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Research Article

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Physiological and Biochemical Quality Response of *Sterculia rhinopetala* Seeds to different Storage Materials and Duration under Ambient Conditions

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Abstract A study was carried out to determine the effects of storage materials and storage duration on physiological seed quality an important indigenous forest tree species (Sterculiarhinopetala). The experiment started from December, 2015 to June, 2016. Seed collection was done at the Bobiri Forest Reserve, Kumasi, Ghana. The experimental design used was 3 x 6 factorial arrangements in Completely Randomized Design (CRD) with three replications. Storage materials used were (jute, paper, nylon, airtight bottle, ziplock bag and no packaging) with three storage durations (0 day, 90 days and 180 days). Physiological and biochemical seed quality parameters were studied. Results revealed that germination percentage, seed vigour, 1000 seed weight, moisture content, carbohydrate, protein and oil contents were maintained when seeds were stored in airtight and ziplock bags for 90 days and 180 days without any deleterious effect on seed quality. The initial germination percentage (95.4%)had reduced slightly to 93.33% and 92.60% when stored in airtight bottle for 90 and 180 days respectively. Seeds packaged in jute, nylon and paper bags had significant reduction in germination percentage after 180 days of storage. The study concluded that storing seeds in airtight bottle and the ziplock materials improved storability than in jute, paper and nylon bags.

Keywords denaturation, storability, vigour, vulnerable

1. Introduction

Globally, the significance of tropical forests is now well understood by scientists, politicians and people of all races [1-3]. Trees sequester carbon dioxide in roots, trunks, stems and leaves while they grow, and in wood products after they are harvested. That means planting trees, whether in a rural or an urban setting, reduces carbon in the atmosphere [4]. The interest in the use of indigenous trees for reforestation projects has been increasing in the past decade. Blakesley *et al*., (2002) addressed the special importance of seed information for nursery planning in restoration projects that involve the use of a large number of native species [5]. Raising trees and preserving their seeds are means of supporting reforestation, combating desertification, safeguarding the environment, mitigating climate change and conserving biodiversity [6].

Seed collection timing, seed handling procedures, germination pretreatments, and storage techniques are lacking for many tropical species [7]. According to Sacande et al. (2004) insufficient baseline information about the potential of indigenous species and the availability of seeds and seedlings are major constraints for the deployment of locally adapted tree species [8]. Engels and Ditlevsen (2004), observed that studies on tropical forest tree seeds in general also remain more complex compared to those on annual crops as a result of dormancy problems and large variations in seed storability leading to rapid decline in seed viability. Consequently, a lot of seeds die over the period between collection and sowing, and thus they are rarely used in planting programmes (even though the demand is increasing). These seeds cannot appropriately be stored for the

conservation of the species (9-10). *Sterculia rhinopetala* is a deciduous timber tree that grows up to about 40 m tall; with bole without branch to about 21 m and its wood is resistant to decay [11-12]. The tree has been described as vulnerable with decreasing population trend according to the IUCN Red List of Threatened Species [13]. It is an undeniable fact that this species requires urgent conservation attention. Research studies on seed of many annual and perennial crops reveal possible long term seed storage in moisture-proof storage materials. Monira *et al*. (2012), reported on the maintenance of high quality soyabean seeds stored in air tight tin containers unlike in cloth bags. Adebisi *et al.* (2008) also included air tight bottles as one of the best materials to store okra seeds on long term basis. According to Vertucci and Roos (1990) optimum protocols for seed storage must take into account the chemical composition of the seed, the physiological status of the seed, and the physical status of water within the seed[14-16]. There is therefore dearth of knowledge on the use of storage materials on important indigenous forest tree seeds like *Sterculia rhinopetala*. The objective of this study however, was to determine the effect of storage materials and storage duration on the physiological and biochemical quality of *Sterculia rhinopetala* seeds.

2. Materials and Methods

2.1. Location of seed collection and seed storage experiment

Bobri Forest Reserve was the selected location for the seed collection activities which took place in December, 2015. This Forest Reserve is in the south-east sub-type of moist semi-deciduous (MSSE) forest in Ghana, making an area of about 5,445 ha [17]. The reserve serves as a research site for the Council for Scientific and Industrial Research-Forestry Research Institute of Ghana (CSIR-FORIG). It is a biodiversity conservation site home to many plants and animal species. Deciduous and evergreen species are represented in about equal proportion often with several canopy layers [18]. The climate has a peak rainfall period in June-July, September-October and a marked dry season in November through March. The seed storage and other laboratory experiments were conducted at the Department of Horticulture, KNUST.

2.2. Experimental Design

A 3 X 5 factorial completely randomized design in three replications was used for this experiment. The factors were; three storage periods (no storage, 60 days and 180 days) and four packaging materials [jute (0.9mm thickness), paper (0.2 mm thickness), airtight bottle and no packaging]. The seeds were desiccated to same moisture content of 3.5% using zeolite beads.

2.3. 1000 Seed Weight Determination

One thousand seed weight was determined by counting out at random 8 replicates of 100 seeds from the pure seed sample. Each replicate was then weighed with electronic balance and the weight recorded. The mean weight of the 8 replicates was calculated, and multiplied by 10 (ISTA, 2007) [19].

2.4. Determination of Germination Percentage

Germination test was carried out according to ISTA (2007) [19]. For each treatment, 400 seeds from the pure seed fraction of a purity test were used to conduct the germination test. The seeds were arranged in four replicates of 100 each on a counting board and planted in a level layer of moist sand in a perforated container. On day eight, each replicate was examined and evaluated separately. Seedlings and seeds were counted and grouped into normal and abnormal seedlings, fresh ungerminated seeds, hard and dead seeds. The percentage germination indicates the proportion of seeds which produced seedlings classified as normal under the conditions and within the period specified. Germination percentage is determined using the formula

$$\text{Germination \%} = \frac{\text{Number of germinated seeds}}{\text{Number of total seeds planted}} \times 100$$

2.5. Determination of Seed vigour

Conductivity test was used in determining the vigour of the seeds. Four replicates of 50 seeds of each treatment were drawn at random and tested for electrical conductivity. Seeds were placed in Erlenmeyer flasks

containing 75 ml ultra pure deionized water equilibrated to 25 °C, then maintained at 25 °C for 24 h. After 24 h of soaking, the flasks was swirled for 10 -15 sec and seeds then taken out of water with a clean forceps. An electrical conductivity dip cell was inserted into the seep water until a stabilized reading was achieved and recorded. The mean of the two control flasks (sterilized distilled water) when measured served as background reading. Conductivity was calculated usingthe formula,

$$\text{Conductivity, } (\mu S\ cm{-}1g{-}1) = \frac{\text{Conductivity reading} - \text{background reading}}{\text{Weight (g) of replicate}}$$

2.6. Vigour index determination

The vigour index formula proposed by Abdul-Baki and Alderson (1973) [20] was used.

Vigour Index = (Shoot length + Root length) X Germination Percentage

2.7. Determination of Moisture Content

The low constant temperature oven method (AOAC, 2007) was used to determine the moisture content of the seeds [21]. Empty glass crucible was thoroughly washed, cleaned and dried for one hour at 130 °C and placed in desiccator to cool. The empty crucible and its cover were then weighed before and after filling. About 5 g milled soybean seed from each sample was weighed and transferred into a previously weighed empty glass crucible and placed in an oven maintained at a temperature of 105 °C and dry for 5 h. Four replicates were taken. At the end of the prescribed period, the container was covered and removed from the oven and allowed to cool in desiccator to room temperature. After cooling, the container with its cover and content was reweighed and figures recorded. Loss in weight was calculated as percentage moisture content using the formula,

$$\%\ \text{Moisture wt} = \frac{\text{weight of wet sample} - \text{weight of dry sample X 100}}{\text{weight of wet sample}}$$

2.8. Determination of chemical seed composition

The oil, protein and carbohydrate were determined using the rules set out in AOAC (2007) [21].

2.9. Measurement of temperature and relative humidity of storage environment

The ambient storage room temperature and relative humidity readings were taken at specified times of 9:00 am, 12:00 pm and 6.00 pm. Acurite manufactured indoor digital humidity and temperature monitor (00325) was used in taking the readings which is shown in table 3.

2.10. Data analysis

Data collected from the experiment were subjected to analysis of variance using Statistix Software Version 9.0. Tukey's HSD (Honest Significant Difference) was used for mean separation at probability level set at p=0.01.

3. Result

3.1. Initial seed physiological and chemical quality characteristics of *S. rhinopetala*

The initial moisture content, vigour, vigour index, 1000 seed weight and germination percentage were 10%, 22.5µS $cm^{-1}g^{-1}$, 2376.7, 779.7g and 95.4% respectively (Table 1).The initial oil, protein and carbohydrate contents of the seed were 23%, 19.2% and 17.4% respectively (Table 2).

Table 1: Initial seed physiological quality characteristics of *S. rhinopetala*

Species	Moisture Content (%)	Vigour (µS $cm^{-1}g^{-1}$)	Vigour Index	1000 seed weight (g)	Germination (%)
S. rhinopetala	10	22.5	2376.7	779.7	95.4

Table 2: The initial biochemical quality of S. rhinopetala

Species	Oil %	Protein %	Carbohydrate %
S. rhinopetala	23.0	19.2	17.4

3.2 Ambient conditions of storage

Relative humidity ranged from 63.2% to 77.82% whereas temperature was between 27.9ºC and 28.2 ºC. The minimum relative humidity was recorded in January, 2016 and the maximum in June, 2016. The minimum temperature was recorded in January, 2016 and the maximum in March, 2016 (Table 3).

Table 3: shows the relative humidity and temperature for the storage environment

Month	Relative Humidity	Temperature
January	63.2	28.2
February	64.5	29.1
March	75.45	29.45
April	72.3	29.79
May	76.46	28.21
June	77.82	27.9

3.3. Effects of storage materials and duration on carbohydrate content of *S. rhinopetala* seeds

Significant storage materials x storage duration interactions were observed in the percent carbohydrate of *S. rhinopetala* seeds (Table 4). Seeds in airtight bottle but not stored produced significantly highest percent carbohydrate yet not different from seeds stored in airtight bottles and ziplock for 180 days. The unpackaged seeds stored for 90 days produced the least carbohydrate which was also not different from those stored in jute bags, nylon bags and paper bags. Among the storage materials, seeds stored in airtight bottles recorded significantly highest carbohydrate content (16.87%) although similar to those stored in ziplock bags (16.15%). The least was recorded by seeds stored without any storage material (13.30%) which were also similar to those in jute (13.30%), nylon (14.13%) and paper bags (14.80%). Among the storage duration, seeds not stored (0 day) produced significantly highest carbohydrate content (16.39%), 1.3 times greater than the least obtained from seeds stored for180 days (12.73%).

Table 4: Effects of packaging materials and storage periods on carbohydrate content of *S. rhinopetala* seeds

Storage materials	Storage duration			
	0 day	90 days	180 days	Mean
Jute	16.50	13.00	11.50	13.30
Nylon	16.40	14.00	12.00	14.13
Paper	16.00	15.40	13.30	14.80
Ziplock	16.60	16.10	14.90	16.15
Airtight bottle	16.80	16.60	15.60	16.87
No Packaging	16.20	12.90	10.50	13.30
Means	16.39	14.70	12.73	
Tukey HSD (0.01):	Storage Material= 1.7 Storage duration= 1.0 Storage mat. x Storage duration= 3.5			

3.4. Effects of storage materials and storage duration on oil content of *S. rhinopetala* seeds

Significant storage material x storage duration interactions were observed in the percent oil content of *S. rhinopetala* seeds (Table 5). Seeds in all the storage materials but not stored contained significantly highest percent oil content. The unpackaged seeds stored for 180 days had the least oil content. Among the storage materials, seeds stored in airtight bottles recorded significantly highest oil content (22.03%) although similar to those stored in ziplock bags (21.83 %). The least was recorded by seeds stored in the unpackaged material (18.90%) which were also similar to those in jute (19.53%), nylon (19.10%) and paper bags (20.30%). Among the storage duration, seeds which were not stored produced significantly highest oil content (23.11%), 1.3 times greater than the least obtained from seeds stored for 180 days (18.17%) (Table 5).

Table 5: Effects of storage materials and storage duration on oil content of S. rhinopetala seeds

Storage materials	**Storage duration**			
	0 day	**90 days**	**180 days**	**Mean**
Jute	23.08	18.83	16.83	19.53
Nylon	23.23	19.83	17.32	19.10
Paper	23.33	20.33	17.82	20.30
Ziplock	23.13	22.63	21.73	21.83
Airtight bottle	22.83	21.70	21.83	22.03
No Packaging	23.03	17.83	15.83	18.90
Means	23.11	20.22	18.17	
Tukey HSD (0.01):	Storage Material= 1.3 Storage duration= 0.7 Storage mat. x storage duration= 2.7			

3.5. Effects of storage duration on the protein content of *S. rhinopetala* seeds

There were significant differences between the storage duration for the protein content of *S. rhinopetala* seeds (Fig. 1). The significantly highest protein was produced by seeds which were not stored (19.91%), whiles the least was produced by seeds stored for 180 days (17.94%).

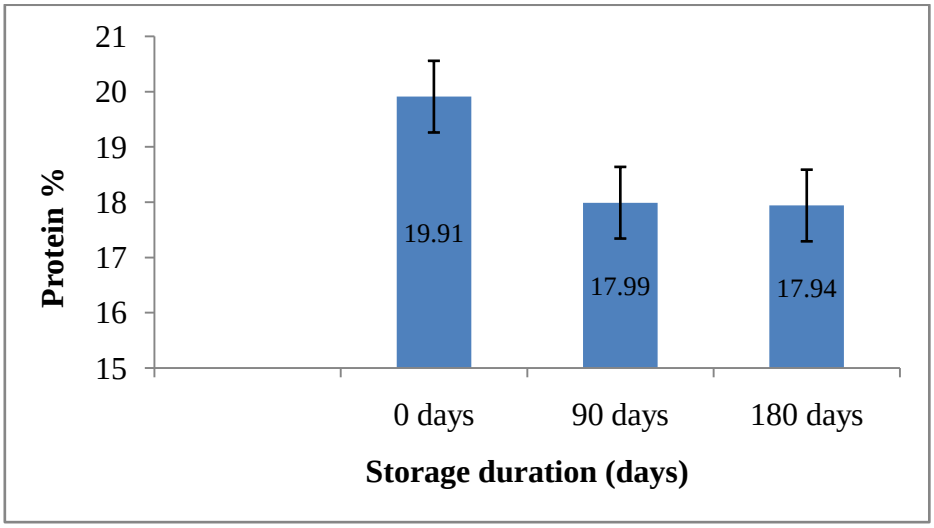

Figure 1: Effects of storage duration on the protein content of S. rhinopetala seeds

3.6. Effects of storage materials and storage duration on the germination percentage of *S. rhinopetala* seeds

There were significant storage materials x storage duration interactions on the germination percentage of *S. rhinopetala* (Table 6). Seeds in airtight bottle without storage recorded the highest germination (95.33%)

although not significantly different from seeds stored in airtight bottle (92.33%) and ziplock bags (91.40%) for 180 days. The least was recorded by unpackaged seeds stored for 180 days (69.32%) which was similar to seeds stored in jute bag (70.10%), nylon (71.30%) and paper bags (72.20%). Among the packaging materials, seeds stored in airtight bottle produced significantly the highest germination percentage (92.60%) which was similar to seeds stored in ziplock bottles (91.60%). The least germination was recorded by unpackaged seeds (78.20%). Among the storage durations, seeds without storage recorded the significantly highest germination percentage (91.12%), which was 1.2 times more than the least germination percentage produced by seeds stored for 180 days (73.40%).

Table 6: Effects of storage materials and storage duration on the germination percentage of *S. rhinopetala* seeds

Storage materials	**Storage duration**			
	0 day	**90 days**	**180 days**	**Mean**
Jute	88.33	77.32	70.10	78.67
Nylon	89.31	78.32	71.30	79.80
Paper	90.33	79.00	72.20	80.70
Ziplock	93.30	92.20	91.40	92.60
Airtight bottle	95.33	93.32	92.33	91.60
No Packaging	90.33	75.40	69.32	78.20
Means	91.12	80.50	73.40	
HSD (0.01):	Storage Material=2.62 Storage duration= 1.58 Storage Mat. x Storage duration= 5.45			

3.7. Effects of storage materials and storage duration on the moisture content of *S. rhinopetala* seeds

There were significant storage materials x storage duration interactions on the moisture content of *S. rhinopetala* seeds (Table 7). Seeds in airtight bottle without storage recorded significantly lowest moisture, but similar to seeds stored in airtight bottle and ziplock bags for 180 days. However, seeds which were not packaged but stored for six months recorded the highest moisture content although similar to those stored in jute, nylon and paper bags for the same duration. Among the packaging materials, unpackaged seeds had significantly the highest moisture (6.35%), while the least moisture percentages were produced by seeds packaged in airtight bottle (3.57%) and ziplock bags (3.62%). Among the storage periods seeds stored for 180 days produced highest moisture (5.73%), which was 1.5 times more than the least moisture produced by seeds without storage (3.71%).

Table 7: Effects of storage materials and storage duration on the Moisture content of *S. rhinopetala* seeds

Storage materials	**Storage duration**			
	0 day	**90 days**	**180 days**	**Mean**
Jute	3.83	6.10	7.00	5.61
Nylon	3.80	6.51	6.10	5.47
Paper	3.70	5.80	5.80	5.51
Ziplock	3.51	3.62	3.65	3.62
Airtight bottle	3.50	3.60	3.60	3.57
No Packaging	3.90	7.00	8.20	6.37
Means	3.71	5.30	5.73	
HSD (0.01):	Storage Material=0.8 Storage duration= 0.5 Storage Mat. x Storage duration= 1.7			

3.8. Effects of storage materials and storage duration on vigour of *S. rhinopetala* seeds

There were significant storage materials x storage duration interactions for the vigour of *S. rhinopetala* seeds (Table 8). Unpackaged seeds stored for 180 days recorded significantly the highest vigour (32.01µScm^{-1g-1}), yet

not different from seeds packaged in jute bags (31.20 μScm^{-g-1}) , nylon (31.15 μScm^{-1g-1}) and paper bags (31.08 μScm^{-1g-1}). The least vigour was produced by seeds which were not stored (22.00 µScm-1g-1) yet similar to seeds packaged in airtight bottle (24.02 µScm-1g-1) and ziplock bags (24.50 µScm-1g-1) stored for 180 days. Among the packaging materials, unpackaged seeds produced the highest vigour (27.67 $\mu Scm^{-1}g^{-1}$), which was 1.2 times more than the least vigour recorded by seeds in airtight bottles (23.01$\mu Scm^{-1}g^{-1}$). Across the storage periods, seeds stored for 180 days had significantly highest vigour (28.42$\mu Scm^{-1}g^{-1}$), whereas the least vigour was produced by seeds which were not stored (23.02 $\mu Scm^{-1}g^{-1}$)

Table 8: Effects of storage materials and storage duration on the vigour of *S. rhinopetala* seeds

Storage materials	**Storage duration**			
	0 day	**90 days**	**180 days**	**Mean**
Jute	23.20	27.90	31.20	27.38
Nylon	23.60	27.00	31.15	26.87
Paper	23.80	25.00	31.08	25.93
Ziplock	22.50	23.20	24.50	23.40
Airtight bottle	22.00	23.00	24.02	23.01
No Packaging	23.00	28.00	32.01	27.67
Means	23.02	25.68	28.42	
HSD (0.01):	Storage Material=1.7 Storage duration= 1.0 Storage Mat. x Storage duration= 3.5			

3.9 Effects of storage materials and storage duration on the vigour index of *S. rhinopetala* seeds

There were significant storage materials x storage duration interactions on the vigour index of *S. rhinopetala*, (Table 9). Seeds with no storage recorded significantly the highest vigour index (2229.30) although similar to seeds stored for 180 days in airtight bottle (2321.32) and ziplock bags (2321.30). Seeds unpackaged and stored for 180 days recorded the least vigour index. Across the packaging materials seeds packaged in airtight bottles recorded significantly highest vigour index (2324.85), but 1.4 times more than seeds not packaged. Among the storage periods, seeds which were not stored recorded significantly highest vigour index (2271.20), which were 1.7 times more than the least produced by seeds stored for 180 days (1320.35).

Table 9: Effects of storage materials and storage duration on the vigour index of *S. rhinopetala* seeds

Storage materials	**Storage duration**			
	0 day	**90 days**	**180 days**	**Mean**
Jute	2200.31	1232.30	1229.34	1718.31
Nylon	2225.01	1230.30	1225.30	1740.04
Paper	2250.30	1238.30	1248.32	1761.72
Ziplock	2325.34	2319.30	2321.30	2324.70
Airtight bottle	2329.30	2326.30	2321.32	2324.85
No Packaging	2221.32	1234.30	1224.32	1708.30
Means	2271.20	1764.00	1320.35	
HSD (0.01):	Storage Material=2.52 Storage duration= 1.58 Storage Mat. x Storage duration=5.45			

3.10. Effects of storage materials and storage duration on the 1000 seed weight of *S. rhinopetala*

There were significant storage materials x storage duration interactions on the 1000 seed weight of *S. rhinopetala* (Table 10). Seeds in airtight bottle but not stored recorded the highest 1000 seed weight although not different from seeds stored in airtight bottles and ziplock bags for 180 days and 90 days respectively. The

unpackaged seeds stored for 180 days and 90 days recorded significantly the lowest 1000 seed weight. Across the packaging materials, seeds packaged in airtight bottle and ziplock bags recorded significantly the highest 1000 seed weight (766.33g) and (765.33g) respectively. Among the storage periods, seeds which were not stored recorded significantly the highest 1000 seed weight (771.11) whiles the least was produced by seeds stored for 180 days.

Table 10: Effects of storage materials and storage duration on the 1000 seed weight of *S. rhinopetala* seeds

Storage materials	**Storage duration**			
	0 day	**90 days**	**180 days**	**Mean**
Jute	763.05	769.01	745.23	747.67
Nylon	744.01	771.50	748.11	748.67
Paper	775.43	772.10	759.00	760.67
Ziplock	775.20	769.20	764.12	765.33
Airtight bottle	776.61	768.61	766.00	766.33
No Packaging	765.21	765.24	750.41	742.67
Means	771.11	738.50	722.67	
HSD (0.01):	Storage Material=5.5 Storage duration= 5.1 Storage Mat. x Storage duration=10.8			

4. Discussion

4.1. Effects of packaging materials and storage periods on physiological quality of *S. rhinopetala*

Airtight and ziplock storage materials were observed to have stored the seeds of *S. rhinopetala* for a longer duration than jute, nylon and paper. These could be attributed to the rapid exchange of gases between the seeds and their ambient environment under high relative humidity for the storage experiment, resulting in reabsorption of moisture by the seeds due to their hygroscopic nature thereby enhancing metabolic activities and oxidation processes. These metabolic activities and oxidation processes eventually depleted the essential food reserves in the seed leading to gradual loss of vigour and viability. The results of the present study agrees with the findings of Tonin and Perez (2006) who reported that the type of packaging at the time of seed storage becomes extremely relevant on the quality indicators, when the packaging can minimize the rate of seed spoilage, and continue to regulate the initial water content of seeds in storage, preventing the speed at which seeds respire [22]. Furthermore, an increase in storage duration under relatively high temperature and humidity could cause a rapid reduction in vigour and viability of stored *S. rhinopetala* seeds. The use of moisture proof storage materials like the airtight bottle and the ziplock bag in the current study served as barrier against gaseous exchange and maintained the quality of the seeds within the period of storage. This supports the findings of Schmidt (2007) who mentioned that seeds of tropical trees, stored into a low oxygen levels, reduce the rate at which their seeds deteriorate and age [23]. Moreover, McCormack (2004) opined that in general, storage for long or short term is improved under ambient humidity if the seed is well packaged. Safe storage of seeds depends primarily on its moisture percentage, temperature and storage duration [24]. Sastry*et al*., (2007) reported that low moisture content reduces respiration and deterioration and thereby enhances the quality of stored seeds [25]. Finally, Abreu *et al*., (2011) also reported that the factors that affect the quality of seeds in storage are; initial quality; the storage environment (with fluctuations in temperature, moisture, oxygen availability; and the container used for storage) together with features inherent to the kind of seed in study[26].

4.2. Effects of packaging materials and storage periods on biochemical properties *S. rhinopetala*

Seeds stored in airtight bottle and ziplock bags for 90 days and 180 days had the highest carbohydrate, oil and protein contents than those which were not packaged or stored in jute, nylon and paper bags but stored for longer duration. As storage duration increased the vital seed internal reserves (proteins, carbohydrates and oil) also reduced drastically possibly due to hydrolysis of available carbohydrates into sugars, peroxidation of seed oil and protein modification and denaturation. The peroxidation of lipids may be the most major cause of

deterioration and loss of viability of seeds, since it is a factor that leads to reduction on content of lipids in seeds during the storage procedure. Many times, such factor may be activated by the action of oxygen on a given polyunsaturated fatty acid, which is present in the membranes of seeds. According to Baillyet *al.* (2002), enzymatic changes may seem to be also useful in studies on seed deterioration where the decrease of antioxidant enzymes were linked to increase peroxidation of lipids as well as to accelerated aging process, with a positive correlation between antioxidant capacity of the enzymes and the vigour of seeds [27]. The results of the present study agrees with findings of Walters *et al.* (2010), who indicated that the chemical degradation of seed components during storage occurs through damages caused by oxidant agents, but the speed of such reactions is defined by properties of the seeds, which by their turn are affected by temperature as well as by moisture [28]. Additionally, It is postulated that seed oil content easily oxidizes, leading to deterioration of the seeds health in storage [29]. However, (Molteberget *al.*, (1995) reported that during storage, lipids are hydrolyzed by the lipases in free fatty acids (FFAs) and glycerol, mainly in high temperatures and moisture contents [30].

5. Conclusion

Results obtained from this research showed that airtight bottle and ziplock storage materials used for storage of *S. rhinopetala* seeds improved viability and vigour for 90 days and 180 days as compared to jute, paper, nylon and the unpackaged seeds. Airtight bottle and ziplock bag which are non-porous materials maintained seed moisture, vigour, vgour index, protein, carbohydrate and oil contents. Seed deterioration was reduced considerably in these packaging materials as compared to the others (jute, nylon, paper and the unpackaged seeds).The initial germination percentage (95.4%) had reduced slightly to 93.33% and 92.60% when stored in airtight bottle for 90 and 180 days respectively. Seeds packaged in jute, nylon and paper bags had significant reduction in germination percentage after 180 days of storage. Storing seeds in airtight bottle and the ziplock materials improved storability than in jute, paper and nylon bags.

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