International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 3982-3989, 2023; Article no.IJECC.106749
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Exploring the Storage Potential of Groundnut Var.TMV (Gn) 13 under Modified Atmospheric Storage Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i103072

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/106749

Original Research Article

Received: 15/07/2023
Accepted: 20/09/2023
Published: 25/09/2023

ABSTRACT

The aim of the study is to identify the suitable modified atmospheric storage condition required for long term storage of groundnut (*Arachis hypogaea* L.) variety TMV (Gn) 13. The experiment was conducted during 2022 at Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore. The groundnut pods and kernels were subjected into different storage conditions *viz.,* pods stored in gunny bag, kernels stored in gunny bag, kernels stored in polythene

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bag, kernels stored with N_2gas and kernels stored in vacuum conditions. The results revealed that pod storage recorded the maximum germination percentage (73%), root length (14.5cm), shoot length(14.3cm), dry matter production (3.47 g 10 seedlings $^{-1}$) and vigour (2136). Similarly, enzymes viz., dehydrogenase(0.72 OD value), peroxidise (1.29U mg^{-1} protein min^{-1}), alpha amylase (13.60mg maltose min^{-1}) and catalase activity (1.253 µmolH_2O_2 min^{-1}g^{-1} protein) were also maximum in pod storage with minimum harmful effect of pest(0.6%) and fungus incidence(17%). The nitrogen storage conditions also have maximum enzyme activity viz., dehydrogenase (0.64 OD value), peroxidise (1.24U mg^{-1} protein min^{-1}), alpha amylase (13.58 mg maltose min^{-1}) and catalase activity (1.220 µmolH_2O_2 min^{-1}g^{-1} protein) with minimum harmful effect of pest (0.6%) and fungus incidence (20%). Present study, it is concluded that groundnut kernels stored under modified atmospheric storage i.e. nitrogen gas storage can maintain the seed longevity by minimizing the deterioration process in groundnut equally as that of pod storage. Further, it will helps to minimize the expenditure towards transport and storage.

Keywords: Modified atmospheric storage; groundnut kernel; seed storability.

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a leguminous plant that is widely cultivated in the tropics and subtropics and it is valued for its high-oil content and edible seeds. It is the fourth most important source of edible oil and a third most important source of vegetable protein in the World. Globally, groundnut covers 327 lakh hectares with the production of 539 lakh tonnes with the productivity of 1648 kg per hectare [1]. Groundnut is valued as a rich source of energy contributed by oil (48–50%) and protein (25–28%) in the kernels and 100 g of kernels provide 567 kcal of energy and 8.5 g of dietary fiber [2]. Additionally, groundnuts are a rich source of minerals, vitamins (Vitamin E, Thiamine, Pantothenic acid, Vitamin B6, Folates, and Niacin) and antioxidants and health improving bioactive compounds such as resveratrol, tocopherol, arginine, p-coumaric acid, polyphenols, flavonoids, isoflavones,*etc*. The consumption of groundnut and its products can reduce risk of inflammation, diabetes, cancer, alzheimer's and gallstone disease.As they are highly nutritious, groundnut and its products can be promoted as nutritional foods to fight energy, protein, and micronutrient malnutrition among the poor people. Due to high nutrient contents of groundnuts, they have been used to combat the malnutrition in developing countries and also reduce the cardiovascular heart disease and gall stone [3].

The private sector has shown little interest in the groundnut seed enterprise due to the low seed multiplication ratio, bulky nature of the produce, quick loss of seed viability, high cost of transportation, low-profit margin, and the self-pollinated nature of the crop. Quick loss in viability period of groundnut leads to create more seed demand and it indirectly affect the seed multiplication chain. Therefore, availability of good quality seeds at right time with affordable price is a great task to the public sector seed services.

The major problem accompanied with groundnut is poor storage because of its possession of polyunsaturated fatty acids which will get break down when there is high temperature and thus results in lipid peroxidation. The seeds produced in one season are not fully consumed in the same season for farm and home, because of its voluminous quantity of production. So the major part of the produce is going for storage to utilize in the next upcoming months either as seed source or food source. The most common method of storage of groundnut was pod storage because of its ability to protect the kernel by limiting the lipid peroxidation. There are numerous techniques such as seed treatment, mid-storage correction to sustain the seed quality during storage. In all this techniques practical difficulties are more. Modified Atmospheric Storage (MAS) is one of the novel approach to protect groundnut kernel with its quality for a longer period compared to kernel under ambient storage. In MAS, the kernels are stored in the atmospheric condition including higher amount of (N_2), (CO_2) and reduced (O_2). In this modified storage condition, the environment that surround the seeds is only altered and does not treated with any material, so it does not pose any health hazard to human, animal and not phytotoxic to the seeds. Seed stored in MAS will reduce the insect population by reducing the temperature that will increase during the respiration of seeds. Riudavets et al., [4] reported that modified atmospheric packaging of maize seed with

(90%CO_2,5%$O_2$and 5% N_2) effectively reduce the *Sitophilus zeamis* population by inhibiting all the life stages of insects thereby it control the proliferation of aflatoxin produced during storage of maize seeds.

Keeping all these points in view, the present investigations were undertaken to explore the storage potential of groundnut variety TMV 13 under modified atmospheric storage conditions.

2. MATERIALS AND METHODS

The laboratory experiments were conducted with groundnut variety TMV (Gn) 13 in the laboratory of Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore during the year 2022 and packaging of the groundnut kernelswas done in the Department of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore with the Modified Atmosphere Packaging (MAP) Unit. The groundnut TMV (Gn) 13 is a red kernel variety released from Oilseeds Research Station, Tindivanam during 2013 and it is widely cultivated in Villupuram, Thiruvannamalai and Coimbatore districts of Tamil Nadu. For pod storage the quantity of 5 kg were stored and for kernel storage the quantity of 300 g kernel with 6.3 moisture content were packed in 700guage polythene bag with three replication and then subjected into following storage conditions.

2.1Treatment Details

M_1- Pod stored in gunny bag under ambient condition
M_2- Kernel stored in gunny bag under ambient condition
M_3- Kernel in polythene bag without any treatment under ambient condition
M_4- Kernel stored with N_2 storage under ambientcondition
M_5- Kernel stored in vacuum storage under ambient condition

The seed quality parameters *viz.*, seed moisture content [5]. seed germination [6], root length, shoot length, dry matter production, vigour index [7], insect infestation, storage fungus infection, alpha amylase [8], catalase [9], peroxidase [10], and dehydrogenase value [11] enzyme activities were analyzed at monthly intervals up to six months of the storage period (P_0, P_1, P_2, P_3,P_4, P_5 and P_6). The data wereanalyzed by Factorial Completely Randomized Design (FCRD) with three replications as suggested by Panse and Sukhatme [12].

3. RESULTS AND DISCUSSION

3.1 Results

The results of this experiment revealed that the modified atmospheric storage condition, period of storage and their interactions showed significant effect with all the seed quality attributes.

Among the storage conditions, the maximum seed moisture content was recorded in kernel stored in gunny bags under ambient storage (M_2) while, the minimum was observed in nitrogen and vacuum storage (M_4&M_5). The moisture content was slowly increased from 6.3 to 7.4%) as the advancement of storage period from P_0 to P_6. On the contrary, the highest germination percentage of 94 per cent at initial period of storage (P_0) was slowly decreased to (47%) t the end of the storage period (P_6). With respect to modified storage conditions,pod stored in gunny bag under ambient condition (M_1) recorded the maximum mean germination (73%) and it was followed by kernel storage under nitrogen storage (M_4) (70%) while, kernel storage at ambient condition (M_2) recorded the minimum mean germination percent (66%).

The maximum root and shoot length of 14.6 and 14.3 cm were observed in pod stored in gunny bag under ambient storage (M_1) while, the minimum length of 13.6 and 13.0 cm were observed in kernel stored in gunny bag (M_2), respectively.The decline trend in seedling length was observed as the advancement of storage period**.** The similar trend was observed in dry matter production and vigour index (Tables 1 &2).

On the six month of storage period, there is no storage pest incidence was observed up to four months of storage (P_4) and then it was slowly increased to 0.4 (P_5) to 8 per cent (P_6). Similarly, the minimum pest incidence and fungus infection of 0.6 and 17 per cent were observed in pod stored in gunny bag while, they were maximum in kernel stored in gunny bag (1.1 and 27 %), respectively (Table 3.).

The enzymes *viz*., alpha amylase, dehydrogenase, catalase and peroxidase also have positive correlation with seed quality and initially they were maximum of 14.01 mg maltose min^{-1}, 1.00 OD value, 1.363 µmolH_2O_2 $min^{-1}g^{-1}$ protein and 1.63 U mg^{-1} protein min^{-1}while, it was minimum of 12.84 mg maltose min^{-1}, 0.29 OD value, 0.935 µmolH_2O_2 $min^{-1}g^{-1}$ protein and 0.88U mg^{-1} protein min^{-1}, respectively. Similarly,

Table 1. Effect of modified atmospheric storage on seed moisture content, seed germination, root length and shoot length of groundnut variety TMV 13

Period of storage (P)	Seed moisture content (%)						Germination (%)						Root length (cm)					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
P_0	6.3	6.3	6.3	6.3	6.3	**6.3**	94	94	94	94	94	**94**	15.2	15.2	15.2	15.2	15.2	**15.2**
P_1	6.3	6.4	6.3	6.3	6.3	**6.3**	90	86	90	90	87	**88**	15.2	15.0	15.1	15.1	15.0	**15.0**
P_2	6.4	6.6	6.4	6.4	6.4	**6.4**	80	71	73	73	74	**74**	14.8	14.1	14.7	14.8	14.9	**14.7**
P_3	6.5	7.2	6.5	6.5	6.5	**6.6**	75	54	62	72	61	**65**	14.6	13.9	14.5	14.1	14.7	**14.4**
P_4	6.7	7.4	6.7	*6.6*	6.7	**6.8**	66	50	54	61	52	**57**	14.3	13.6	12.5	13.9	13.8	**13.7**
P_5	6.8	7.6	6.8	6.7	6.8	**6.9**	54	42	58	53	50	**51**	14.0	13.5	11.7	13.8	12.9	**13.2**
P_6	7.0	8.0	7.6	7.4	7.3	**7.4**	55	40	46	50	45	**47**	13.8	12.7	11.5	13.3	12.2	**12.7**
Mean	**6.5**	**7.0**	**6.7**	**6.6**	**6.6**		**73**	**62**	**67**	**70**	**66**		**14.6**	**14.0**	**13.6**	**14.3**	**14.1**	
	P		**M**		**PXM**		**P**		**M**		**PXM**				**M**		**PXM**	
SED	0.068		0.057		0.151		0.608		0.514		1.360		0.124		0.105		0.277	
CD(0.05)	0.135		0.114		0.302		1.212		1.025		2.711		0.247		0.209		0.553	

Table 2. Effect of modified atmospheric storage on shoot length, dry matter production and vigour index of groundnut variety TMV 13

Period of storage (P)	Shoot length (cm)						Dry mater production (g seedlings^{-10})						Vigour index					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
P_0	14.7	14.7	14.7	14.7	14.7	**14.7**	3.74	3.74	3.74	3.74	3.74	**3.74**	2810	2810	2810	2810	2810	**2810**
P_1	14.6	14.0	14.3	14.6	14.3	**14.4**	3.68	3.56	3.60	3.66	3.61	**3.62**	2691	2494	2587	2587	2549	**2582**
P_2	14.5	13.9	14.1	14.4	14.3	**14.2**	3.56	3.43	3.50	3.53	3.52	**3.50**	2344	1988	2131	2132	2160	**2151**
P_3	14.4	12.8	13.7	14.3	14.0	**13.8**	3.45	3.33	3.40	3.42	3.40	**3.40**	2175	1414	1748	2044	1750	**1826**
P_4	14.4	12.1	13.4	14.1	13.6	**13.5**	3.36	3.30	3.32	3.34	3.32	**3.32**	1894	1285	1397	1708	1425	**1542**
P_5	14.2	11.9	13.1	14.0	13.0	**13.2**	3.27	3.13	3.21	3.25	3.27	**3.22**	1523	1066	1473	1473	1295	**1366**
P_6	13.7	11.6	12.8	13.2	12.8	**12.8**	3.24	3.11	3.10	3.21	3.20	**3.17**	1512	968	1118	1325	1125	**1210**
Mean	**14.3**	**13.0**	**13.7**	**14.1**	**13.8**		**3.47**	**3.37**	**3.41**	**3.45**	**3.43**		**2136**	**1717**	**1895**	**2011**	**1873**	
	P		**M**		**PXM**		**P**		**M**		**PXM**		**P**		**M**		**PXM**	
SED	0.138		0.116		0.308		0.032		0.027		0.071		0.032		0.027		0.072	
CD(0.05)	0.275		0.232		0.615		0.064		0.054		0.143		0.064		0.054		0.143	

Table 3. Effect of modified atmospheric storage on insect infestation, storage fungus infection and alpha amylase activity of groundnut variety TMV 13

Period of storage (P)	Insect infestation (%)						Storage fungus infection (%)						Alpha amylase activity (mg maltose min^{-1})					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
P_0	0.0	0.0	0.0	0.0	0.0	**0.0**	4	4	4	4	4	**4**	14.01	14.01	14.01	14.01	14.01	**14.01**
P_1	0.0	0.0	0.0	0.0	0.0	**0.0**	8	16	8	8	8	**10**	13.96	13.64	13.73	13.86	13.81	**13.80**
P_2	0.0	0.0	0.0	0.0	0.0	**0.0**	12	24	20	16	16	**18**	13.84	13.52	13.67	13.79	13.71	**13.70**
P_3	0.0	0.0	0.0	0.0	0.0	**0.0**	16	28	24	20	24	**22**	13.74	13.44	13.60	13.70	13.63	**13.62**
P_4	0.0	0.0	0.0	0.0	0.0	**0.0**	20	36	32	24	28	**28**	13.68	13.38	13.51	13.62	13.59	**13.55**
P_5	0.0	4.0	0.0	0.0	0.0	**0.8**	24	40	36	32	32	**33**	13.15	13.09	13.13	13.27	13.23	**13.17**
P_6	4.0	4.0	4.0	4.0	4.0	**4.0**	32	44	40	36	36	**38**	12.94	12.79	12.82	12.83	12.86	**12.84**
Mean	**0.6**	**1.1**	**0.6**	**0.6**	**0.6**		**17**	**27**	**23**	**20**	**21**		**13.60**	**13.41**	**13.49**	**13.58**	**13.54**	
	P		**M**		**PXM**		**P**		**M**		**PXM**		**P**		**M**		**PXM**	
SED	0.017		0.015		0.039		0.209		0.176		0.466		0.132		0.111		0.295	
CD(0.05)	0.034		0.029		0.077		0.416		0.352		0.930		0.263		0.223		0.589	

Table 4. Effect of modified atmospheric storage on dehydrogenase, catalase and peroxidase enzyme activities of groundnut variety TMV 13

Period of storage (P)	Dehydrogenase activity (OD value)						Catalase activity ($\mu molH_2O_2$ $min^{-1}g^{-1}$ protein)						Peroxidase activity (U mg^{-1} protein min^{-1})					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
P_0	1.00	1.00	1.00	1.00	1.00	**1.00**	1.363	1.363	1.363	1.363	1.363	**1.363**	1.63	1.63	1.63	1.63	1.63	**1.63**
P_1	0.92	0.72	0.82	0.85	0.83	**0.83**	1.358	1.327	1.338	1.345	1.342	**1.342**	1.56	1.40	1.50	1.55	1.54	**1.51**
P_2	0.81	0.66	0.71	0.74	0.73	**0.73**	1.343	1.290	1.317	1.339	1.333	**1.324**	1.36	1.25	1.28	1.35	1.32	**1.31**
P_3	0.73	0.59	0.62	0.69	0.68	**0.67**	1.310	1.231	1.309	1.324	1.215	**1.278**	1.27	1.11	1.15	1.21	1.18	**1.18**
P_4	0.54	0.41	0.46	0.50	0.48	**0.48**	1.285	1.150	1.211	1.215	1.203	**1.212**	1.11	1.01	1.04	1.08	1.06	**1.06**
P_5	0.47	0.33	0.35	0.41	0.38	**0.39**	1.131	0.956	0.978	0.982	0.988	**1.007**	1.09	0.90	0.93	0.97	0.95	**0.97**
P_6	0.38	0.20	0.26	0.32	0.27	**0.29**	0.985	0.879	0.934	0.947	0.932	**0.935**	0.98	0.79	0.86	0.89	.0.87	**0.88**
Mean	**0.72**	**0.56**	**0.60**	**0.64**	**0.62**		**1.253**	**1.170**	**1.207**	**1.220**	**1.196**		**1.29**	**1.16**	**1.20**	**1.24**	**1.22**	
	P		**M**		**PXM**		**P**		**M**		**PXM**		**P**		**M**		**PXM**	
SED	0.005		0.004		0.011		0.011		0.009		0.024		0.012		0.010		0.026	
CD(0.05)	0.010		0.009		0.023		0.022		0.018		0.487		0.023		0.020		0.053	

the maximum enzyme activity was observed in pod stored in gunny bag and nitrogen storage, which was followed by vacuum storage (Table 4).

3.2 Discussion

Seed deterioration orageing is a universal physiological phenomenon which leads to loss of viability. The rate of seed deterioration is vary with the crop species and it is triggered by unfavourable storage conditions [13,14]. Obviously, the seed deterioration rate is faster in oilseed crops and which is due to auto oxidation fatty acids i.e. more lipid peroxidation. In order to overcome or manipulate the deleterious effect of storage environment, MAS is a novel approach for storing groundnut kernels for longer period.

In the present study, it was evidenced that seed stored as such as a pod in gunny bag recorded good storability in terms of germination (Fig. 1), seedling length, dry matter production, vigour index and enzyme activities and it was equally on par with the kernel stored under nitrogen storage. It clearly indicated that kernel storage also possible to maintain the storability in groundnut when kernels are stored under nitrogen which is followed by vacuum storage. The similar kind of result was obtained by Quiong Wu et al*.,* [15], Photchanachai [16], Carla Barbosa et al*.,* [17] and Sajid Ali et al*.,* [18].

The reason for the long term maintenance of seed quality in pod storage is due to the microclimate that prevails inside the pod. When the groundnut stored as pod it occupy more space than stored as kernel. The problem associated with kernel is auto-oxidation, peroxidation more prone to insect attack loss of natural antioxidant and rancidity which will affect the seeds standard and also make it unfit for human consumption. The seeds are naturally provided with both enzymatic and non enzymatic antioxidant which will protect the seeds under the adverse situation of lipid peroxidation. The seed coat with deeper color contain more polyphenol content and high flavonoid content and thus have the stronger antioxidant ability [19]. Vakeswaran et al*.,* [20] suggested that the seeds stored with pod in the modified atmospheric packaging of 40% CO_2 given higher vigour and viability even after the 12 month of storage. Copeland [21] highlighted the consequences of deteriorative changes in seed which include membranedegradation, accumulation of toxic metabolites, decreased enzymatic activity, lipid auto-oxidation, and failure of repair mechanisms, genetic degradation, and reduced yield, finally loss of germination or death. In kernel storage, the kernels are exposed to environment and this environment oxygen promote the auto-oxidation and lipid peroxidation in groundnut which results in the production free radical, hydrogen peroxide which damage cell structure and ultimately leads to poor seed viability. The similar result were also reported by Guillaumin [22], Rathi et al*.*, [23], Bera et al., [24], and Bera et al., [25].

Kernel stored in gunny bag | **Pod stored in gunny bag** | **Kernel stored in nitrogen gas**

Fig. 1. Comparative assessment of seedling quality of TMV 13 under different modified atmospheric storage condition such as kernels stored in gunny bag, pod stored in gunny bag and kernel stored in nitrogen gas

4. CONCLUSION

Of the outset, it is concluded that groundnut kernels stored under modified atmospheric storage i.e., nitrogen gas storage can maintain the seed longevity by minimizing the deterioration process in groundnut equally as that of pod storage with the germination percentage (70%), root length (14.3 cm), shoot length(14.1cm),dry matter production (3.45 g 10 seedlings^{-1}) and vigour (2011). Similarly, enzymes viz., dehydrogenase(0.64 OD value), peroxidise (1.24U mg^{-1} protein min^{-1}), alpha amylase (13.58 mg maltose min^{-1}) and catalase activity **(**1.220 µmolH_2O_2 min^{-1}g^{-1} protein**)** were also maximum in nitrogen storage conditions with minimum harmful effect of pest (0.6%) and fungus incidence(20%). Further, it will helps to minimize the expenditure towards transport and storage.

ACKNOWLEDGEMENT

The authors wish to thank the Department of Seed Science & Technology, Tamil Nadu Agricultural University, Coimbatore for technical support and thank M/s. Virbac Animal Health India Pvt. Ltd., Coimbatore for their financial assistance for successful conduct of this research programme.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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