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Seed Physiological and Biochemical Parameters of Groundnut (*Arachis hypogaea* L.) As Influenced by Different Packaging Materials and Storage Conditions

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ABSTRACT

A lab experiment was carried out to study that seed physiological and biochemical parameters of groundnut as influence by different packaging materials and storage conditions. Groundnut seeds were stored in different packaging materials viz., gunny bags and high density polythene bags and vacuum packed bags stored at room temperature (25 ± 2º C) and cold storage (4 ± 1º C) for a period of 18 months. The treatments having six combinations and consisting of different containers viz., gunny bags, high density polythene bags and vacuum packed bags were replicated four times in both cold and ambient storage conditions in completely randomized design. The results of the study revealed that the seed biochemical parameters viz., oil content and enzyme activity such as α-amylase, lipase and protease and seed physiological parameters such as mineral content (Cu, Mn, Zn and Mn), moisture content and electrical conductivity values were higher in vacuum packed seeds than gunny, HDPE bags for soybean seeds stored under cold storage compared to room temperature throughout the storage period. Among the containers, the seeds stored in vacuum packed bags maintained the seed biochemical and seed physiological parameters with least deterioration compared to seeds stored in gunny bags and high density polythene bags.

Keywords: *Moisture content, electrical conductivity, mineral content, biochemical parameters, oil content, vacuum packaging and cold storage.*

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is another important oilseed crop of tropical and subtropical regions of the world. It is a primary source of edible oil and has a high oil content (44-50 %) and protein content (25 %) and is also a valuable source of vitamins E, K and B. It is the richest plant source of thiamine and is also rich in niacin, which is low in cereals.

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It occupies an area of 25.20 m ha with a production of 35.90 m tons and a productivity of 1420 kg per ha in the world. India is the largest groundnut growing country accounting 31.70 per cent of world area (8.00 m ha) and 37.50 per cent of production (7.30 m tons) with a productivity of 1298 kg per ha. In Karnataka, it is being cultivated over an area of 0.82 m ha with a production of 4.0 lakh tons and a productivity of 791 kg per ha[5].

Groundnut seed is a poor storer. Storing seeds after harvest till the next cropping season without impairing the quality is of prime importance for successful seed production. The problem of loss of seed viability is more severe in groundnut harvested in the summer season and about 50 per cent viability could be lost within 4-5 months of storage. Seed storage in groundnut is an imperative and inescapable for sensitivity of seed to environment, seasonal demand, dormancy, specificity of planting time, necessity of carry over and need of buffer seed stock. Research on storability of seeds in India is of recent origin with the development of organized seed production and marketing. It is stipulated that 80 per cent of certified seeds produced in India require storage for one planting season and 20 per cent of seeds is carried over for subsequent sowing[7]. However, when the awareness and infrastructure is developed, substantial quantity of seeds can be stored for few planting seasons as a safeguard against monsoon failure and as a precaution against production of poor quality seeds. Seed deterioration has been ascribed to physical, physiological, bio-chemical and pathological detrimental changes occurring in seeds leading to death and has been characterized as inexorable, irreversible, inevitable, and minimal at the time of physiological maturity and variable among kinds of seeds, varieties and seed lots[15]. The farmer's practice of storing crop seeds in gunny bags as well as in cloth bags hastens up the seed quality deterioration process, thus resulting in poor seed quality. The use of high density polyethylene (HDPE) and metallised polyester polyethylene (MPP) packaging materials in seed storage were found to retain the quality, but for a limited period. Oxidation of seed food reserves ingredients such as carbohydrates, protein, lipids, vitamins, pigments and aroma compounds is one of the most important causes of quality loss during processing and storage. A better solution therefore could be the use of low oxygen atmosphere packing system. Vacuum packaging is a technology that is being widely used in the meat industry, wherein the product is placed in a pack of low oxygen permeability, air is evacuated and the package sealed. The relative high cost of crop seeds and the overwhelming importance of retaining their seed quality for next season justify the selection of proper packaging strategy

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 soybean seeds (JS-335) 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 throughout the storage period while, for ambient storage, bags were stored in the laboratory at room temperature (25 ± 2 °C). Soybean seeds were packed in 500 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 15 kg to gunny and high density polythene 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 treatments having six combinations and consisting of different containers viz., gunny bags, high density polythene bags and vacuum packed bags were replicated four times in both cold and ambient storage conditions in completely randomized design. The observations on various seed physiological parameters viz., electrical conductivity[45] (Presley,1958) , and the per cent moisture were obtained by using MB 45 Halogen Moisture Analyzer from Ohaus, USA, while estimation of mineral content i.e. Copper (Cu), Zinc (Zn), Iron (Fe) and Manganese (Mn) contents in seed were estimated using Atomic Absorption Spectrophotometer (AAS-4141, Electronic Corporation of India Ltd.) , oil content in seeds was estimated by the Soxhlet apparatus which was later on modified by Randall[50] and determination of all the biochemical parameters i.e. α-amylase activity, lipase enzyme activity and protease enzyme activity was estimated by methods devised by Jayaraman[26] and Poulle and Jones[44], respectively at bimonthly interval upto18 months. The analysis and interpretation of the experimental data was done as suggested by Panse and Sukhatme[42] with level of significance used as P = 0.01

RESULTS AND DISCUSSION

Influence on seed physiological parameters

Moisture content (%)

The moisture content of groundnut seeds (Table 1) differed significantly between the treatment upto 18 months of storage except at initial stage. In general, no fluctuation in observed in the moisture content was observed in vacuum packed seeds during storage for 18 months and there after a slight decline in the moisture content with an advancement in the storage period. Fluctuations in the moisture content of groundnut seeds were observed in gunny bags as well as high density polythene bags, irrespective of storage at room temperature or cold storage throughout the storage period. At 18 months of storage, the minimum moisture content (8.41 and 8.39 %) was observed in vacuum packed seeds stored at cold storage and room temperature while the maximum values of moisture content (13.94 and 11.33 %) were recorded in gunny bags and high density polythene bags at cold storage followed by room temperature (10.53 and 9.70 %), respectively. It is clear from the results that significantly higher moisture content was observed in gunny bags and high density polythene bags stored under in cold storage at all the stages of storage upto 18 months and less fluctuation in moisture content was observed in cold storage. These results are in agreement with the findings of Malekar *et al*[29]., in wheat, Rajendra prasad *et al*[48]., in groundnut kernels, Gurmitsingh and Hari Singh[24], Remya[53] in chilli powder, Roshany[54] in whole chilli and Monira *et al*[34]., in soybean storability for longer period.

Electrical conductivity (dSm^{-1})

The electrical conductivity (dSm^{-1}) of groundnut seeds differed significantly between the treatments during storage period (Table 2). The electrical conductivity of vacuum packed seeds was lower and a slow increase with an advancement in storage period, as compared to gunny bags as well as high density polythene packed seeds at room temperature. At 18 months of storage, the vacuum packed seeds recorded significantly lower values of electrical conductivity (0.429 and 0.435 dSm^{-1}) at cold storage and room temperature, as compared to all other treatments significantly higher values of electrical conductivity (0.604 dSm^{-1}) were recorded in gunny bags at room temperature, and it was on par with high density polythene bags (0.580 dSm^{-1}). It is clear that the vacuum packed seeds could maintain significantly lower values of electrical conductivity while, the higher values of electrical conductivity were recorded in cloth bags followed by high density polythene bags at all the stages of storage. The values of electrical conductivity were varied significantly in gunny bags as well as in high density polythene bags upto 18 months of storage. Similar results were obtained by Biradar Patil *et al*[8]., and Raiker *et al*[47]., in rice, Padma and Reddy[40] in brinjal seeds, Narayanaswamy *et al*[36]., in groundnut, Shanmugavel *et al*[57]., in soybean, Nataraj *et al*[37]., in sunflower, Ravi Hunje *et al*[51]., in chilli and Asha[6] in maize seeds.

Mineral's content

Copper content (Cu, ppm)

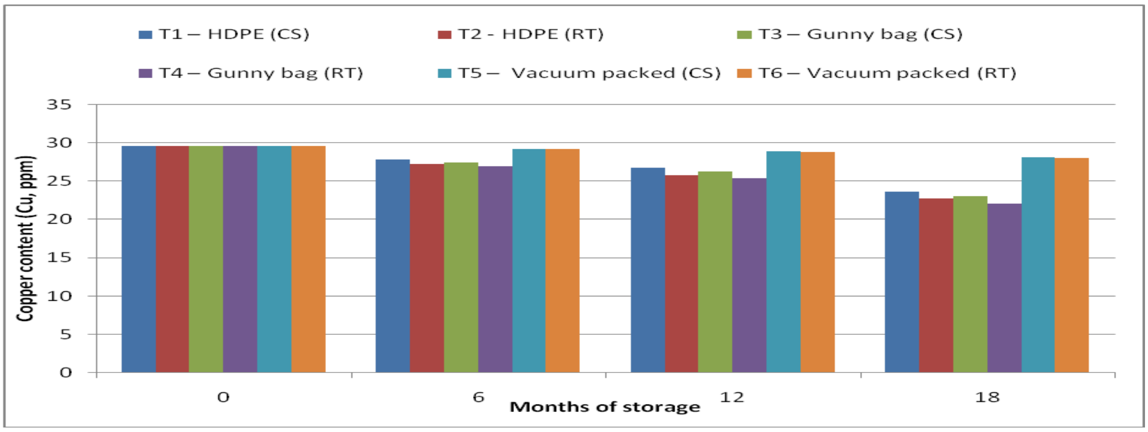

Fig. 1: Influence of packaging and storage conditions on copper content (Cu, ppm) at different time intervals of storage in groundnut seeds

Copper content (ppm) of groundnut seeds differed significantly between treatments and there was a gradual decline with progress in storage period (Fig.,1). The reduction was greater in gunny bags as well as high density polythene packed seeds from the initial stage i.e., 8 months to 18 months of storage, stored under room temperature.At 10 months of storage, higher copper content (22.23 and 22.20 ppm) was recorded in vacuum packed seeds stored under cold storage or room temperature compared to high density polythene bag seeds (19.83 and 18.90 ppm) followed by gunny bag seeds (19.50 and 18.57 ppm), respectively. The values of copper content in gunny bag seeds as well as high density polythene bag seeds were on par with each other, under both cold storage and at room temperature. A similar trend continued at all the stages of storage even upto 18 months. The vacuum packed seeds recorded significantly higher copper content (21.83 ppm) under cold storage, over all other treatments at 18 months' storage. Lower copper content (15.20 ppm) was recorded in gunny bag seeds kept under room temperature, which was also onpar with high density polythene bags at room temperature (15.32 ppm).

Iron content (Fe, ppm)

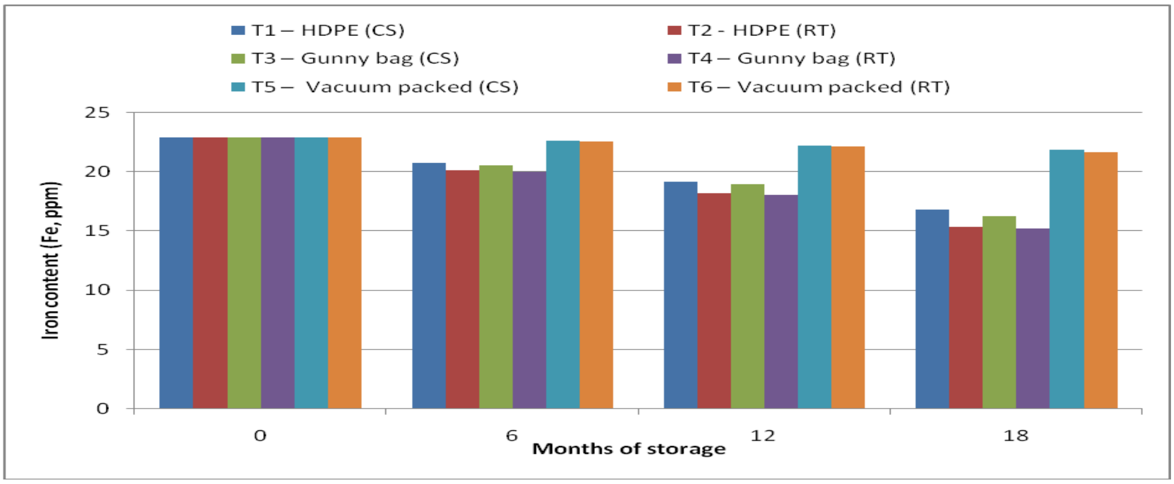

Fig. 2: Influence of packaging and storage conditions on iron content (Fe, ppm) at different time intervals of storage in groundnut seeds

The data related to the iron content (ppm) of groundnut seeds differed significantly between treatments recorded with progress in storage period (Fig.,2). The iron content in gunny bags as well as high density polythene packed seeds was when reduced to great extent from the initial stage to upto 18 months of storage when stored under room temperature. At 10 months of storage, significantly higher iron content (56.33 and 56.28 ppm) was recorded in vacuum packed seeds stored under cold storage and room temperature compared to high density polythene bags (53.23 and 52.07 ppm) followed by gunny bags (52.90 and 51.93 ppm), respectively. The values iron content in of gunny bag seeds kept at cold storage was on par with high density polythene bags stored at room temperature. A similar trend was continued at all the stages of storage period. At the end of storage i.e., 18 months the vacuum packed seeds recorded significantly higher values of iron content (55.68 and 55.53 ppm) stored under cold storage and room temperature, over all other treatments and lower value of iron content (48.37 ppm) was recorded in seeds stored in gunny bags and kept under room temperature, which was on par with high density polythene bags (48.40 ppm).

Zinc content (Zn, ppm)

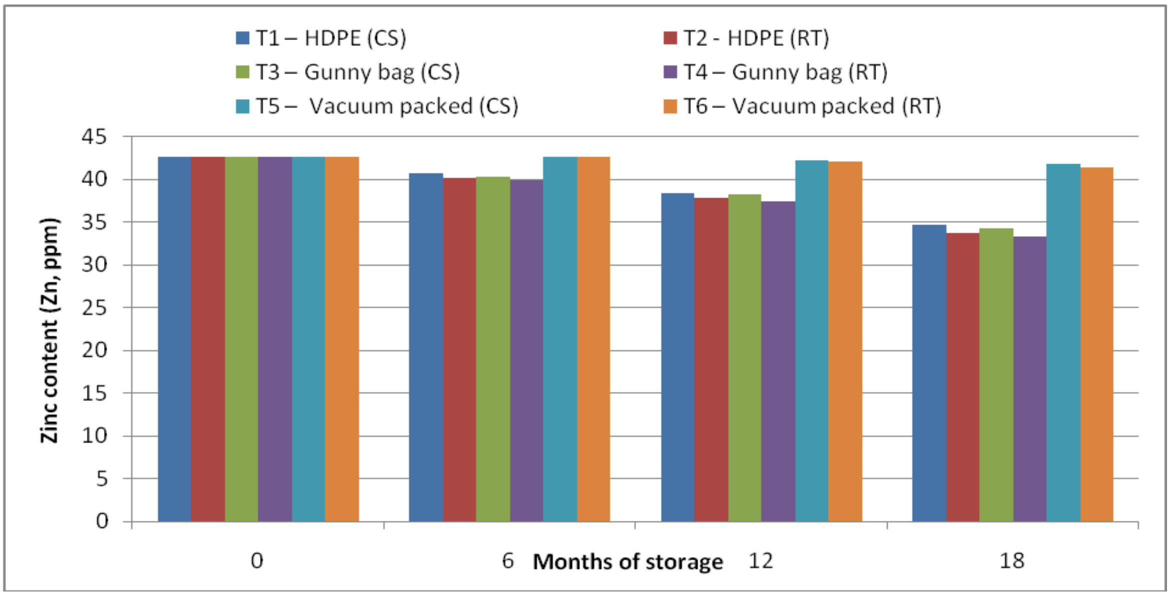

Fig. 3: Influence of packaging and storage conditions on zinc content (Zn, ppm) at different time intervals of storage in groundnut seeds

The zinc content (ppm) of groundnut seeds presented in (Fig., 3) indicated significant differences among the treatments during storage. The zinc content was considerably declined in gunny bag seeds and high density polythene bags from 6 months onwards and upto 18 months of storage irrespective of storage conditions while, the zinc content in vacuum packed seeds were found to be stable and slow decline was observed with progress in storage period. At the end of storage i.e., 18 months, vacuum packed seeds stored under cold storage recorded significantly higher zinc content (46.98 ppm) over all other treatments, followed by vacuum packed seeds stored under room temperature (46.86 ppm). The lower zinc content (41.07 ppm) was recorded in seed stored in gunny bags at room temperature which were on par with high density polythene bags (41.10 ppm).

Manganese content (Mn, ppm)

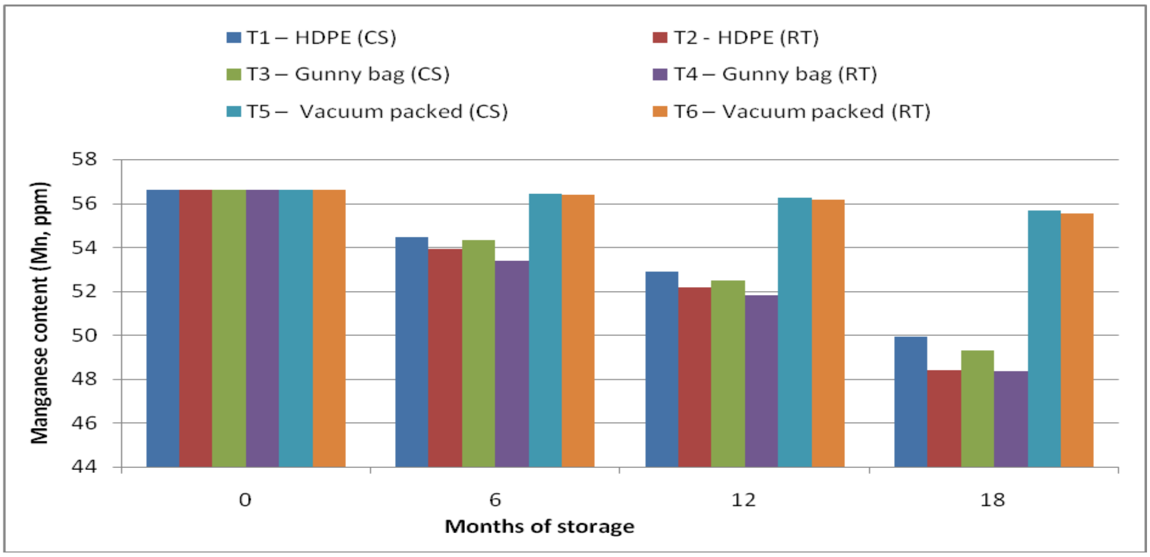

Fig. 4: Influence of packaging and storage conditions on manganese content (Mn, ppm) at different time intervals of storage in groundnut seed

The manganese content (ppm) of groundnut seeds as influenced by different packaging and storage conditions differed significantly between the treatments during storage period (Fig.,4). The manganese content in vacuum packed seeds was maximum and a slow decline was observed with the progress in storage period. While, he manganese content of gunny bags as well as high density polythene packed seeds was found to reduce greatly from the initial stage to upto 18 months of storage under room temperature. At 18 months of storage, the vacuum packed seeds recorded significantly higher manganese content (28.20 ppm) under cold storage and it was superior over all other treatments. The lower manganese content (22.13 ppm) was recorded in gunny bags kept under room temperature, which was also on par with high density polythene bags at room temperature (22.80 ppm).

It is clear from the above results for all the mineral's content that the seeds stored in gunny bags under cold storage were on par with the high density polythene bags stored under cold storage similarly the gunny bags stored at room temperature was also on par with high density polythene bags stored at room temperature. The vacuum packed seeds could maintain higher mineral's content values throughout the storage period. The vacuum packed seeds could maintain higher manganese content values throughout the storage period. Mineral elements like zinc, copper, iron and manganese are very crucial for plant growth and human health, and play a key role in various physiological and biochemical processes. Results pertaining to mineral contents during study including copper, iron, zinc and manganese of soybean seeds showed gradual decrease with an advancement of storage period at all the stages of storage. Among the containers, the decrease in mineral content was very less in vacuum packed bags compared to HDPE, and gunny bags throughout the storage period under both ambient and cold storage. Variation in the mineral contents between the packaging materials could be attributed to redistribution of mineral elements in seeds and possible microbial contamination[9] (Bognar *et al.*, 1990). In the HDPE bags mineral content values were higher than gunny bags, but it was lower than vacuum packed bags. Same results were obtained by Fagbohun and Faleye[21] (2012) in groundnut, Fagbohun *et al*[20]., in melon seeds, Echendu *et al*[17]., in cocoyam chips, Mata *et al*[31]., Perring and Pearson[43], Deepa *et al*[14]., in chilli and Zagory and Kader[60] in green beans.

Higher reduction of iron content in HDPE and gunny bags may be attributed to its sensitivity to temperature. Kayisoglu and Demirci[27] reported that copper, iron, zinc and manganese contents in both conventional and vacuum packed bags were affected significantly and decreased with an increased storage period of 10 months. At 18 months of storage, vacuum packed bags recorded significantly higher values of copper, iron, zinc and manganese compared to HDPE, while significantly lower values were found in gunny bags stored under both ambient and cold storage. Similarly, Alinnor and Akalezi[4] also reported a decrease in Zn, Cu and Fe of cocoyam and white yam stored for six months. Higher mineral contents during cold storage compared to ambient storage could be attributed due to lower internal physiological and biochemical processes in the seed there by prolonging the shelf life of seeds during storage. Higher micronutrients in vacuum packed bags compared to gunny bags, may be due to decrease in ash content[27]. Similar findings were also reported in shelled melon seeds[20], millet seeds[20], cocoyam chips[17], okra[20], and greenbean[43,60].

α-amylase activity (mg maltose released/min)

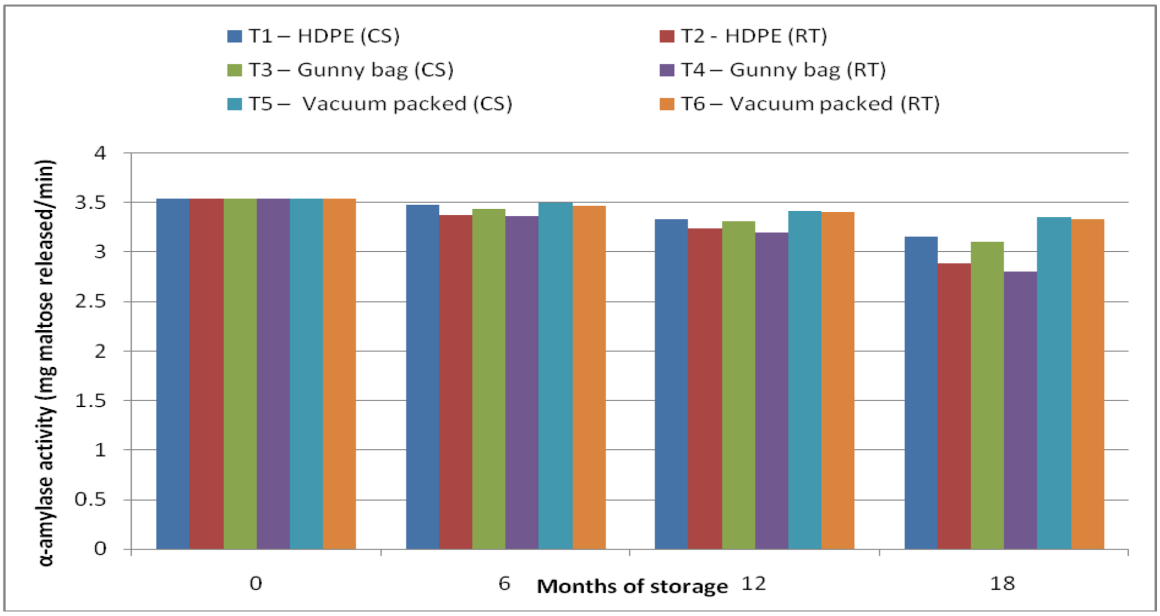

Fig. 5: Influence of packaging and storage conditions on α-amylase activity (mg maltose released/min) at different time intervals of storage in groundnut seeds

α-amylase activity (mg maltose released/min) of groundnut seeds differed significantly between treatments and there was a gradual decline with progress in storage period (Fig., 5). The reduction was greater in gunny bag as well as high density polythene packed seeds from the initial stage upto 18 months of storage stored under room temperature. At the end of storage i.e., the18 months the vacuum packed seeds recorded significantly higher α-amylase activity (3.36 mg maltose released/min) stored under cold storage over all other treatments. Lower seeds of α-amylase activity (2.81 mg maltose released/min) were recorded in gunny bag seeds kept under room temperature, which was also on par with high density polythene bags at room temperature (2.89 mg maltose released/min). From the results, it is clear that the vacuum packed seeds could maintain higher α-amylase activity values over high density polythene bags followed by cloth bags at all the stages of storage. Similar observations were also reported in wheat seeds[13] and in naturally aged gram, chickpea and wheat seeds[2] and in mustard[55].

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

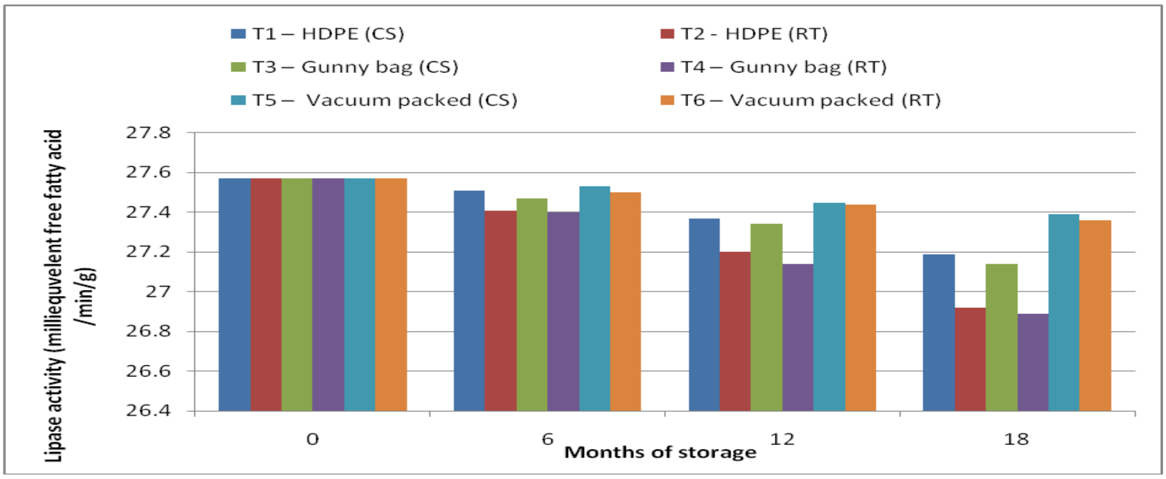

Fig. 6: Influence of packaging and storage conditions on lipase activity (milliequvelent free fatty acid /min/g) at different time intervals of storage in groundnut seeds

Lipase activity (meq. free fatty acid /min/g) of groundnut seeds differed significantly between treatments and there was gradual decline with an advancement in storage period (Fig.,6). The reduction was greater in gunny bag as well as high density polythene packed seeds from the early stage to upto 18 months of storage, stored under room temperature. At the end of storage i.e.,18 months vacuum packed seeds recorded significantly higher lipase activity (27.39 meq. free fatty acid /min/g) over all other treatments, followed by vacuum packed seeds at under room temperature (27.36 meq. free fatty acid /min/g). Lipase activity (26.89 meq. free fatty acid /min/g) was recorded in gunny bag seedsat room temperature followed by high density polythene bags (26.92 meq. free fatty acid /min/g). It is clear from the results that the vacuum packed seeds could maintain higher lipase activity values at all the stages of storage; while the gunny bags and the high density polythene bags stored under cold storage recorded on par values throughout the storage period. Our results are in good agreement with results of Dhaliwal *et al*[16]., and Chaitanya *et al*[12]., Mohamed[33] in wheat and Eze and Chilaka[19] in cucurbitaceous seeds. Increase in protease activity during storage may be due to decline in protein content[12].

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

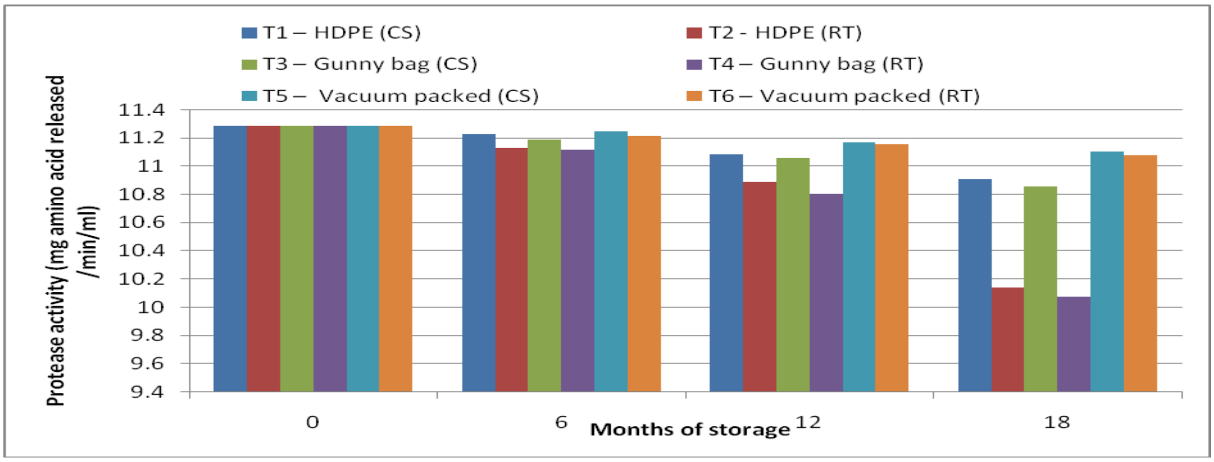

Fig. 7: Influence of packaging and storage conditions on protease activity (mg amino acid released /min/ml) at different time intervals of storage in groundnut seeds

Protease activity (mg amino acid released /min/ml) of groundnut seeds differed significantly between treatments during storage period (Fig.,7). The decline in protease activity of vacuum packed seeds was very minimum and a slow decline with an advancement in storage period. While, gunny bags as well as high density polythene bag seeds was found to reduce great from the initial stage to 18 months of storage under room temperature. At the end of storage, vacuum packed seeds recorded significantly higher protease activity (11.11 mg amino acid released /min/ml) over all other treatments, followed by vacuum packed seeds stored under room temperature (11.08 mg amino acid released /min/ml). The lower protease activity (10.08 mg amino acid released /min/ml) was recorded in gunny bags followed by high density polythene bags (10.14 mg amino acid released /min/ml). It is clear from the results that the vacuum packed seeds could maintain higher protease activity. While, gunny bags and the high density polythene bags recorded on par values of protease activity at the cold storage throughout the storage period. Similar results were observed by Chauhan *et al*[13]., in wheat, Scialabba *et al*[56]., in radish, Pallavi *et al*[41]., in sunflower. Same results of lipase activity were also observed in germinated seeds of castor bean[39], *Jatropha curcas* and the African bean[18].

Loss of viability of seeds has been correlated to enzymatic activity. Abdul-Baki[1] reported that the activity of respiratory and associated enzymes *viz.*, peroxidase, glutamic acid oxidase and catalase, activity of hydrolytic enzymes *viz., α-amylase, lipase,* proteases, phytases and phosphatases is associated with the degradation of organelles membranes, nucleoproteins, etc. In crop 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 amounts of protein represents enzymes concerned with metabolic processes during seed development and germination[32]. 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. These findings are in agreement with those of Sopanen and Lauriere[59], Huang *et al*[25]., in castor, Mostarin *et al*[35]., in bush bean, Sana *et al*[55]., and Rehman and Shah[52] in wheat, Govind and Tumkur[23] in sorghum and Neg and Anderson[38] in quinoa, Liukkonen *et al*[28]., in oat seeds, Ghavidel and Davoodi[22] and Rahman *et al*[46]., in mungbean

Oil content (%)

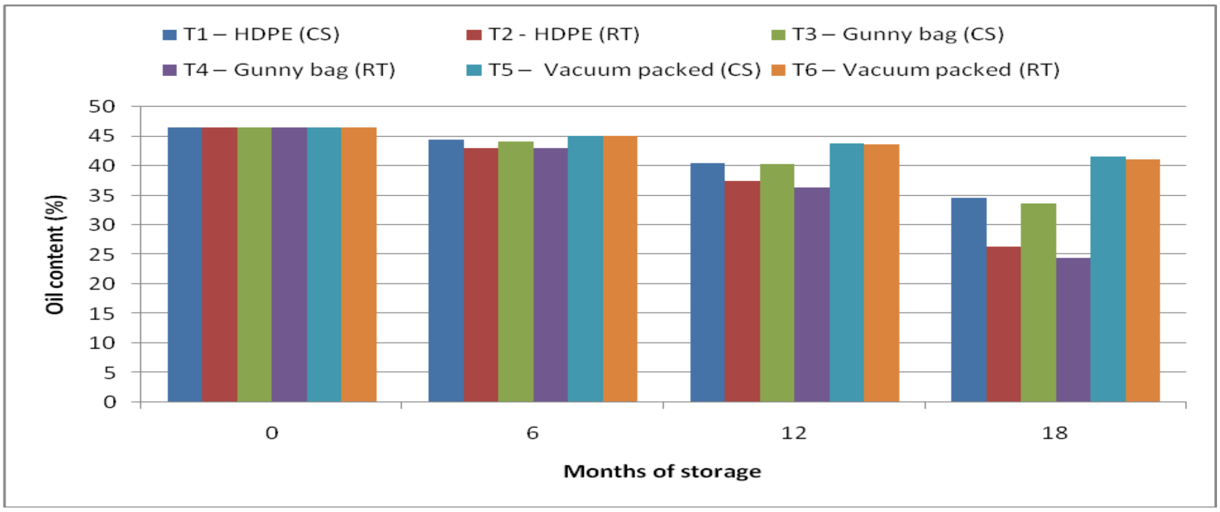

Fig. 8: Influence of packaging and storage conditions on oil content (%) at different time intervals of storage in groundnut seeds

Oil content (%) of groundnut seeds differed significantly between treatments during the storage period (Fig.,8). The decline in oil content of vacuum packed seeds was very minimum and a slow decline with advancement in storage period, while, gunny bags as well as high density polythene bag seeds was found to reduce greatly from the initial stage to 18 months of storage under room temperature. Among the treatments, at initial stage upto 8 months of storage, no significant differences were observed in oil content; but after 10 months of storage significant differences between treatments at all the stages of storage. At ten months of storage, vacuum packed seeds recorded significantly higher oil content (41.63 %) over all other treatments, followed by vacuum packed seeds stored under room temperature (41.07 %). The lower oil content (24.38 %) was recorded in gunny bag seeds, followed by high density polythene bags (26.33 %). It is clear from the results that the vacuum packed seeds could maintain higher oil content values. While, at all stages of storage the gunny bags and the high density polythene bags stored under cold storage recorded on par values of oil content throughout the storage period. In oil seed crops i.e. soybean, auto-oxidation of lipids and increase of free fatty acids during storage period are the main reasons for rapid deterioration of the oilseeds. Martini *et al*[30]., reported that storage condition of oil seeds before industrial extraction might influence the quality of the crude oil. Similarly, Neg and Anderson[38] also showed that storage time and storage temperature had significant effect on free fatty acid content in Quinoa (*Chenopedium quinoa*) seed oil. Different longevity of seed storage as well as storage conditions exert significant influence on oil content. The decline in oil content of vacuum packed seeds was very minimum and a slow decline with advancement in storage period, while, gunny bags as well as high density polythene bag seeds was found to reduce greatly from the initial stage to 18 months of storage under room temperature. During the tenth month of storage, significantly higher oil content was recorded in vacuum packed and the lower oil content was recorded in seeds stored in HDPE, and gunny bags. It is clear from the results that the vacuum packed seeds could maintain higher oil content values compared to all other treatments. Similar results were also noticed by Ramamoorthy and Karivaratharaju[49] in groundnut, Branimir *et al*[10]., Akowuah *et al*[3]., and Canakci[11] in *Jatropha curcas* and Sisman[58] in sunflower.

Table 1: Influence of packaging and storage conditions on electrical conductivity (EC, dSm^{-1}) at different time intervals of storage in groundnut seeds

Treatments	Storage period (months)									
	0	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**
T_1 – HDPE (CS)	0.397	0.399	0.403	0.410	0.416	0.426	0.444	0.469	0.502	0.530
T_2 – HDPE (RT)	0.397	0.402	0.408	0.414	0.433	0.455	0.470	0.499	0.534	0.580
T_3 – Gunny bag (CS)	0.397	0.401	0.406	0.416	0.428	0.438	0.451	0.479	0.510	0.546
T_4 – Gunny bag (RT)	0.397	0.405	0.410	0.421	0.443	0.458	0.494	0.512	0.546	0.604
T_5 – Vacuum packed (CS)	0.397	0.397	0.399	0.402	0.405	0.408	0.410	0.416	0.421	0.429
T_6 – Vacuum packed (RT)	0.397	0.398	0.400	0.404	0.406	0.410	0.413	0.421	0.427	0.435
S.Em(±)	**0.001**	**0.016**	**0.013**	**0.001**	**0.002**	**0.002**	**0.008**	**0.002**	**0.002**	**0.005**
C. D. (1%)	**NS**	**NS**	**NS**	**0.002**	**0.006**	**0.005**	**0.024**	**0.005**	**0.006**	**0.014**

HDPE = High density polythene
NS = Non significant
CS = Cold storage
RT = Room temperature

Table 2: Influence of packaging and storage conditions on mobilization efficiency (ME, %) at different time intervals of storage in groundnut seeds

Treatments	Storage period (months)									
	0	2	4	6	8	10	12	14	16	18
T_1 – HDPE (CS)	8.52	12.37	12.53	12.30	12.50	12.40	12.07	11.70	11.50	11.33
T_2 – HDPE (RT)	8.52	10.30	10.23	10.20	11.40	11.37	11.03	10.01	9.90	9.70
T_3 – Gunny bag (CS)	8.52	14.03	15.70	14.67	14.47	14.37	14.33	14.30	14.32	13.93
T_4 – Gunny bag (RT)	8.52	12.77	12.50	12.13	12.90	12.89	12.73	12.01	10.83	10.53
T_5 – Vacuum packed (CS)	8.52	8.59	8.58	8.56	8.53	8.51	8.50	8.49	8.47	8.41
T_6 – Vacuum packed (RT)	8.52	8.56	8.54	8.53	8.52	8.50	8.49	8.47	8.45	8.39
S.Em(±)	**0.01**	**0.21**	**0.09**	**0.16**	**0.10**	**0.09**	**0.10**	**0.09**	**0.10**	**0.16**
C. D. (1%)	**NS**	**0.61**	**0.28**	**0.49**	**0.29**	**0.27**	**0.29**	**0.27**	**0.30**	**0.46**

HDPE = High density polythene CS = Cold storage
NS = Non significant RT = Room temperature

CONCLUSIONS

Seed physiological and biochemical parameters deterioration is an inexorable and an irreversible process. The quality and viability of groundnut seeds are subjected to variations during storage conditions and it has been found that the life span of seeds depends on moisture content of the seeds, relative humidity, temperature, light and oxygen content under which the seeds are stored. It has been found in the present study that it is possible to extend the shelf life of groundnut seeds up to 18 months without deterioration in seed biochemical parameters *viz.*, oil content and enzyme activity such as α-amylase, lipase and protease and seed physiological parameters such as mineral content (Cu, Mn, Zn and Mn), moisture content and electrical conductivity by storing them under vacuum packaging. Since seed is an important input in agriculture which determines not only the production but also the productivity, it is essential to maintain the seed quality as well as seed vigor.

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