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Influence of Packaging and Storage Conditions on Enzymatic Activities in Paddy

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ABSTRACT

The study was conducted to find out the influence of packaging and storage conditions on enzymatic activities of paddy. Paddy seeds were stored in different packaging materials viz; vacuum packed bags (C_1), polythene bags (C_2), cloth bags (C_3) and gunny bags (C_4) stored at room temperature (25 ± 2º C) and cold storage (4 ± 1º C) for a period of 18 months.Treatments involved packing of seeds with different packaging materials (vacuum packed bags, gunny, polythene and cloth bags) stored under both room temperature and cold storage. All the enzymes decreased with an increased storage period. Among the containers, lower enzymatic activities were observed in vacuum packed bags compared to polythene bags. But a higher enzymatic activity was observed in gunny bags followed by cloth bags.

Key words: *Paddy, Enzymes, Anti-oxidants, Vacuum packaging, Storage*

INTRODUCTION

In cereal seeds, the development of amylase activity constitutes an important event in germination. During germination of seeds, a massive breakdown of the reserve substances begins with the help of amylolytic, proteolytic and lipolytic enzymes and the products are transported to the growing seedlings for their development. The remaining small amount of protein represents enzymes concerned in metabolic processes during seed development and germination[8].

Paddy is the most important and extensively grown food crop in the world and is the staple food of more than 60 per cent of the world population. India has the largest area under paddy in the world and ranks second in production after China. In paddy, upon storage, many enzymatic changes, oxidation and respiration occur. If the viability and vigor is not maintained properly during storage period, it will be difficult to sell it as a seed material for the next season. Post harvest storage life of paddy largely depends on the genotypes, treatment, packaging material and storage conditions. In storage, viability and vigour of the seeds is regulated by many physio-chemical factors as the seed is hygroscopic in nature, seed quality is affected by variation in moisture content, relative humidity and temperature.

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To combat these factors, it is better to store the seeds in moisture vapour proof containers like polythene bag, aluminium foil, tin or any sealed container to maintain the quality for longer period. Research concerning these aspects is very meagre. Keeping these aspects in the view and considering their importance in maintaining viability for longer period the present investigation was carried out.

MATERIALS AND METHODS

A storage experiment was carried out for a period of 18 months at Department of Crop Physiology, University of Agricultural Sciences, Dharwad. Freshly harvested paddy seeds (BPT-5204) were dried under sun and stored under different storage conditions and containers. The temperature maintained in the cold storage was around (4 °C ± 1°C) and relative humidity was 85 to 90 per cent. For ambient storage, bags were stored in the laboratory at room temperature (25 ± 2 °C). Paddy seeds were packed in 100 g vacuum packed bags (The machine used for vacuum packaging of different seeds was OLPACK 501/V manufactured by INTERPRISE–BRUSSELS S.A., BRUXTAINER DIVISION, Belgium) and polythene bags while 5 kg paddy was packed in cloth bags and gunny bags. After packaging of all the seeds in different containers, 50% bags were stored properly in the iron racks without stacking so that all the bags were uniformly exposed to the particular treatment condition; while 50% bags were stored under cold storage.The treatment consisting of different containers viz., vacuum packed bags, polythene bags, cloth bags and gunny bags were replicated thrice in both cold and ambient storage conditions in completely randomised design with factorial concept. Observations recorded on Copper, zinc, iron and manganese contents in seed samples were estimated using Atomic Absorption Spectrophotometer (AAS-4141, Electronic Corporation of India Ltd.)The αamylase activity was estimated by Bernfeld method[2]. Starch standard solution (1.0 ml) was pipetted out into a test tube to which 1.0 ml of properly diluted enzyme source was added. Then it was incubated at 27 ^{o}C for 15 min and the reaction was stopped by adding 2.0 ml of dinitrosalicyclic acid reagent. The solution was heated on a boiling water bath for 5 min and 1.0 ml potassium sodium tartarate solution was added, while the tubes were warm. Then cooled under running tap water and made up the volume to 10 ml with distilled water. The absorbances of samples were measured at 540 nm using UV visible spectrophotometer (UVS-2700 Labomed, UK). A standard graph with 0-100 µg maltose was prepared. The amylase enzyme activity in the samples was calculated using standard graph developed with maltose and expressed as mg maltose released per minute[2].Lipase activity was estimated by Jayaraman[6], 1981. Exactly 25 ml of 0.1 M phosphate buffer (pH 7.0) was taken into a conical flask, containing 5.0 ml of substrate solution, to which 2.0 ml of enzyme solution was added. The reaction mixture was incubated at 37 ºC for one hour. After exactly one hour, 5.0 ml each of ethanol and ether were added to stop the reaction. Finally, one drop of phenolphthalein indicator was added to the mixture and titrated was carried out against 0.1N NaOH till pink color was obtained. Similarly, a blank titration was done against 0.1N NaOH by adding equal volume of distilled water in place of enzyme source. The enzyme activity was calculated by the following formula and expressed as milli equivalent free fatty acid /min[6].

$$= \frac{\text{Volume of alkali consumed x Strength of alkali}}{\text{Wt. of sample in (g) x Time in min}}$$

Protease enzyme activity was determined by Poulle and Jones[10] method. One ml of haemoglobin substrate solution and 1.0 ml of enzyme extract were pipetted out into test tubes and mixed thoroughly, then incubated at 37 ^{0}C for one hour. After incubation, the

mixed solution was centrifuged at 10,000 rpm for 10 minutes at 4^0 C and the supernatant was collected and used as enzyme source. The absorbance was measured at 280 nm in a UV visible spectrophotometer (UVS-2700 Labomed, UK). The protease enzyme activity in the samples was calculated by using following formula and expressed as mg amino acid released per hour per ml of the sample[10].

$= A_{280}$ x Volume of enzyme extract (1.0 ml)

Peroxidase activity was estimated following the method of Mahadevan and Sridhar[7] with some modifications. Three ml of buffer solution, 0.05 ml guaicol solution, 0.1 ml enzyme extract and 0.03 ml hydrogen peroxide solution were pipetted out into a cuvette. The absorbance was adjusted to zero at 436 nm in a UV-Vis spectrophotometer. The change in absorbance was noted at an interval of 20 seconds after adding 0.5 ml of 2.0 per cent hydrogen peroxide. The enzyme activity was expressed as change in absorbance (ΔOD)per gram protein per minute.

RESULTS AND DISCUSSION

α-amylase activity:

Results obtained on α-amylase activity (mg maltose released/min) as influenced by different packaging and storage conditions presented in Table 1 indicated significant differences between the treatments from 8 months of storage and upto 18 months of storage. Among the storage containers, there was gradual reduction in α-amylase activity with advancement in storage period under ambient storage (S_1) and cold storage (S_2) at all the stages of storage. gunny bags (C_4) recorded significantly higher values of α-amylase activity over all other treatments, while in vacuum packaged bags (C_1) significantly higher α-amylase activity was observed compared to all other treatments at all the stages of storage. At 8 months of storage, higher alpha-amylase activity was observed in gunny bags stored under ambient storage (C_4S_1) (52 mg maltose released/min) followed by gunny bags stored under cold storage (C_4S_2) (51.9 mg maltose released/min) over all other treatments. Lower values of alpha-amylase activity (mg maltose released/min) were observed in vacuum packed bags stored under cold storage (C_1S_2) (51.3 mg maltose released/min) followed by vacuum packed bags stored under ambient condition (C_1S_1) (51.6 mg maltose released/min) over all other treatments. A similar trend continued at 10, 12, 14, 16 and 18 months of storage under both ambient storage (S_1) and cold storage (S_2). At the end of storage, significantly higher α-amylase activity was observed in gunny bags (C_4) (46.3 mg maltose released/min) followed by cloth bags (C_3) (46.0 mg maltose released/min) compared to polythene bags (C_2) under both ambient storage (S_1) and cold storage (S_2). It was further observed that ambient storage (S_1) recorded higher αamylase activity compared to cold storage (S_2); while lower values were observed in vacuum packed bags stored under cold storage (C_1S_2) followed by vacuum packed bags stored under ambient condition (C_1S_1). It is clear from results that comprehensible from results gunny bags (C_4) maintained higher α-amylase activity throughout the storage period in all the treatments. In cereal seeds, the development of amylase activity constitutes an important event in germination. During germination of seeds, a massive breakdown of the reserve substances begins with the help of amylolytic, proteolytic and lipolytic enzymes and the products are transported to the growing seedlings for their development. The remaining small amount of protein represents enzymes concerned in metabolic processes during seed development and germination[8]. In the present investigation α-amylase enzyme decreased with an increased storage period (Fig. 1). Gunny bag stored seeds recorded higher amylase activity compared to vacuum packed seeds followed by cloth bags. Decreased α-amylase activity with an increase in storage period may due to reduction of free sugars and amino acids. Similar observations were also reported in wheat seeds[4] and in naturally aged gram, chickpea and wheat seeds[1].

Lipase activity (meq.free fatty acid/min/g)

The data on lipase activityas influenced by different packaging and storage conditions showed significant differences due to storage period (Table 2). Significant differences were observed between the treatments from 6 months of storage and upto 18 months of storage, but not in storage conditions and their interaction. Significantly lower values of lipase activity were observed in vacuum packaged bags (C_1), which was significantly lower compared to all other treatments. Among the storage containers, significantly higher lipase activity was observed in gunny bags (C_4) under both ambient storage (S_1) and cold storage (S_2), which was significantly superior over all other treatments. Lipase activity decreased with an increase in storage period in all the containers and at all the stages of storage period. At 8th months of storage, lower lipase activity was observed in vacuum packed bags stored under cold storage (C_1S_2) (1.49 meq. free fatty acid/min/g) followed by vacuum packed bags stored under ambient condition (C_1S_1)(1.51 meq. free fatty acid/min/g). While higher lipase activity (meq. free fatty acid/min/g) was observed in gunny bags stored under ambient storage (C_4S_1)(1.78 meq. free fatty acid/min/g) followed by gunny bags stored under cold storage (C_4S_2) (1.77 meq. free fatty acid/min/g), which was significantly lower compared to all other treatments. Similar trend continued from 10 months of storage and up to 18 months of storage. During 18 months of storage gunny bags (C_4) recorded significantly higher lipase activity (1.95 meq. free fatty acid/min/g) under both ambient storage (S_1) and cold storage (S_2), which was significantly higher compared to all other treatments. However, the treatments cloth bags stored under ambient storage (C_3S_1), cloth bags stored under cold storage (C_3S_2) and gunny bags stored under ambient storage (C_4S_1), gunny bags stored under cold storage (C_4S_2) did not differ significantly among themselves.

Protease activity (mg amino acid released/min/ml)

The observations on protease activity presented in Table 3 revealed significant differences between treatments from 14 months to 18 months of storage. Among the storage containers, maximum protease activity was observed in gunny bags (C_4) followed by cloth bags (C_3) under both ambient storage (S_1) and cold storage (S_2), which were significantly higher compared to all other treatments; while significantly lower protease activity was found in vacuum packaged bags (C_1) followed by polythene bags (C_2) and no significant differences among themselves. No significant differences were found between storage conditions and storage containers and their interactions up to 12 months of storage. It was further observed that as the storage period progressed, protease activity decreased in all the treatments throughout the storage period. At 14months of storage, higher protease activity was observed in gunny bags stored under ambient storage (C_4S_1) (2.52 mg amino acid released/min/ml) followed by gunny bags stored under cold storage (C_4S_2) (2.55 mg amino acid released/min/ml), which was significantly higher compared to all other treatments. The lower values of protease activity (mg amino acid released /min/ml) was observed in vacuum packed bags stored under ambient condition (C_1S_1) (2.28 mg amino acid released/min/ml) followed by vacuum packed bags stored under cold storage (C_1S_2) (2.25 mg amino acid released/min/ml), which was significantly lower compared to all other treatments. A similar trend continued upto 18 months of storage. The treatments polythene bags stored under ambient storage (C_2S_1), polythene bags stored under cold storage (C_2S_2), cloth bags stored under ambient storage (C_3S_1) and cloth bags stored under cold storage (C_3S_2) were at par with each other. At 18 months of storage, higher values of protease activity (mg amino acid released /min/ml) were observed gunny bags (C_4) (2.63 mg amino acid released/min/ml), which was superior over all other treatments under ambient storage (S_1) and cold storage (S_2). While, vacuum packaged bags (C_1) recorded lower protease activity (2.30 mg amino acid released/min/ml) compared to all other treatments. It was further observed that ambient storage (S_1) recorded significantly

higher protease activity among all the treatments compared to cold storage (S_2). The treatment combinations vacuum packed bags stored under ambient condition (C_1S_1), vacuum packed bags stored under cold storage (C_1S_2) and polythene bags stored under ambient storage (C_2S_1), polythene bags stored under cold storage (C_2S_2), cloth bags stored under ambient storage (C_3S_1) and cloth bags stored under cold storage (C_3S_2) did not differ significantly among themselves. Lipase and protease activity was found to be slightly less in vacuum packed bags compared to gunny bags. There was higher lipase activity in gunny bags followed by cloth bags (Fig. 2 to 3). There was increase in the activity of these enzymes with an advancement in storage period. Our results are in agreement with results of Dhaliwal *et al*[5]., and Chaitanya *et al*[3]. Increase in protease activity during storage may be due to decline in protein content[3].

Peroxidase activity (ΔODmg protein/ min)

The results of peroxidase activity presented in Table 4 revealed significant differences between storage containers from 10 months of storage and up to 18 months of storage due to storage period. No significant differences were observed among the storage containers and storage conditions and their interaction up to 8 months of storage. Significantly higher peroxidase activity was observed in gunny bags (C_4) compared to all other treatments under both ambient storage (S_1) and cold storage (S_2), which was on par with cloth bags (C_3). Among the containers, vacuum packaged bags (C_1) recorded significantly lower values of peroxidase activity over all other treatments. However, it was on par with polythene bags (C_2). At 10^{th} months of storage, lower peroxidase activity (ΔODmg protein/ min) was found in vacuum packed bags stored under ambient condition (C_1S_1)(11.18) followed by vacuum packed bags stored under cold storage (C_1S_2) (11.22), which were significantly lower compared to all other treatments. Significantly higher peroxidase activity (ΔODmg protein/ min) was found in gunny bags stored under ambient storage (C_4S_1)(11.51) followed by gunny bags stored under cold storage (C_4S_2)(11.48). Among interactions cloth bags stored under ambient storage (C_3S_1), cloth bags stored under cold storage (C_3S_2), gunny bags stored under cold storage (C_4S_2), polythene bags stored under ambient storage (C_2S_1) and vacuum packed bags stored under ambient condition (C_1S_1) were at par with each other. A similar trend continued up to 18 months of storage. At 18 months of storage, gunny bags (C_4) recorded significantly higher peroxidase activity (11.42 ΔODmg protein/ min), followed by cloth bags (C_3) (11.38ΔODmg protein/ min).The lower peroxidase activity (ΔODmg protein/ min)was observed in vacuum packed bags stored under cold storage (C_1S_2) (10.62), which was lower over all other treatments followed by vacuum packed bags stored under ambient condition (C_1S_1). The treatments cloth bags stored under ambient storage (C_3S_1), cloth bags stored under cold storage (C_3S_2), gunny bags stored under cold storage (C_4S_2) did not differ significantly among themselves. It is clear from the results that, ambient storage (S_1) recorded higher peroxidase activity among all the treatments compared to cold storage (S_2) throughout the storage. Among the containers, gunny bags (C_4) maintained high peroxidase activity up to 18 months of storage and decreased with a progress in storage period among all the containers. The peroxidase activity was higher in gunny bags followed by cloth bags and lower in vacuum packed bags and polythene bags (Fig. 4). Peroxides activity decreases substantially with ageing, due to which seeds become more sensitive to the effects of oxygen and free radicals in membrane unsaturated fatty acids and produce lipid peroxidation products such as monaldehyde and lipid conjugants. Similar results were observed by Chauhan *et al*[4]., in wheat, Scialabba*et al*[11]., in radish, Pallavi*et al*[9]., in sunflower. Among the storage conditions, ambient storage recorded higher enzyme activities compared to cold storage. This may be due to higher temperature and higher metabolic activity under ambient storage.

Chauhan *et al*[4]., studied the level of various enzymes and found that reason might be cause of seed deterioration under natural ageing is

decrease in enzyme activity in seeds lowers its respiratory potential, which in turn lowers both the energy (ATP) and food supply to the germinating seed. Several changes in the enzyme macromolecular structure may contribute to their lower effectiveness. They may undergo compositional changes by losing or gaining certain functional groups, by oxidation of sulf-hydral groups or by conversion of amino acids within the protein structure.

Table 1: Influence of packaging and storage conditions on *α*amylase activity (mg maltose released/min) at different periods of storage in paddy

Treatments	Storage period (months)									
	0	2	4	6	8	10	12	14	16	18
Storage conditions mean (S)										
S_1	56	55.7	54.5	53.04	51.8	50.3	49.2	48.1	47.1	46.3
S_2	55.9	55.6	54.3	52.8	51.6	50.2	49	47.9	46.9	45.9
Storage containers mean (C)										
C_1	56.0	55.4	54.2	52.7	51.5	50.0	48.8	47.8	46.81	45.7
C_2	55.8	55.5	54.3	52.8	51.6	50.2	48.9	47.9	46.92	46.3
C_3	56.1	55.	54.5	53.0	51.8	50.4	49.2	48.1	47.16	46.0
C_4	55.9	55.9	54.6	53.2	51.9	50.5	49.3	48.2	47.27	46.3
Interaction mean (S x C)										
S_1 x C_1	55.8	55.5	54.3	52.8	51.6	50.1	48.9	47.9	46.9	45.7
S_1 x C_2	55.9	55.7	54.4	52.9	51.7	50.2	49.0	48.0	47.0	46.9
S_1 x C_3	56.1	55.8	54.6	53.1	51.9	50.4	49.2	48.2	47.2	46.1
S_1 x C_4	56.0	55.9	54.7	53.2	52.0	50.5	49.3	48.3	47.3	46.5
S_2 x C_1	56.0	55.3	54.0	52.6	51.3	49.9	48.7	47.6	46.6	45.6
S_2 x C_2	55.8	55.4	54.2	52.7	51.5	50.0	48.8	47.7	46.8	45.8
S_2 x C_3	56.0	55.7	54.5	53.0	51.8	50.3	49.1	48.1	47.1	46.0
S_2 x C_4	55.8	55.8	54.6	53.1	51.9	50.4	49.2	48.2	47.2	46.1
Grand Mean	55.9	55.6	55.4	52.9	51.7	50.2	49.0	48.0	47.0	46.0
S.Em±										
S	0.04	0.10	0.10	0.08	0.07	0.07	0.07	0.06	0.05	0.06
C	0.07	0.15	0.14	0.12	0.10	0.10	0.09	0.08	0.08	0.09
S×C	0.09	0.20	0.19	0.17	0.14	0.13	0.13	0.11	0.11	0.12
C.D. (1%)										
S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C	NS	NS	NS	NS	0.30	0.29	0.27	0.24	0.23	0.26
S×C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Influence of packaging and storage conditions on lipase activity (m.eq. free fatty acid /min/g) at different periods of storage in paddy

Treatments	Storage period (months)									
	0	2	4	6	8	10	12	14	16	18
Storage conditions mean (S)										
S_1	1.44	1.49	1.55	1.61	1.66	1.71	1.73	1.71	1.79	1.80
S_2	1.46	1.48	1.52	1.57	1.62	1.66	1.70	1.73	1.77	1.79
Storage containers mean (C)										
C_1	1.43	1.44	1.44	1.47	1.50	1.53	1.54	1.57	1.60	1.62
C_2	1.45	1.46	1.46	1.53	1.61	1.64	1.67	1.70	1.72	1.73
C_3	1.47	1.51	1.51	1.64	1.69	1.75	1.79	1.84	1.87	1.89
C_4	1.44	1.53	1.53	1.73	1.77	1.83	1.86	1.88	1.92	1.95
Interaction mean (S x C)										
S_1 x C_1	1.42	1.44	1.45	1.48	1.51	1.54	1.56	1.59	1.61	1.62
S_1 x C_2	1.47	1.47	1.52	1.53	1.62	1.65	1.68	1.71	1.73	1.74
S_1 x C_3	1.44	1.51	1.57	1.71	1.75	1.80	1.83	1.87	1.89	1.91
S_1 x C_4	1.41	1.54	1.65	1.74	1.78	1.85	1.87	1.90	1.93	1.95
S_2 x C_1	1.45	1.43	1.44	1.46	1.49	1.51	1.52	1.55	1.59	1.61
S_2 x C_2	1.43	1.45	1.48	1.52	1.60	1.63	1.67	1.69	1.72	1.72
S_2 x C_3	1.49	1.50	1.53	1.57	1.64	1.71	1.75	1.82	1.86	1.88
S_2 x C_4	1.47	1.52	1.63	1.73	1.77	1.81	1.86	1.87	1.92	1.94
Grand Mean	1.45	1.48	1.53	1.59	1.65	1.69	1.72	1.75	1.78	1.80
S.Em±										
S	0.01	0.03	0.03	0.04	0.03	0.03	0.02	0.02	0.02	0.02
C	0.02	0.04	0.05	0.05	0.05	0.04	0.03	0.03	0.02	0.03
S×C	0.03	0.06	0.06	0.07	0.06	0.05	0.04	0.04	0.03	0.04
C.D. (1%)										
S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C	NS	NS	NS	0.15	0.14	0.12	0.08	0.09	0.07	0.09
S×C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Influence of packaging and storage conditions on protease activity (mg amino acid released/min/ml) at different periods of storage in paddy

Treatments	Storage period (months)									
	0	2	4	6	8	10	12	14	16	18
Storage conditions mean (S)										
S_1	2.13	2.17	2.24	2.30	2.35	2.40	2.42	2.43	2.47	2.49
S_2	2.14	2.16	2.21	2.26	2.31	2.35	2.39	2.41	2.45	2.47
Storage containers mean (C)										
C_1	2.12	2.12	2.15	2.16	2.20	2.23	2.25	2.27	2.28	2.31
C_2	2.16	2.14	2.19	2.23	2.29	2.33	2.35	2.38	2.40	2.41
C_3	2.14	2.19	2.23	2.32	2.37	2.43	2.47	2.51	2.56	2.58
C_4	2.13	2.21	2.32	2.41	2.45	2.51	2.55	2.54	2.61	2.63
Interaction mean (S x C)										
$S_1 \times C_1$	2.14	2.12	2.16	2.17	2.21	2.24	2.26	2.28	2.29	2.31
$S_1 \times C_2$	2.16	2.15	2.20	2.23	2.30	2.35	2.36	2.39	2.41	2.42
$S_1 \times C_3$	2.11	2.19	2.25	2.39	2.43	2.48	2.51	2.54	2.57	2.59
$S_1 \times C_4$	2.12	2.22	2.33	2.42	2.46	2.53	2.55	2.52	2.61	2.63
$S_2 \times C_1$	2.10	2.11	2.13	2.15	2.18	2.21	2.23	2.25	2.27	2.30
$S_2 \times C_2$	2.15	2.13	2.18	2.22	2.28	2.32	2.35	2.37	2.39	2.40
$S_2 \times C_3$	2.17	2.18	2.21	2.25	2.32	2.39	2.43	2.48	2.54	2.56
$S_2 \times C_4$	2.15	2.20	2.31	2.41	2.45	2.49	2.54	2.55	2.60	2.62
Grand Mean	2.14	2.16	2.22	2.28	2.33	2.38	2.40	2.42	2.46	2.48
S.Em±										
S	0.02	0.03	0.03	0.05	0.05	0.05	0.05	0.05	0.05	0.05
C	0.02	0.04	0.04	0.06	0.07	0.07	0.07	0.07	0.07	0.08
S×C	0.04	0.06	0.06	0.09	0.09	0.10	0.11	0.09	0.10	0.11
C.D. (1%)										
S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C	NS	NS	NS	NS	NS	NS	NS	0.20	0.22	0.23
S×C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Influence of packaging and storage conditions on peroxidase activity (ΔOD mg protein/min) at different periods of storage in paddy

Treatments	Storage period (months)									
	0	2	4	6	8	10	12	14	16	18
Storage conditions mean (S)										
S_1	11.45	11.48	11.48	11.45	11.41	11.35	11.30	11.26	11.22	11.10
S_2	11.51	11.44	11.45	11.42	11.38	11.32	11.22	11.16	11.10	11.03
Storage containers mean (C)										
C_1	**11.47**	**11.35**	**11.33**	**11.31**	**11.28**	**11.20**	**11.02**	**10.91**	**10.85**	**10.69**
C_2	**11.41**	**11.35**	**11.34**	**11.30**	**11.27**	**11.18**	**11.11**	**11.06**	**10.97**	**10.80**
C_3	**11.54**	**11.55**	**11.56**	**11.54**	**11.50**	**11.48**	**11.44**	**11.41**	**11.40**	**11.37**
C_4	**11.49**	**11.60**	**11.63**	**11.57**	**11.53**	**11.50**	**11.48**	**11.46**	**11.43**	**11.41**
Interaction mean (S x C)										
$S_1 \times C_1$	11.44	11.38	11.36	11.34	11.31	11.18	11.08	11.02	10.93	10.76
$S_1 \times C_2$	11.41	11.36	11.35	11.31	11.28	11.23	11.18	11.14	11.09	10.84
$S_1 \times C_3$	11.53	11.56	11.58	11.55	11.51	11.49	11.45	11.42	11.41	11.38
$S_1 \times C_4$	11.43	11.61	11.64	11.58	11.53	11.51	11.50	11.48	11.45	11.42
$S_2 \times C_1$	11.52	11.31	11.30	11.28	11.25	11.22	10.96	10.81	10.76	10.62
$S_2 \times C_2$	11.42	11.33	11.32	11.29	11.25	11.14	11.05	10.98	10.86	10.75
$S_2 \times C_3$	11.56	11.54	11.54	11.53	11.48	11.46	11.43	11.40	11.38	11.35
$S_2 \times C_4$	11.54	11.58	11.62	11.56	11.52	11.48	11.46	11.43	11.41	11.40
Grand Mean	11.48	11.46	11.46	11.43	11.39	11.34	11.26	11.2	11.16	11.07
S.Em±										
S	0.02	0.05	0.07	0.06	0.06	0.06	0.06	0.04	0.04	0.03
C	0.03	0.08	0.09	0.09	0.09	0.09	0.08	0.05	0.05	0.05
S×C	0.05	0.11	0.13	0.13	0.13	0.12	0.11	0.07	0.07	0.07
C.D. (1%)										
S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C	NS	NS	NS	NS	NS	0.27	0.24	0.15	0.15	0.14
S×C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

CONCLUSION

The activities of enzymes *viz;* amylase, lipase, protease and peroxidase activity slightly less in vacuum packed bags compared to gunny bags and cloth bags, irrespective of paddy and rice grains. All the enzymes decreased with an increased storage period. Among the storage conditions, cold storage recorded better seed quality, physiological and biochemical parameters over room temperature, irrespective the storage containers throughout the storage period of 18 months.

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