S₂P₅ (21.51 %).

As the storage progressed, the deterioration occurred due to the high respiration rate increased due to high moisture content. As the storage period advances, the vigor of the seed declines due to the catabolic activity going on in the seed, and thus, the seed, though viable, fails to emerge. The decline in seed vigor depends on storage conditions, that is, temperature, relative humidity, and seed moisture contents. High temperature, relative humidity, and moisture in the storage environment appear to be principal factors involved in the deterioration of seed quality.

The seeds stored in the cloth bag (P₁) noticed the lowest α -amylase activity at cold and ambient temperatures, respectively. The same container recorded lower mean amylase activity and catalase activity (0.88 μ .mol/min/mg) (0.67 mmol/min/g), respectively. This result is in agreement with Mollah *et al.* (2016) and Rao *et al.* (2006) in onion seeds as well as Barua *et al.* (2009) in chilli seeds. Seeds stored in cloth bags and stored in ambient storage conditions showed less α -amylase activity and catalase activity after 18 months of storage period. Peroxidation of unsaturated fatty acids is one of the main reasons for loss of storability, which occurs due to decreased levels of antioxidants, reduced activity of free radical and peroxide scavenging enzymes, and increased lipid peroxidation. These results are in agreement with the studies of Chiu *et al.* (1995) and Hsu and Sung (1997) in watermelon and Bailly *et al.* (1996) in sunflower seeds.

Conclusion:

It was concluded that storage containers and duration were found to be compatible with packing in vapor-proof containers (plastic bag 700 gauge) and preserved in cold storage to maintain good quality parameters and the lowest enzymatic activity during storage. There was a gradual reduction in seed quality parameters during the storage in both cold and ambient storage environments. However, the reduction process was relatively slower in the cold storage environment compared to the ambient storage environment, mainly due to lower respiration rate and metabolic activity governed by lower temperature during the storage period. Significantly lower enzymatic activity was shown in seeds stored in cloth bags after the 18 months of storage duration. Enzyme activity decreased along with the increase in storage duration and decreased seed viability level. Significantly, the highest enzyme activity was observed in seeds stored in vacuum-packed bags stored in cold storage conditions till the end of the 18 months of storage period.

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Table 1 Influence of packaging material and storage conditions on α -amylase (μ . mol/min/mg) during storage in onion seeds

| Treatments | Storage (Months) | | | | | | | | |
|--|------------------|-------|-------|-------|-------|-------|-------|-------|------|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| Storage conditions (S) | | | | | | | | | |
| S₁: Ambient | 2.54 | 2.28 | 2.07 | 1.90 | 1.59 | 1.46 | 1.22 | 0.88 | 0.68 |
| S₂: Cold | 2.55 | 2.47 | 2.36 | 2.27 | 2.18 | 2.05 | 1.94 | 1.78 | 1.62 |
| S. Em (\pm) | 0.0005 | 0.007 | 0.003 | 0.004 | 0.005 | 0.004 | 0.007 | 0.008 | 0.01 |
| C. D. (1%) | 0.002 | 0.031 | 0.013 | 0.018 | 0.022 | 0.019 | 0.033 | 0.033 | 0.04 |
| Packaging materials (P) | | | | | | | | | |
| P₁: Cloth bag | 2.50 | 2.29 | 2.12 | 1.96 | 1.73 | 1.62 | 1.41 | 1.07 | 0.88 |
| P₂: High-density polythene bag | 2.52 | 2.33 | 2.16 | 2.02 | 1.81 | 1.68 | 1.51 | 1.25 | 1.03 |
| P₃: Polythene bags (700 gauge) | 2.54 | 2.39 | 2.23 | 2.11 | 1.90 | 1.78 | 1.61 | 1.36 | 1.17 |
| P₄: Aluminum laminated pouch | 2.56 | 2.41 | 2.27 | 2.16 | 1.97 | 1.83 | 1.66 | 1.46 | 1.30 |
| P₅: Vacuum packed bags | 2.59 | 2.44 | 2.29 | 2.19 | 2.00 | 1.86 | 1.70 | 1.51 | 1.39 |
| S. Em (\pm) | 0.0008 | 0.011 | 0.005 | 0.006 | 0.008 | 0.007 | 0.012 | 0.012 | 0.01 |
| C. D. (1%) | 0.003 | 0.04 | 0.021 | 0.028 | 0.034 | 0.030 | 0.052 | 0.052 | 0.06 |
| Interaction (S x P) | | | | | | | | | |
| S₁P₁ | 2.50 | 2.23 | 2.02 | 1.85 | 1.52 | 1.38 | 1.13 | 0.69 | 0.49 |
| S₁P₂ | 2.52 | 2.26 | 2.05 | 1.89 | 1.58 | 1.45 | 1.21 | 0.88 | 0.68 |
| S₁P₃ | 2.54 | 2.28 | 2.07 | 1.91 | 1.60 | 1.47 | 1.23 | 0.93 | 0.73 |
| S₁P₄ | 2.56 | 2.30 | 2.09 | 1.93 | 1.62 | 1.49 | 1.25 | 0.95 | 0.75 |
| S₁P₅ | 2.59 | 2.33 | 2.12 | 1.96 | 1.65 | 1.53 | 1.29 | 0.99 | 0.79 |
| S₂P₁ | 2.51 | 2.36 | 2.22 | 2.08 | 1.95 | 1.87 | 1.70 | 1.45 | 1.27 |
| S₂P₂ | 2.53 | 2.41 | 2.29 | 2.17 | 2.05 | 1.92 | 1.82 | 1.63 | 1.40 |
| S₂P₃ | 2.55 | 2.52 | 2.40 | 2.32 | 2.22 | 2.10 | 2.00 | 1.80 | 1.62 |
| S₂P₄ | 2.57 | 2.53 | 2.45 | 2.40 | 2.33 | 2.18 | 2.08 | 1.98 | 1.85 |
| S₂P₅ | 2.60 | 2.55 | 2.47 | 2.43 | 2.35 | 2.20 | 2.12 | 2.05 | 2.00 |
| Mean | 2.55 | 2.38 | 2.22 | 2.09 | 1.89 | 1.76 | 1.58 | 1.34 | 1.16 |
| S. Em (\pm) | 0.001 | 0.016 | 0.007 | 0.009 | 0.011 | 0.010 | 0.017 | 0.017 | 0.02 |
| C. D. (1%) | 0.004 | 0.070 | 0.029 | 0.040 | 0.049 | 0.043 | 0.074 | 0.074 | 0.09 |
| C.V (%) | 0.08 | 1.23 | 0.56 | 0.81 | 1.09 | 1.03 | 1.95 | 2.33 | 3.41 |

Storage conditions (S): S₁: Ambient storage, S₂: Cold storage, Packaging materials (P): P₁: Cloth bag, P₂: High density polythene bag, P₃: Polythene bags (700 gauge), P₄: Aluminum laminated pouch, P₅: Vacuum packed bags (Initial=2.60 μ .mol/min/mg)

Table 2. Influence of packaging material and storage conditions on catalase activity (mmol/min/g) during storage in onion seeds

| Treatments | Storage (Months) | | | | | | | | |
|--|------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| Storage conditions (S) | | | | | | | | | |
| S₁: Ambient | 1.68 | 1.65 | 1.50 | 1.35 | 1.27 | 1.17 | 1.05 | 0.94 | 0.79 |
| S₂: Cold | 1.69 | 1.67 | 1.64 | 1.62 | 1.58 | 1.52 | 1.47 | 1.38 | 1.25 |
| S. Em (±) | 0.002 | 0.001 | 0.002 | 0.001 | 0.004 | 0.001 | 0.001 | 0.001 | 0.009 |
| C. D. (1%) | 0.010 | 0.004 | 0.011 | 0.006 | 0.017 | 0.005 | 0.008 | 0.008 | 0.039 |
| Packaging materials (p) | | | | | | | | | |
| P₁: Cloth bag | 1.67 | 1.62 | 1.51 | 1.39 | 1.32 | 1.21 | 1.09 | 0.88 | 0.67 |
| P₂: High-density polythene bag | 1.67 | 1.65 | 1.52 | 1.42 | 1.37 | 1.23 | 1.19 | 1.12 | 0.95 |
| P₃: Polythene bags (700 gauge) | 1.68 | 1.66 | 1.59 | 1.48 | 1.41 | 1.36 | 1.24 | 1.16 | 1.05 |
| P₄: Aluminum laminated pouch | 1.69 | 1.68 | 1.56 | 1.48 | 1.44 | 1.37 | 1.28 | 1.20 | 1.13 |
| P₅: Vacuum packed bags | 1.71 | 1.70 | 1.68 | 1.65 | 1.62 | 1.57 | 1.52 | 1.43 | 1.30 |
| S. Em (±) | 0.004 | 0.001 | 0.004 | 0.002 | 0.006 | 0.002 | 0.003 | 0.003 | 0.01 |
| C. D. (1%) | 0.016 | 0.007 | 0.018 | 0.009 | 0.027 | 0.009 | 0.012 | 0.12 | 0.06 |
| Interaction (S x P) | | | | | | | | | |
| S₁P₁ | 1.67 | 1.60 | 1.42 | 1.22 | 1.10 | 0.95 | 0.76 | 0.45 | 0.20 |
| S₁P₂ | 1.67 | 1.65 | 1.45 | 1.25 | 1.16 | 0.98 | 0.95 | 0.91 | 0.70 |
| S₁P₃ | 1.69 | 1.66 | 1.53 | 1.35 | 1.25 | 1.20 | 1.00 | 0.95 | 0.85 |
| S₁P₄ | 1.69 | 1.68 | 1.45 | 1.33 | 1.28 | 1.20 | 1.05 | 0.98 | 0.95 |
| S₁P₅ | 1.71 | 1.70 | 1.67 | 1.65 | 1.61 | 1.56 | 1.52 | 1.42 | 1.25 |
| S₂P₁ | 1.68 | 1.65 | 1.61 | 1.58 | 1.54 | 1.48 | 1.42 | 1.32 | 1.15 |
| S₂P₂ | 1.68 | 1.66 | 1.61 | 1.60 | 1.58 | 1.49 | 1.44 | 1.34 | 1.20 |
| S₂P₃ | 1.69 | 1.67 | 1.65 | 1.63 | 1.58 | 1.53 | 1.48 | 1.38 | 1.25 |
| S₂P₄ | 1.69 | 1.68 | 1.67 | 1.64 | 1.60 | 1.55 | 1.51 | 1.43 | 1.32 |
| S₂P₅ | 1.71 | 1.70 | 1.69 | 1.66 | 1.63 | 1.48 | 1.53 | 1.32 | 1.35 |
| Mean | 1.69 | 1.66 | 1.57 | 1.49 | 1.43 | 1.35 | 1.27 | 1.16 | 1.02 |
| S. Em (±) | 0.005 | 0.002 | 0.006 | 0.003 | 0.009 | 0.003 | 0.004 | 0.004 | 0.021 |
| C. D. (1%) | 0.023 | 0.015 | 0.025 | 0.013 | 0.039 | 0.013 | 0.018 | 0.018 | 0.087 |
| C.V (%) | 0.58 | 0.26 | 0.68 | 0.38 | 1.14 | 0.40 | 0.60 | 0.65 | 3.57 |

Storage conditions (S): S₁: Ambient storage, **S₂:** Cold storage, **Packaging materials (P): P₁:** Cloth bag, **P₂:** High density polythene bag, **P₃:** Polythene bags (700 gauge), **P₄:** Aluminum laminated pouch, **P₅:** Vacuum packed bags
(Initial=1.72 mmol/min/g)