The effect of pre-treatment and storage conditions on the germination potential of *Albizia lebbeck* (l.) *Benth*. and *A. odoratissima* (l.f.) *Benth*. seeds

Akinyele, A.O.[1,2] and Ajayi, A.O.[2]

[1]School of Environment, Natural Resources and Geography, Bangor University, Wales
[2]Department of Forest Production and Products, University of Ibadan, Nigeria
[1]Corresponding author's email: afsa3e@bangor.ac.uk, akinyelejo@yahoo.co.uk
ajayioluwatobiloba808@yahoo.com

ABSTRACT

The study investigated the influence of pre-treatment and storage conditions on the germination potential of *Albizia lebbeck* (l.) Benth. and *A. odoratissima* (l.f.) Benth. seeds. Mature fruits were harvested and after extraction, the seeds were divided into two batches, with one batch dried to a moisture content of 2% while the other batch was left as fresh seeds. Each batch was subjected to three storage conditions- kilner jar (KJ, 25±2ºC), paper packet (PP, 25±2ºC) and refrigeration (4±2ºC) and stored for 30, 60 and 90 days. The experiment was a 2x3x2x3 factorial in complete randomized design. Germination rate and cumulative germination percentages (CGP) were recorded and subjected to descriptive statistics and analysis of variance (ANOVA) at $p<0.05$. Storage period and storage containers had significant effects ($p<0.05$) on daily seed germination but not moisture content. Storage period and storage media had significant effect on CGP of *A. lebbeck* and *A. odoratissima* at $p<0.05$. The highest CGP was 54% and was significantly lower in *A. lebbeck* seeds stored for 30 days than 68% in seeds stored for 60 days and 64% in those stored for 90 days. *A. odoratissima* seeds stored for 90 and 60 days had significantly higher CGP of 91% and 90% respectively, than seeds stored for 30 days with CGP of 74%. *A. lebbeck* seeds in PP had significantly higher CGP (68%), than refrigeration (57%) and KJ (60%). Refrigerated *A. odoratissima* seeds had significantly higher CGP (96%) than KJ and PP, both with 80%. *A. lebbeck* seeds cannot be stored at room temperature for over two months and retain viability. Refrigerated *A. odoratissima* seeds had high germination percentage after three months.

Keywords: *Albizia*, seed germination, seed storage

INTRODUCTION

Albizia species are trees which provide arrays of benefit such as timber, food, fuel wood, medicines, nutrient recycling, and protection of soil as well as environmental services (Faisal *et al*. 2012). They also serve as fodder for livestock and wild animals. Chulet *et al.* (2010) reported the presence of different chemical constituents like alkaloids, tannins, carbohydrates, flavanoids, proteins and amino acids in *A. lebbeck* (L.) Benth, thereby confirming its use as a medicinal plant. *A. lebbeck* and *A. odoratissima* (L.f) Benth. belong to the family Fabaceae and sub family Mimosoideae. *A. lebbeck* is commonly called silk plant, silk tree or siris while *A. odoratissima* is called mimosa, tea shade tree, rosewood or black siris (Warrier 2010). They are widely distributed across West African countries and India (Faisal *et al*. 2012).

The most significant factors that influence seed storage are temperature, moisture, seed characteristics, microorganisms, and storage structure (Govender *et al*. 2008).

According to these authors, storage temperature and seed moisture content are ranked as most important factors affecting seed longevity. Seeds of many plant species are exceptionally tolerant to severe environmental conditions provided they are in a state of desiccation (Rajjou and Debeaujon 2008). Therefore, seeds may be classified based on moisture content, into orthodox, intermediate and recalcitrant. According to Roberts and Ellis (1989), orthodox seeds are desiccation-tolerant because they can be stored for long periods, if their water contents are reduced to 1 to 5% of fresh mass. Their longevity is increased with decreasing water content and storage temperature (Ellis *et al*. 1990). Sealed containers at a temperature of -18°C (or less) should ensure their viability retention for a century or more (Sasaki 1980).

The definition of recalcitrant seeds has been coined by Berjak *et al.* (1989) as "Seeds that are shed wet and cannot be dehydrated or stored". They are damaged by desiccation and are often sensitive to low temperatures and have a short storage life (Chin and Roberts 1980). Species exhibiting storage behaviour that is clearly intermediate between recalcitrant and or orthodox are termed "intermediate seeds". These are seeds that can be dried to water contents low enough to qualify as orthodox but are sensitive to the low temperatures typically employed for storage of orthodox seeds (Ellis *et al.* 1991). Navarro and Guitian (2003) stated that the characteristics of the microsite occupied by a seed may strongly influence its probability of germination and subsequent survival. Accumulation of antioxidant components in dry seeds during the tardy maturation step on the mother plant contributes to controlling their storability potential (Bailly 2004). However, storage behaviour can differ among species within a genus (Hong and Ellis 1996; Hong *et al*. 1998), Therefore, the need to investigate the appropriate storage methods that would maintain seed quality, viability and availability is important. Several studies including McDonald (1999) and Hsu *et al*. (2003) have revealed that seed germination characteristics are affected by storage period. Proper storage conditions may effectively retain substantial viability in seeds over a considerable storage period (Chen *et al.* 2007). Seeds cannot retain their viability indefinitely and after a period, the seeds deteriorate (Pascual *et al.* 2006). This is because of the effect of the interaction of moisture content, temperature, and storage duration on seed germination. Offiong *et al.* (2000) were of the view that the environmental and inherent properties of seeds play an important role in their ability to germinate. Factors such as storage method, duration, moisture content of seed in storage and temperature could cause decrease in germination percentage of seeds in storage. Seed quality evaluation can be conducted through physical and germination vigour tests that provide information about viability potential of the seeds under various periods of storage (McDonald 1994; Akbudak and Bolkan 2010). Inappropriate storage conditions such as room temperature storage often results in low seed germination, seed deterioration and loss of viability during storage which are natural phenomenon (Nasreen *et al.* 2000). Storage of seed is an essential part of a regeneration system which requires regular and sustained seed supply. Consequently, seeds which are attacked by insects and fungi while still in the pods such as *Albizia* species are unfit for sowing (Orwa *et al.* 2009*)* and should not be stored. Seeds of Fabaceae family exhibit dormancy due to hard testa, which makes them impermeable to water and gases (Shaik *et al*. 2008; Ali *et al*. 2011). *Albizia* species are no exception as their hard seed coat makes their germination irregular. Missanjo *et al.* (2013) reported the increased scarcity of *A. lebbeck* in Malawi due to deep seed dormancy. They also

recommended mechanical scarification by either puncturing with hot needle or scaling with knife as the best pre-treatment for *Albizia* species in terms of achieving high germination percentage and germination value. This study investigated the effect of moisture content, storage environments and storage duration on the germination of *A. lebbeck and A. odoratissima* seeds over a period of up to 90 days.

MATERIALS AND METHODS

Fruit collection and seed extraction

Mature pods of *A. lebbeck* and *A. odoratissima* were collected from mother trees in the field gene bank of National Centre for Genetic Resources and Biotechnology (NACGRAB), Moor Plantation, Ibadan, Nigeria at latitude 7º22'N and longitude 3º50'E, and altitude of 230m above sea level (Akinyele and Orosun 2016). Immediately after collection, the pods were transferred to the nursery of the Department of Forest Resources Management, University of Ibadan, Nigeria where the seeds were extracted manually from the pods and cleaned. Seed viability was tested using the floating test method as used by Fahrettin and Huseyin (2007) and Wakawa and Akinyele (2016). Seeds were put in a beaker with water that is twice the weight of the seeds and left overnight. Seeds that sank were deemed to be viable while those that floated were discarded.

Experimental design

The experiment was a 2x3x2x3 factorial in complete randomized design - factor A (species) at 2 levels: *A. lebbeck and A. odoratissima*, factor B (storage period) at 3 levels: 30, 60 and 90 days; factor C (seed moisture content) at 2 levels: Dried (constant moisture content of 2%) and Fresh; factor D (storage condition) at 3 levels: kilner jar (KJ) at 25±2 ºC, paper packet (PP) at 25±2 ºC and refrigerator at 4±2ºC. There were 18 treatment combinations with 3 replicates for each treatment. A total of 2,700 viable seeds per species were air dried on filter papers for 60 minutes at room temperature (25±2 ºC) to remove surface moisture. Seeds of each species were divided into two equal parts and one part was oven dried at 60 ºC until a constant moisture content of 2% was attained and the other part left as fresh seeds. Fresh seeds with 75% moisture content (1,350 seeds) and dried seeds with 2% moisture content (1,350 seeds) were subjected to 3 storage conditions: KJ at 25±2 ºC, PP at 25±2 ºC and refrigerator at 4±2ºC. Seeds at 4±2ºC were stored in the cold storage facility in the tissue culture laboratory while the rest of the experiment was carried out in the nursery. Fifty seeds of both fresh and dried were taken from each storage condition after 30 days, 60 days and 90 days, carefully nicked at the hilium with a scalpel, sown in sterilized river sand inside a green house and watered daily.

Data collection and analysis

Germination count was recorded daily for 28 days and classified as normal or abnormal according to the ISTA (1993) rules. The germination criterion was a visible protrusion of the plumule from the germination media. Seeds exhibiting abnormal germination were excluded from germination counts. Cumulative germination percentage (CGP) was recorded daily. All data generated were subjected to ANOVA at $p<0.05$. Significant means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS

Effect of storage duration on germination of *A. lebbeck and A. odoratissima*

ANOVA showed that storage period had significant ($p<0.05$) effect in terms of daily mean germination and CGP of *A. lebbeck* and *A. odoratissima* seeds (Table 1). The CGP of *A. lebbeck* stored for 30 days was significantly lower than those stored for 60

and 90 days. An average of 14 seeds germinated per day for *A. lebbeck* stored for 60 days while those stored for 90 days had an average of 13 seeds germinating per day and the lowest was 11 seeds per day after 30 days (Table 2). The CGP of *A. odoratissima* seeds stored for 30 days were significantly lower than those stored for 60 and 90 days. Germination rate was 18 seeds per day for seed stored for 60 and 90 days respectively. Seeds stored for 30 days germinated at 15 seeds per day. The CGP of *A. lebbeck* increased from 54% for the 30day storage treatment to 68% for the 60 day treatment and then dropped to 64% for the 90 day treatment. Seeds of *A. odoratissima* stored for 90 days had CGP of 91% while seeds stored for 60 and 30 days had CGP of 90% and 74% respectively.

Table 1. Effect of storage period, seed moisture content and storage media on germination *A. lebbeck* and *A. odoratissima*

Source of variation	Mean daily germination of *A. lebbeck*	CGP of *A. lebbeck*	Mean daily germination of *A. odoratissima*	CGP of *A. odoratissima*
Storage period (P)	36.67*	916.73*	68.51*	1712.67*
Moisture content (MC)	8.9 ^{ns}	222.59 ^{ns}	11.03 ^{ns}	275.63 ^{ns}
Storage media (T)	19.44*	486.01*	60.28*	1506.89*
S*MC	22.16*	553.95*	4.91	122.74
P*T	8.51 ^{ns}	212.62 ^{ns}	21.44*	535.89*
MC*T	13.65 ^{ns}	341.26 ^{ns}	14.58*	364.52*
P*MC*T	9.25	231.31	33.17*	829.30*
Error	5.19	129.834	3.67	91.70
Total	123.77	3094.30	217.59	5439.34

*Significant ($p<0.05$) ns=not significant ($p>0.05$)

Table 2. Effect of storage period, moisture content and storage environment on the germination of *A. lebbeck* and *A. odoratissima* seeds

	Treatment	Daily germination of *A. lebbeck*	Daily germination of *A. odoratissima*	CGP of *A. lebbeck*	CGP of *A. odoratissima*
Storage period (days)	30 days	11a	15a	54a	74a
	60 days	14b	18b	68b	90b
	90 days	13b	18b	64b	91b
Seed moisture content	Fresh (100%)	13a	18a	64a	88a
	Dry (2%)	12a	17a	60a	83a
Storage media	Refrigerator (4±2 ºC)	12a	19a	57a	96a
	Kilner jar (25±2 ºC)	12a	16b	60a	80b
	Paper packet (25±2 ºC)	14b	16b	68b	80b

Note: Means with the same letter along the same column are not significantly different from each other at $p<0.05$

Effect of moisture content on the mean daily germination and cumulative germination percentage of *A. lebbeck and A. odoratissima*

Seed moisture content had no significant ($p>0.05$) effect on the germination of *A. lebbeck* and *A. odoratissima* seeds (Table 1). The CGP of fresh or dry seeds were not significantly different from each other in for both species. Fresh seeds of *A. lebbeck* had germination rate of 13 seeds per day with CGP of 64% while dry *A. lebbeck* seeds had germination rate of 12 seeds per day with CGP of 60% (Table 2). Fresh

seeds of *A. odoratissima* also had a higher germination rate of 18 seeds per day with CGP of 88% while dry seeds had germination rate of 17 seeds per day with CGP of 83%.

Effect of storage media on the mean daily germination and cumulative germination percentage of *A. lebbeck and A. odoratissima*

Storage media showed significant ($p<0.05$) effect on the germination of both *A. lebbeck* and *A. odoratissima* seeds (Table 1). The CGP of *A. lebbeck* seeds stored in refrigerator and KJ were not significantly different from each other but they were significantly lower than those stored in PP. *A. lebbeck* seeds stored in PP at room temperature had highest germination rate of 14 seeds per day while refrigerated and KJ seeds had 12 germinants each. The CGP of *A. odoratissima* seeds stored in refrigerator was significantly higher than those stored in in KJ and PP. Refrigerated seeds had highest germination rate of 19 seeds per day, while seeds in KJ and PP had 16 seeds each per day (Table 2). *A. lebbeck* seeds in PP recorded the highest CGP at 68%, while seeds in KJ had 60% and refrigerated seeds had CGP of 57%. *A. odoratissima* recorded the highest CGP of 96% for seeds stored in the KJ while those in PP had CGP of 80%.

Interaction effect of treatments on germination of *A. lebbeck and A. odoratissima*

a) Moisture content and storage period

The interaction effect between seed moisture content and storage duration was significant on germination of *A. lebbeck* seeds but not *A. odoratissima* (Table 1). The CGP dry seeds stored for 30 days was significantly different form all the other treatments in both species. The CGP of fresh seeds stored for 30 and 90 days were significantly different for *A. odoratissima* but not for *A. lebbeck*. Fresh seeds that were stored for 60 days gave the best results for both mean seed germination (14 and 18 seeds per day) and CGP (72% and 92%) for *A. lebbeck* and *A. odoratissima* respectively. The least mean seed germination (9 and 14 seeds per day) and CGP (47% and 69%) were obtained from seeds that were dried and stored only for 30 days (Table 3).

b) Storage period and storage condition

The interaction effect between storage duration and storage media on the average number of seeds that germinated and CGP was not significant for *A. lebbeck* but was significant for *A. odoratissima* (Table 1). The CGP for *A. lebbeck* seeds refrigerated for 30 days was significantly lower than those of other treatments apart from KJ for the same storage period. The average seed germination and CGP were highest in seeds that were kept in PP for 60 days (15 seeds per day and 76% CGP) while those refrigerated for 30 days had the least (9 seeds germinating per day and 45% CGP) (Table 4). The CGP of seeds stored in KJ for 60 days and 90 days were significantly lower than those of other treatments for *A. odoratissima*. The highest germination was recorded from seeds refrigerated for three months (20 seeds per day and 99% CGP) while the least germination (12 seeds per day and 60% CGP) was obtained from PP seeds refridgerated for 30 days.

Table 3. Interaction effect of moisture content and storage duration on germination of *A. lebbeck* and *A. odoratissima*

Storage period (days)	Seed moisture content	Daily mean germination of *A. lebbeck*	Daily mean germination of *A. odoratissima*	CGP of *A. lebbeck*	CGP of *A. odoratissima*
30	Dry	9.42c	13.82c	47.11c	69.11c
60	fresh	14.31b	18.44a	71.56b	92.22a
90	fresh	11.87a	18.27a	59.33a	91.33a
30	fresh	12.13a	15.78b	60.67a	78.89b
60	dry	12.71ab	17.56ab	63.56ab	87.78ab
90	dry	13.73ab	18.4a	68.67ab	92.0a

Note: Means with the same letter along the same column are not significantly different from each other at $p<0.05$

Table 4. Interaction effect of storage environment and storage duration on germination of *A. lebbeck* and *A. odoratissima*

Storage period (days)	Storage condition	Daily mean germination of *A. lebbeck*	Daily mean germination of *A. odoratissima*	CGP of *A. lebbeck*	CGP of *A. odoratissima*
30	Refrigerator	8.93d	19.2ab	44.67d	96.0ab
30	Kilner jar	10.73cd	13.27c	53.67bd	66.33c
30	Paper packet	12.67abc	11.93c	63.33abc	59.67c
60	Refrigerator	13.67ac	18.47ab	68.33ac	92.33ab
60	Kilner jar	11.73ab	17.47a	58.67ab	87.33a
60	Paper packet	15.13c	18.07ab	75.67ac	90.33ab
90	Refrigerator	11.87ab	19.8ab	59.33ab	99.0b
90	Kilner jar	13.73ac	17.0a	68.67ac	85.0a
90	Paper packet	12.8abc	18.2ab	64.0abc	91.0ab

Note: Means with the same letter along the same column are not significantly different from each other at $p<0.05$

c) Seed moisture content and storage condition

The interaction effect of seed moisture content and storage environment on the mean germination rate and CGP was not significant for *A. lebbeck* but was significant for *A. odoratissima* (Table 1). The CGP of fresh *A. lebbeck* seeds stored in PP was significantly higher than those of other treatments. The highest mean germination of fresh seeds stored in PP was 15 seeds per day and 74% CGP while refrigerated fresh seeds had the least (11 seeds per day and 56% CGP) (Table 5). The CGP of fresh *A. odoratissima* seeds stored in KJ and dry seeds stored in PP were not significantly different from each other but significantly lower than those of other treatments. Refrigerated fresh seeds of *A. odoratissima* had the best mean seed germination (19 seeds per day) and CGP (97%) while the least germination values of 15 seeds per day and 76% CGP were obtained with dried seeds stored in the PP (Table 5).

Seed moisture content, storage condition, storage period

ANOVA revealed that the interaction effect of the three treatments was significant ($p<0.05$) for germination of *A. odoratissima* seeds but not significant for *A. lebbeck* (Table 1). The CGP of dry seeds of *A. odoratissima* stored for 30 days in PP and KJ were significantly different from other treatments. The highest mean daily germination of 20 seeds and CGP of 99% were obtained with fresh seeds of *A. odoratissima* refrigerated for 90 days (Table 6). Dry seeds refrigerated for 90 days also had mean germination rate of 20 seeds per day and a CGP of 98%. Dry

seeds refrigerated for 30 days had a mean germination rate of 19 seeds per day and a CGP and 98%.

The CGP of fresh refrigerated seeds of *A. lebbeck* stored for 30 days was significantly different from other treatments. Fresh seeds of *A. lebbeck* stored in PP for 30 days had the highest mean germination rate of 17 seeds per day and CGP of 83%. Fresh seeds stored in PP for 60 days had mean germination rate of 16 seeds per day and a CGP of 81%. Dried seeds of *A. lebbeck* stored in KJ for 90 days had mean germination rate of 15 seeds and a CGP of 73% while fresh seeds refrigerated for 60 days had germination rate of 14 seeds per day and a CGP of 72% (Table 6). Only 14 seeds were recorded daily for dry seeds stored in PP for 60 and 90 days while CGP was 71 % and 68% respectively.

Table 5. Interaction effect of seed moisture content and storage condition on germination of *A. lebbeck* and *A. odoratissima*

Seed moisture content	Storage condition	Daily mean germination of *A. lebbeck*	Daily mean germination of *A. odoratissima*	CGP of *A. lebbeck*	CGP of *A. odoratissima*
Fresh	Refrigerator	11.11a	19.38d	55.56a	98.89d
Fresh	Kilner jar	12.31a	15.6a	61.56a	78.0a
Fresh	Paper packet	14.89b	17.51bc	74.44b	87.56bc
dry	Refrigerator	11.87a	18.93cd	59.33a	94.67cd
dry	Kilner jar	11.82a	16.22ab	59.11a	81.11ab
dry	Paper packet	12.18a	14.62a	60.89a	73.11a

Note: Means with the same letter along the same column are not significantly different from each other at $p<0.05$

Table 6: Interaction effect of all treatments on germination of *A. lebbeck* and *A. odoratissima*

Storage period (days)	Storage condition	Seed moisture content	Daily mean germination of *A. lebbeck*	Daily mean germination of *A. odoratissima*	CGP of *A. lebbeck*	CGP of *A. odoratissima*
30	Refrigerator	Fresh	8.27a	19.07de	41.33a	95.33de
30	Kilner jar	Fresh	11.6abcde	11.33b	58.0abcd	56.67b
30	Paper packet	Fresh	16.53e	16.93cde	82.67f	84.67cde
30	Refrigerator	Dry	9.6abc	19.33de	48.0abc	96.67de
30	Kilner jar	Dry	9.87abc	15.2c	49.33abc	76.0b
30	Paper packet	Dry	8.8ab	6.93a	44.0ab	34.67a
60	Refrigerator	Fresh	14.4ef	19.07de	72.0ef	95.33de
60	Kilner jar	Fresh	12.4bcde	18.0cde	62.0bcde	90.0cde
60	Paper packet	Fresh	16.13e	18.27cde	80.67f	91.33cde
60	Refrigerator	Dry	12.93cdef	16.87cde	64.67cdef	89.33cde
60	Kilner jar	Dry	11.07abcde	16.93cde	55.33abcd	84.67cde
60	Paper packet	Dry	14.13def	17.87cde	70.67def	89.33cde
90	Refrigerator	Fresh	10.67abcd	20.0e	53.33abcd	95.33de
90	Kilner jar	Fresh	12.93cdef	17.47cde	64.67cdef	87.33cde
90	Paper packet	Fresh	12.0bcde	17.33cde	60.0bcde	86.67cde
90	Refrigerator	Dry	13.07cdef	19.6de	65.33cdef	98.0de
90	Kilner jar	Dry	14.53ef	16.53cd	72.67ef	82.67cd
90	Paper packet	Dry	13.6def	19.07de	68.0def	95.33de

Note: Means with the same letter along the same column are not significantly different from each other at $p<0.05$

DISCUSSION

This study revealed that seed storage period and storage condition affected the germination potential of *A. lebbeck.* In *A. odoratisima* seeds, as storage period increased, there was an increase in the cumulative and average daily seeds germination. This could be because storage capacity of many species is increased when the moisture content of the seeds is linked with a reduced environmental temperature (Walters 1998). The results of this study are in agreement with Oboho and Ngalum (2014) who showed that storage method and duration affected the seed moisture content and germination of *Treculia africana*. Dresch *et al.* (2014) also reported that *Campomanesia adamantium* seeds at 15.3% moisture content did not tolerate storage at different storage period. Adelani and Joseph (2014) observed a similar trend in the storability of *Acacia auriculiformis* while Escandon *et al.* (2013) reported that germinability decreases with increase in age of stored seeds of *Jatropha curcas.* Nuga *et al.* (2011) recorded a progressive decrease in the viability and germination capacity of the seeds of *Treculia africana* as storage period increased. Kazeem Ibrahim *et al.* (2016) observed a reduction in percentage germination of *Caesaplinia bonduc* (L.) Roxb seeds stored at different periods and an increase in germination percentage at storage temperature of 6^{o}C when compared with seeds stored at room temperature. These reports could be attributed to the deterioration which sets in when seeds are not properly stored or they are stored for long duration.

Fresh seeds of both *A. lebbeck and A. odoratissima* in storage recorded best germination potentials although both species had different responses to storage temperatures in the various storage environments. This could be because moisture content is one of the factors determining safe storage of seeds which, if not adhered to could lead to loss of viability in storage over time (Siddique and Wright, 2003) and reduced temperature in the various storage environments helps seeds to remain viable for extended periods (Adelani and Joseph, 2014).

However, while *A. lebbeck* seeds which were kept in PP gave the best germination rate, refrigerated seeds of *A. odoratissima* seeds had optimum viability and germination. The results agree with Evans (1992) who reported that seeds of forest tree species should be stored in a cool dry place preferably under refrigeration. The temperature and the length of time of storage of this species did not influence the ability of these species to germinate optimally in this study.

On the other hand, storage media and duration of storage affects the viability and germination ability of *A. odoratissima* seeds with proper management of storage media and storage duration of these seeds having the potential to improve the seed quality and germination percentage. This is because seeds of plants respond differently to conditions of storage, and the time of viability of seeds of forest trees vary greatly by species (Onyekwelu and Fayose 2007). The results suggest that the quality of the seed of *A. odoratissima*, improves with prolonged storage period up to 90 days in the refrigerator. Pritchard *et al.* (1995) stated that the speed of spontaneous germination of *Araucaria hunsteinii* seeds during storage depends on the moisture content and the storage media. In a study carried out by Gbadamosi (2013) on seeds of *Picralima nitida*, germination was only recorded in fresh seeds stored for a maximum period of six months at ambient room temperature but not in any other storage condition. This is contrary to the results of this study where moisture content did not have significant effect on the germination of seeds of *A. lebbeck* and *A. odoratissima*. This could be attributed to desiccation tolerance of the *Albizia*

species. Santoso *et al.* (2012) also found that seeds of *Jatropha curcas* could be stored in the ambient room storage for at least five months and their viability would be preserved. Germination of seed is a function of duration of storage, storage temperature and moisture content at storage (Croft *et al*. 2012). The deterioration in seed quality, viability and germination potentials of *A. lebbeck* after a month may be because of biochemical manifestation (Copeland and MacDonald 2001), membrane degradation (Singh and Dadlani 2003), decrease in enzyme activity (Perl *et al*. 1978), or changes in chemical constituents of the cell (Verma *et al*. 2003). Although it was anticipated that lower temperature storage conditions would maintain better viability of seeds and improve the germination percentage over time, *A. lebbeck* behaved contrarily to this expectation while *A. odoratissima* confirmed the assumption in this study. Viability of refrigerated fresh seeds of *A. odoratissima* for 90 days was maintained as the germination potentials of these species remained 99%. This could be because of adequate moisture content and exchange of gases in the seeds which helps in maintaining proper level of sugars and starches which are required for good germination of the seeds.

CONCLUSION

Albizia species responded differently to the various storage conditions. The viability of fresh seeds of *A. lebbeck* can only be maintained for 30 days in paper packet before decreasing while storage of fresh seeds of *A. odoratissima* at 4 ± 2^0C retained viability for a longer period. This confirms the feasibility of short term storage at a lower temperature regime. However, there is need for further studies on long term storage of the seeds of *Albizia* species.

Acknowledgements

The authors acknowledge the support of National Centre for Genetic Resources and Biotechnology, Moor Plantation for provision of the seeds and Department of Crop Protection and Environmental Biology, University of Ibadan for the use of their storage facilities.

REFERENCES

Adelani, D.O. and Joseph, A. 2014. Storability of Japanese acacia in northern guinea savannah ecological zone in Nigeria. *Forests and Forest Products Journal.*7:1-10.

Akbudak, N., and Bolkan, H. 2010. Diagnostic method for predicting tomato seedling emergence. *Journal Food Environment*. (8):170–174.

Akinyele, A.O. and Orosun, B.O. 2016. Influence of Hormone in the Propagation of *Synsepalum dulcificum* (Schumach & Thonn.) Daniell. *Ghana Journal of Forestry*. Volume 32: 16-23.

Akinyele, A.O. and Onasanya, O.D. 2014. Effect of pre-treatments and sowing media on germination of seeds of *Tetrapleura tetraptera* (Schum & Thonn) Taub. *Nig. J. Ecology* 13:47-53.

Ali, H.H., Tanveer, A., Nadeem, M.A. and Asghar, H.N. 2011. Methods to break seed dormancy of *Rhynchosia capitate* a summer annual weed. *Chilean Journal of Agricultural Research.* 71:483-487.

Bailly, C. 2004. Active oxygen species and antioxidants in seed biology. *Seed Science Research* 14: 93-107.

Baskin, J.M. and Baskin, C.C. 2004. A classification system for seed dormancy, *Seed Science Research*, vol.14, pp.1-16.

Berjak, P., Farrant, J.M. and Pammenter, N.W. 1989. The basis of recalcitrant seed behaviour. In: R.B. Taylorson (Editor). *Recent advances in the development and germination of seeds.* Plenum Press, New York. pp. 89–108.

Chen, S.Y., Kuo, S.R. and Chien C.T. 2007. Storage behaviour of seeds of *Cinnamomum osmophloeum* and *Neolitsea aciculata* var *variabillima* (Lauraceae). *Seed Science and Technology* 35:237-243.

Chin, H.F. and Roberts, E.H. 1980. *Recalcitrant crop seeds.* Tropical Press Sdn. Bhd. Kuala Lumpur, 120 pp.

Chulet, R., Joseph, L., George, M. and Pradhan, P. 2010. Pharmacognostic standardization and phytochemical screening of *Albizia lebbeck*. *Journal of Chemical and Pharmaceutical Research*, 2432-443.

Copeland, L.O. and McDonald, M. 2001. Principle of Seed Science Technology. 4th edition Norwell, Massachusetts: Kluwer Academic Publishers. 488pp.

Croft, M., Bicksler, A., Manson, J. and Burnette, R. 2012. Vacuum sealing vs. refrigeration: Which is the most effective way to store seeds? *ECHO Asia Notes*14:1-6.

Dresch, D.M., de Paula Quintão Scalon, S., Masetto, T. E. and Mussury, R. M. 2014. Storage of *Campomanesia adamantium* (Cambess.) O. Berg Seeds: Influence of Water Content and Environmental Temperature. *American Journal of Plant Sciences*, 5:2555-2565. http://dx.doi.org/10.4236/ajps.2014.517269

Ellis, R.H., Hong, T.D. and Roberts, E.H. 1990. An intermediate category of seed storage behavior? 1. Coffee. *Journal of Experimental Botany* 41: 1169–1174.

Ellis, R.H., Hong, T.D. and Roberts, E.H. 1991. An intermediate category of seed storage behavior? Effects of provenance, immaturity, and imbibition on desiccation-tolerance in coffee. *Journal of Experimental Botany* 42: 653-657.

Escandon, J.M., Silva, B.C.F., Silva, S.R.S., Granja, J.A.A., Alves, M.C.J. L. and Pompelli, M.F. 2013. Germination responses of *Jatropha curcas* seeds to storage and ageing. *Industrial Crops and Products.* 44:684-690.

Evans. J. 1992. Plantation forestry in the tropics: tree planting for industrial, social, environmental, and agroforestry purposes. Clarendon Press.

Faisal, M., Singh, P.P. and Irchhaiya, R. 2012. Review on *Albizia lebbeck* a potent herbal drug. *International Journal of Pharmaceutics*, 3:63-68.

Fahrettin, T. and Huseyin, D. 2007. Seed germination of three provenances of *Pinus brutia* (Ten.) as influenced by stratification, temperature and water stress. *Journal of Environmental Biology*, 28:133-136.

Gbadamosi A.E. 2013. Effect of moisture content, temperature and storage duration on seed germination of *Picralima nitida* (Stapf). *Ibadan Journal of Agricultural Research* 10(1): 25-33.

Govender, V., Aveling, T.A. and Kritzinger, Q. 2008. The effect of traditional storage methods on germination and vigour of maize (*Zea mays* L.) from northern KwaZulu-Natal and southern Mozambique. *South African Journal of Botany*. 74:190-6.

Hong, T.D, Ellis, R.H. and Linington, S. 1998. *Compendium of information on seed storage behaviour*. The Royal Botanic Gardens.

Hong, T.D. and Ellis, R.H. 1996. *A protocol to determine seed storage behaviour* (No. 1). Bioversity International.

Hsu, C.C., Chen, C.L., Chen, J.J. and Sung, J.M. 2003. Accelerated aging-enhanced lipid peroxidation in bitter gourd seeds and effects of priming and hot water soaking treatments. *Science of Horticulture*. 98:201-212.

International Seed Testing Association (ISTA). 1993. International rules for seed testing. Rules 1993. *Seed Science and Technology* 21 (Suppl.):1-75.

Kazeem-Ibrahim, F., Akinyele, O.A. and Asinwa, O.I. 2016. Influence of different storage temperatures and periods on the germination of *Caesaplinia bonduc* (L.) Roxb seeds. *Journal of Forestry Research and Management*. Vol. 13, 71-82.

McDonald, M.B. 1994. Seed lot potential: viability, vigour and field performance. *Seed Science Technology*. 22:421–425.

McDonald, M. B. 1999. Seed deterioration: physiology, repair and assessment. *Seed Science Technology*. 27:177-237.

Missanjo, E., Maya, C., Kapira, D., Banda, H. and Kamanga-Thole, G. 2013. Effect of Seed Size and Pretreatment Methods on Germination of *Albizia lebbeck*. International Scholarly Research Notices. Volume 2013, Article ID 969026, 4 pages http://dx.doi.org/10.1155/2013/969026.

Mudasir, Q., Fatima, K. and Haukat, S.K. 2012. Effect of pre-treatment on the germination of *Abrus precatorius (*Linn) by soaking in water. *Indian Journal Applied Pure Biology* 27:105-108.

Nasreen, S., Khan, B.R. and Mohmad, A.S. 2000. The effect of storage temperature, storage period and seed moisture content on seed viability of soya bean. *Pakistan Journal of Biological Science*. 3:2003-2004.

Navarro, L. and Guitian, J. 2003. Seed germination and seedling survival of two threatened endemic species of the northwest Iberian Peninsula. *Biological Conservation*, 109:313-320.

Nuga, O., Okonkwo, H.O. and Deckor, A. 2011. Influence of storage duration on the Viability and germination of *Treculia africana* (Decne). *Tree Crop Journal.* 5:12-17.

Oboho, E.G. and Ngalum, E.L. 2014. Germination response of *Treculia africana* (Dacne) seeds in relation to moisture content, storage method and its duration. *Journal of Applied and Natural Science*. 6:88-94.

Offiong, M.O, Oboho, G.E, Ndaeyo, N.U. 2000. Influence of Storage methods and duration on the germinability of three agroforestry tree species. *Nigeria Journal of Agricultural Technology*. 9:30-37.

Onyekwelu, J. C and Fayose, O. J. 2007. Effect of storage method on the germination and proximate composition of *Treculia africana* seed. Conference on International Agricultural Research for Development. University of Kassel-Witzerhausen and University of Gottingen. 34-39.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Anthony, S. 2009. Agroforestry Database: a tree reference and selection guide. (http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp) as accessed on 26 October, 2016.

Pascual, B., Bautista, A.S, López-Galarza, S., Alagarda, J. and Maroto, J.V. 2006. Germination behaviour after storage of caper seeds. *Seed Science and Technology*. 34:151–159.

Perl, M., Luria, I. and Gelmond, H. 1978. Biochemical changes in sorghum seeds affected by accelerated ageing.

Journal of Experimental Botany. 29:479-509.

Pritchard, H.W., Tompsett, P.B., Manger, K. and Smidt, W. J. 1995. The effect of moisture content on the low temperature responses of *Araucaria hunsteinii* seed and embryos. *Annals of Botany*, 76:79-88.

Rajjou, L. and Debeaujon, I. 2008. Seed longevity: survival and maintenance of high germination ability of dry seeds. *Comptes rendus biologies*, 331:796-805.

Roberts, E.H. and Ellis, R.H. 1989. Water and sedd survival. *Annals of Botany* 63: 39-52

Santoso, B.B., Budianto, A.R.I.S. and Aryana, I.M. 2012. Seed viability of *Jatropha curcas* in different fruit maturity stages after storage. *Bioscience*, 4:113-117.

Sasaki, S. 1980. Storage and germination of dipterocarp seeds. *Malaysian Forester* 43: 290-308.

Shaik, S, Dewir, Y.H., Singh, N. and Nicholas, A. 2008. Influences of pre-sowing seed treatments on germination of the cancer bush (*Sutherlandia frutescens*), a reputed medicinal plant in arid environments. *Seed Science Technology*. 36:795-801.

Siddique, A.B. and Wright, D. 2003. Effects of different drying time and temperature on moisture percentage and seed quality (viability and vigour) of pea seeds (*Pisum sativum* L.). *Asian Journal of Plant Science*, 2: 978-982.

Silva, L.M., Fernandes, G.W. 2014. Effect of seed storage on germination, seedling growth and survival of *Mimosa foliolosa* (Fabaceae): implications for seed banks and restoration ecology. *Tropical Ecology*, *55*(3):385-392.

Singh, K.K., Dadlani, M. 2003. Effect of packaging on vigor and viability of soybean (*Glycine max* (l.) Merrill) seed during ambient storage. *Seed Research*. 31:27-32.

Verma, S.S., Tomer, R.P.S. and Verma, U. 2003. Loss of viability and vigour in Indian mustard seeds stored under ambient conditions. *Seed Research* 31:98-101

Walters, C. 1998. Understanding the Mechanisms and Kinetics of Seed Aging. Seed Science Research, 8, 223-244.

Wakawa, L.D and Akinyele, A.O. 2016. Effects of Pretreatment on the Germination Response of old seeds of *Tetrapleura tetraptera* (Schum & Thonn) Taub. *Journal of Forest Science and Environment.* Volume 1:81-86.

Warrier, K.C.S. 2010. *Albizia lebbeck* (L.) Benth. Manual of Economically Important Forestry Species in South India (Eds.) Krishnakurnar, N., Palanisamy, K., Hegde, M., Warrier, K.C.S., Krishnarnoorthy, M. Institute of Forest Genetics and Tree Breeding, India.