

Full Length Research Paper

Physiological quality of African eggplant seeds as influenced by natural fermentation and drying methods

Hillary Mireku Botey^{1,2*}, Julius Onyango Ochuodho², Lucas Ngode², Eric Owusu Danquah¹ and Richard Agyare R.³

¹CSIR-Crops Research Institute, Box 3785, Kumasi, Ghana.

²Department of Seed, Crop and Horticultural Sciences, University of Eldoret 1125-30100, Eldoret, Kenya.

³CSIR-Savannah Agricultural Research Institute, Tamale, Ghana.

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Seed extraction and drying methods are important procedures employed after harvesting fruits of African eggplant as these methods affect the seed quality. This study sought to evaluate the seed physiological quality of two cultivars of African eggplant subjected to various durations of natural fermentation and different drying methods. In the first study, fruits were fermented for 0, 6, 12, 24 and 48 h before seed extraction. In the second experiment, seeds were extracted and subjected to sun/24 h; shade/24 h; shade/48 h; desiccant (silica gel)/24 h; shade/24 h + 30 °C oven (24 h); 30°C/24 h; 35 °C/24 h; 45 °C/24 h; 50°C/24 h and 60°C/24 h for drying. The seed quality evaluation were seed moisture content, seed dry weight, first count, seed germination and accelerated aging. The results suggest that African eggplant seeds do not require natural fermentation during extraction for enhanced seed germination. All drying methods were able to reduce seed moisture content to an ideal level for storage and maintained seed physiological quality. The latent effect of these methods on seed physiological quality needs to be studied.

Key words: *Solanum aethiopicum*, drying, fermentation, seed quality, seed extraction.

INTRODUCTION

The African eggplant (*Solanum aethiopicum* L.) is one of the most commonly consumed fruit vegetable in Ghana and West Africa. It is considered the third most cultivated and consumed after tomato, onion and before okra in Ghana (Horna et al., 2007; Osei et al., 2010). Seeds that are borne in fleshy fruits are subjected to several postharvest handling practices which do affect the quality

of seeds positively or negatively. Two of such important practices are seed extraction and drying methods.

Several seed extraction methods such as wet, dry, natural fermentation, chemical fermentation, and mechanical extraction have been used to extract seed from fruit vegetables such as tomato (Demir and Samit, 2001), egusi melon (Ogbonna and Odo, 2011), cucumber

*Corresponding author. E-mail: hmireku@gmail.com.

(Chethan et al., 2013) and eggplant (França et al., 2013; Rahman et al., 2015). These various methods had varied effects on seed quality among different species. Silva et al. (1982) observed that natural fermentation gave a lower germination than acid treatment fermentation in tomato. Demir and Samit (2001) also observed the same results. For eggplant, França et al. (2013) observed no significance difference among seed extraction methods used on first germination count. A reduced percent seed germination was observed when fermentation duration was extended to 48 h either with acid or without. In cucumber, seeds extracted with natural fermentation resulted in highest germination (94.5%) and seed vigour compared to alkali or acid extraction methods (Chethan et al., 2013). These studies suggest that each species has an ideal extraction method for maintaining maximum seed quality. There is few studies reported on how natural fermentation, a common practice by smallholder farmers influence the seed quality of the African eggplant (*Solanum aethiopicum* L.).

After seed extraction from fleshy fruits, the next important step in maintaining the quality of seed is drying. Seed moisture content (MC) plays critical role in determining the longevity of seed in several vegetables (Wang et al., 2001). Generally, seeds are harvested at high moisture content and need to be dried before storage with a careful attention to the rate and extent of post-harvest drying (Babiker et al., 2010). Botey et al. (2021a) reported a seed moisture content of 42 - 46% when fruits were harvested at the recommended harvest stage of 60-76 days after anthesis in African eggplant. While most vegetable seeds can withstand drying to extend their storage life with low moisture content (Wang et al., 2001), this may differ with species.

This suggests that not all kinds of drying methods will suit equally well under given set of conditions in retaining viability and vigour of seeds, hence each crop should be evaluated accordingly. The extent to which these various drying methods reduce seed moisture and influence the physiological quality of African eggplant seeds is however not known. The present study sought to evaluate the physiological quality of African eggplant seeds subjected to different natural fermentation and drying methods.

MATERIALS AND METHODS

A first experiment was carried out to evaluate the effect of extraction methods on the physiological quality of seeds. The trial was conducted at the University of Eldoret, Department of Seed, Crop and Horticultural Sciences, Kenya. Fifty fruits of two cultivars (cv. *Oforiwa* and *Kpando*) were harvested 70 days after anthesis (DAA) and processed same day or less than 48 h to avoid possible after-ripening effect. For seed extraction, ten fruits were carefully cut individually with sharp knife and seeds were extracted immediately by hand from the pulp or put in a plastic container containing distilled water placed in an ambient condition for 6, 12, 24 and 48 h for fermentation. Well-formed seeds after the

fermentation periods separated from the pulp and remained at the bottom of the container while immature seeds which were floating were discarded. Seeds were thoroughly rinsed with running water. After each natural fermentation period, the seed moisture content was determined for each treatment using the oven method at 105°C ± 3 for 24 h on fresh wet basis (Brasil, 2009). All the seeds after each treatment were dried under shade for 48 h. Seed quality tests were evaluated as follows:

Seed dry weight: Sub-samples of seeds extracted from each treatment were dried in oven at 30°C for 24 h after which seed weight by weighing four replicates of 100 seeds on an analytical balance to two decimal places and the mean results expressed in grams.

Germination test: Four replications of 50 seeds for each treatment were used. Seeds were evenly spread on a two layer Whatman paper moistened with distilled water and placed in a petri dish. The petri dishes were then incubated at 30/20°C in an 8/16 h alternating light/dark periods as recommended by Botey et al. (2021a). Germination was conducted for 14 days. Daily germination was recorded until the 14th day. Results were expressed as a mean percentage of normal seedlings for each lot.

First germination count: This was done together with the germination test by counting the number of normal seedlings identified on 7th day after sowing.

Accelerated ageing test: Accelerated aging was conducted in plastic boxes measuring 14 x 12 x 4.5 cm. A fiber mesh screen was suspended inside the plastic box on which seeds were evenly distributed to form a thin layer. Approximately 2.0 g of seeds from each treatment was used. To create the desired humidity condition for the test, 40 ml of water was added to each plastic box. The boxes were covered and maintained in an incubator at 42°C for 72 h, after which seeds were submitted to the germination test as previously described. Evaluations were performed seven days after sowing and the results expressed as mean percentage of normal seedlings for each lot.

Experiment II: The objective was to evaluate the seed physiological quality of African eggplant cultivars as influenced by drying method. Seeds were extracted from 5 harvested fruits of each cultivar at the same maturity stage as in the first experiment. Extracted seed were then immediately washed under running water and subjected to the various drying methods of sun/24 h; shade/24 h; shade/48 h; desiccant (silica gel)/24 h; shade/24 h + 30°C oven (24 h); 30°C/24 h; 35 °C/24 h; 45°C/24 h; 50°C/24 h and 60°C/24 h. The seed moisture content was measured after the different treatments following the same methodology as previously described in the first experiment. The seed physiological quality was measured by first germination count as an indication of seed vigour and percentage seed germination. First germination count was recorded after 7 days of sowing. Final seed germination percentage was calculated after day 14 as number of seeds germinated against total number of seeds sown and expressed as a percentage.

Design and statistical analysis

Experiment I: A completely randomized design in a factorial arrangement was used for this experiment. Cultivar and fermentation durations constituted the factors. Treatments were replicated four times. The African eggplant cultivar were cv. *Oforiwa* and cv. *Kpando*. The fermentation durations were 0, 6, 12, 24 and 48 h. The data collected were subjecting to analysis of variance

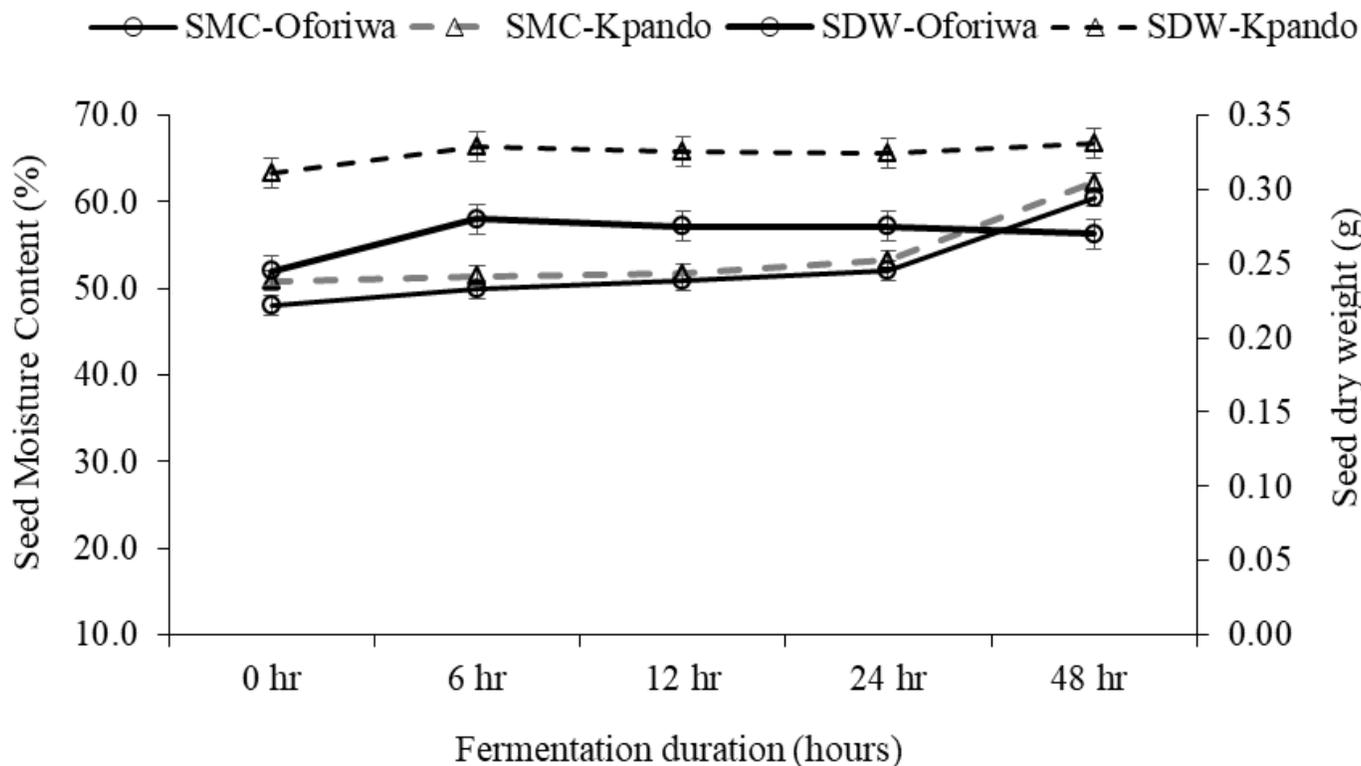


Figure 1. Seed moisture contents (SMC) and Seed dry weight of cv. *Oforiwa* and cv. *Kpando* African eggplant seeds as influenced by various fermentation duration (means ± SEM bars).

(ANOVA) and treatment means compared using the Tukey test at 5% significant level.

Experiment II: Data was similarly analyzed in a two cultivar x eight drying methods factorial in a completely randomized design (CRD) with four replications. Data were subjected to normality tests (Shapiro-Wilks) before analysis of variance (ANOVA) and means compared using Tukey’s test at the 5% significant level.

RESULTS AND DISCUSSION

The effects of fermentation duration on seed moisture content and seed dry weight of the cultivars of African eggplant is presented in Figure 1. As indicated in Figure 1, the analysis of variance of the data gave significant results ($p < 0.05$) for the individual effects of duration of natural fermentation and cultivar in seed moisture, first count, and accelerated ageing except on germination percentage (Table 1). The interactive effects were significant for all studied variables hence their individual effects is not further discussed.

Increasing the fermentation period of the seeds of African eggplant resulted in increased seed moisture content in both cultivars (Figure 1). Seed moisture content increased from 47 to 60.3% after 48 h of

fermentation. The cultivar *Kpando* showed a slightly higher absorption capacity compared to cv. *Oforiwa*. For normal eggplant (*Solanum melongena*), Franca et al. (2013) also observed an increasing seed moisture content from 58 to 74% when seeds were fermented naturally or with acid. Similar trend of seed moisture content was reported by Lopes et al. (2001) for pomegranate seeds. Variation in moisture and water uptake among the cultivars is attributed to genetic differences (Sabongari and Aliero, 2004) as reported for tomatoes and for African eggplant (Botey et al., 2021b). Cultivar *Kpando* which had a slightly higher water uptake (seed moisture) capacity is relatively heavier (dry seed weight (g) as observed in Figure 1. This cultivar is also larger in size with bigger surface area for absorption than cv. *Oforiwa* which has smaller seeds. Cultivar *Kpando* had more dormant seeds compared to cv. *Oforiwa* (Table 1), which suggests that cellular walls were not completely dry and had readily available openings to absorb more water (Sabongari and Alieno, 2004).

The first germination count (seed vigour) was significantly ($p < 0.05$) influenced by the fermentation period and the cultivars (Table 1). The highest percentage first count was observed after 6 h of fermentation in both cultivars (76% in cv. *Oforiwa* and 59% in cv. *Kpando*).

Table 1. Effect of fermentation duration on first germination count, percentage germination and accelerated ageing (mean \pm standard deviation) for cv. *Ofoirwa* (CV1) and cv. *Kpando* (CV2) African eggplant seeds subjected to varied durations of natural fermentation.

Treatment	First germination count (%)		Germination (%)		Accelerate ageing (%)	
	CV1	CV2	CV1	CV2	CV1	CV2
0 h No fermentation	73 \pm 5.03 ^{ab}	32 \pm 9.79 ^e	99 \pm 2.00 ^a	89 \pm 5.03 ^{ab}	62 \pm 1.70 ^c	52 \pm 1.70 ^c
6 h fermentation	76 \pm 3.20 ^a	52 \pm 7.30 ^c	99 \pm 2.00 ^a	86 \pm 4.00 ^c	61 \pm 1.50 ^c	54 \pm 1.50 ^c
12 h fermentation	55 \pm 3.82 ^c	39 \pm 3.82 ^d	98 \pm 2.30 ^a	86 \pm 7.65 ^c	80 \pm 0.95 ^a	82 \pm 2.50 ^a
24 h fermentation	67 \pm 3.82 ^b	49 \pm 6.83 ^c	98 \pm 2.30 ^a	88 \pm 8.00 ^c	71 \pm 1.50 ^b	60 \pm 1.70 ^b
48 h fermentation	76 \pm 4.61 ^a	47 \pm 3.82 ^c	96 \pm 3.26 ^{ab}	90 \pm 6.92 ^{bc}	70 \pm 1.50 ^b	83 \pm 5.80 ^a

Means followed by the same letter in the column do not differ significantly based on Tukey test at 5% probability level. 1 data was transformed before statistical analysis.

These percentages were not significantly different when seeds were fermented up to 48 h in both cultivars. However, when seeds were subjected to sub-optimal conditions through accelerated ageing (AA %) (Table 1), seeds fermented up to 12 h proved resilient with 80 - 82% seed germination in both cultivars. In normal eggplant (*Solanum melongena* L.), Chethan et al. (2013) observed a higher seed vigour index I and II in cucumber seeds subjected to natural fermentation for 24 h. This suggests that fermentation improves seed vigour in African eggplant although the period is less than those reported for eggplant. Rahman et al. (2015) also reported similar results of an improved seedling vigour when eggplant was extracted by the wet method which is similar to natural fermentation. The authors observed a higher seedling vigour index in wet seeds extraction than those extracted without fermentation (Rahman et al., 2015).

Fermentation period did not improve seed germination percentage (Table 1). However, germination capacity differed between the cultivars (Table 1). The difference was only observed among the cultivars, attributable to genetic difference. Results by Franca et al. (2013) for eggplant (*S. melongena*) on the contrary showed a significant decrease in percentage germination when seeds were fermented up to 48 h. In the case of tomato, Sabongari and Aliero (2004) reported an improvement in germination when seeds were soaked with maximum germination occurring after 24 h but declined when this period was extended to 36 h. The decreased observed at longer fermentation periods could be due to reduced oxygen content (anoxia) in the water resulting in lower germinative capacity. Cardoso et al. (2001) also reported an increase in germination percentage when yellow passion fruits were subjected to fermentation. These varied results suggest that each crop species behave differently to fermentation. It has been reported that each species has an ideal fermentation period without causing anoxia. Lopes et al. (2001) reported 72 h for pomegranate

and Franca et al. (2013) recommended 24 h for eggplant. From this study, the African eggplant seeds can be extracted after harvesting at the optimum time without fermentation. For the purpose of improving seed vigour, up to 12 h of fermentation would be ideal.

The African eggplant seeds attain physiological maturity at high moisture contents ranging from 46- 52% (Botey et al., 2021b). Therefore, the seeds should be extracted and dried early enough to obtain better quality seeds. The various methods employed for drying seeds of African eggplant resulted in varied levels of moisture content of seeds. Oven drying of seeds at 35, 45 and 50°C for 24 h reduced seed moisture content significantly from initial 47% seed moisture content to 3.4 and 6.6% compared to other types of drying (Figure 2). Oven drying temperatures applied in this study were able to remove 85.5 to 93% moisture within 24 h of drying. Shade drying removed the lowest moisture content (80.4%) followed by desiccant drying (81.7%). The other drying methods reduced seed moisture down to 8.3 and 9.2% except shade drying for 48 h in cv. *Kpando* (6.1%).

This is consistent with the observation made by Franca et al. (2013) for eggplant, when the reduction in moisture content was greater for oven drying temperatures. Oven drying was able to dry seeds quickly at higher temperatures because the capacity of air to remove moisture depends on the surrounding temperature and humidity. The higher the temperature, the lower the humidity and the greater the moisture removal capacity of the surrounding air. Seeds dried in the open (sun or shade drying) have the tendency to reabsorb moisture from the surrounding air due to its hygroscopic nature. Ravi et al. (2007) also reported similar results for chilli seeds dried under sun (8.74%) and shade (9.58%). Chilli seeds dried using oven at 35°C gave the lowest seed moisture content of 8.59% (Ravi et al., 2007).

Taking into consideration the recommendation by George (2000) that 6% seed moisture content is suitable for eggplant seeds storage and a general observation

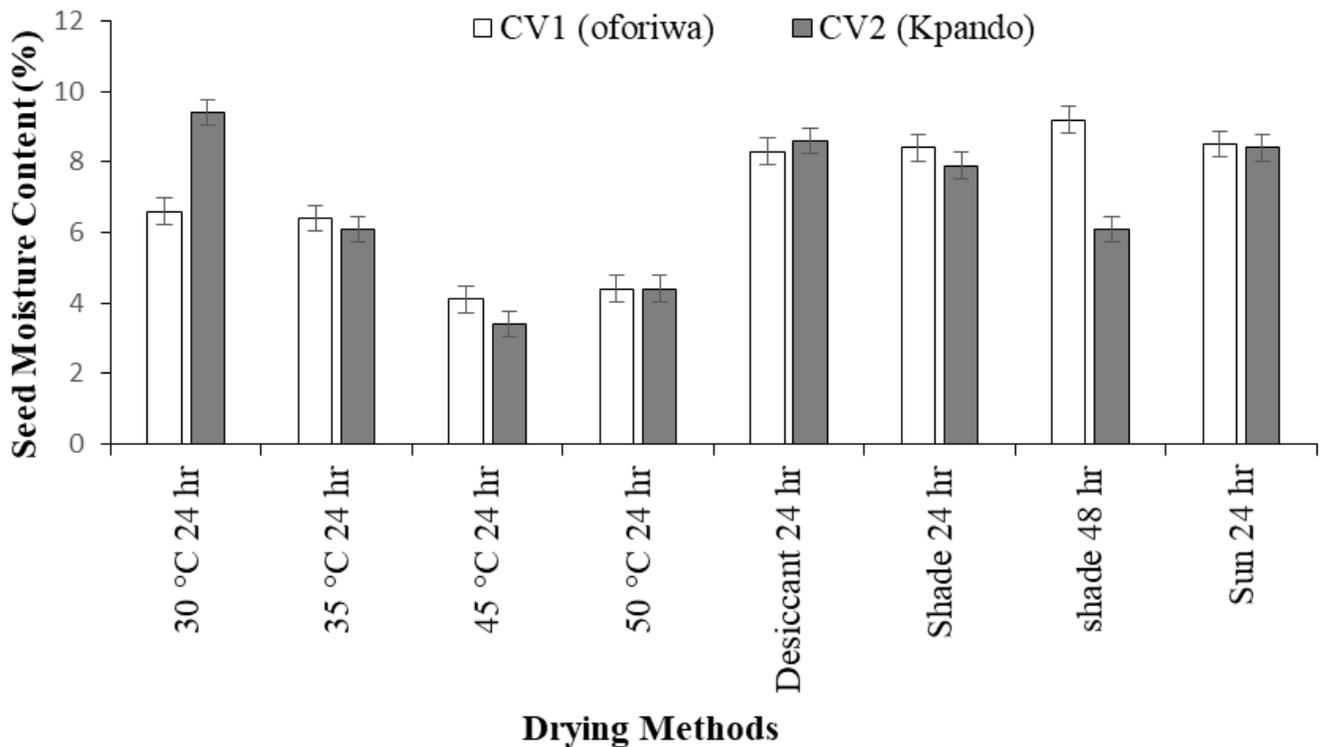


Figure 2. Seed moisture content of cv. *Oforiwa* and *Kpando* African eggplant seeds as affected by different drying methods.

that vegetable seeds stored longer at seed moisture content below 8% (Ells et al., 2020), it can be suggested from this study that oven drying at 35-50°C for 24 h can reduce African eggplant seeds to these required moisture levels. The other methods such as desiccant or shade drying period may be extended to obtain similar moisture levels.

With the exception of the first germination count, the different drying methods caused minimal effect on seed germination percentage as all seeds for both cultivars germinated above 70% (Figure 3). Seeds dried in oven at low temperatures of 30 and 35°C had comparable germination values ranging from 85 to 96% as the other types of drying methods. Ravi et al. (2007) reported similar results (83 to 90%) for chilli (*Capsicum annum* L.) seeds when subjected to sun, shade and oven drying. When oven temperatures were elevated to 45 and 50°C, seed germination for cv. *Kpando* reduced by 16.2 to 21%. Cultivar *Oforiwa* on the other hand reduced by 26% when temperature was increased to 45°C. This suggest that although oven drying was able to dry seeds quickly and efficiently, high temperatures may cause damage to seed viability and vigour. This results corroborate with Siddique and Wright (2003) who reported a small decrease in germination percentage when peas (*Pisum sativum* L.) seeds were dried between 40 and 60°C. Similarly, seed

physiological quality decreased at 60 and 70°C drying temperatures for Adzuki beans (*Vigna angularis*) (Resende et al., 2012). Drying sweet sorghum at 40°C negatively affects germination (Ullmann et al., 2015) and above 40°C also affects soybean seed quality (Hartmann Filho et al., 2016). This observation is consistent with the view by Marcos-Filho (2005), that fast and excessive drying can affect seed viability.

According to Franca et al. (2013), the effect of drying on seed physiological quality may be observed immediately after drying or during storage as a latent effect. In the case of eggplant, drying did not affect seed germination immediately and after storing for 6 months (França et al., 2013). This could be as a result of the relatively low temperatures (38°C) applied by the authors and the low moisture contents of seeds (4-6%) prior to germination test. The effect of higher drying temperatures is most damaging when seed moisture content is high (Almekinders and Louwaars, 1999). In the present study, the seed moisture contents prior to germination were low. Any possible negative effect could be latent during storage as observed by Araújo et al. (2000). It concluded that drying at temperatures of 50 and 60°C and storing at higher relative humidity were harmful to seed quality of sweet corn (Araújo et al., 2000). For drying of vegetable seed, temperature not exceeding 35°C has been

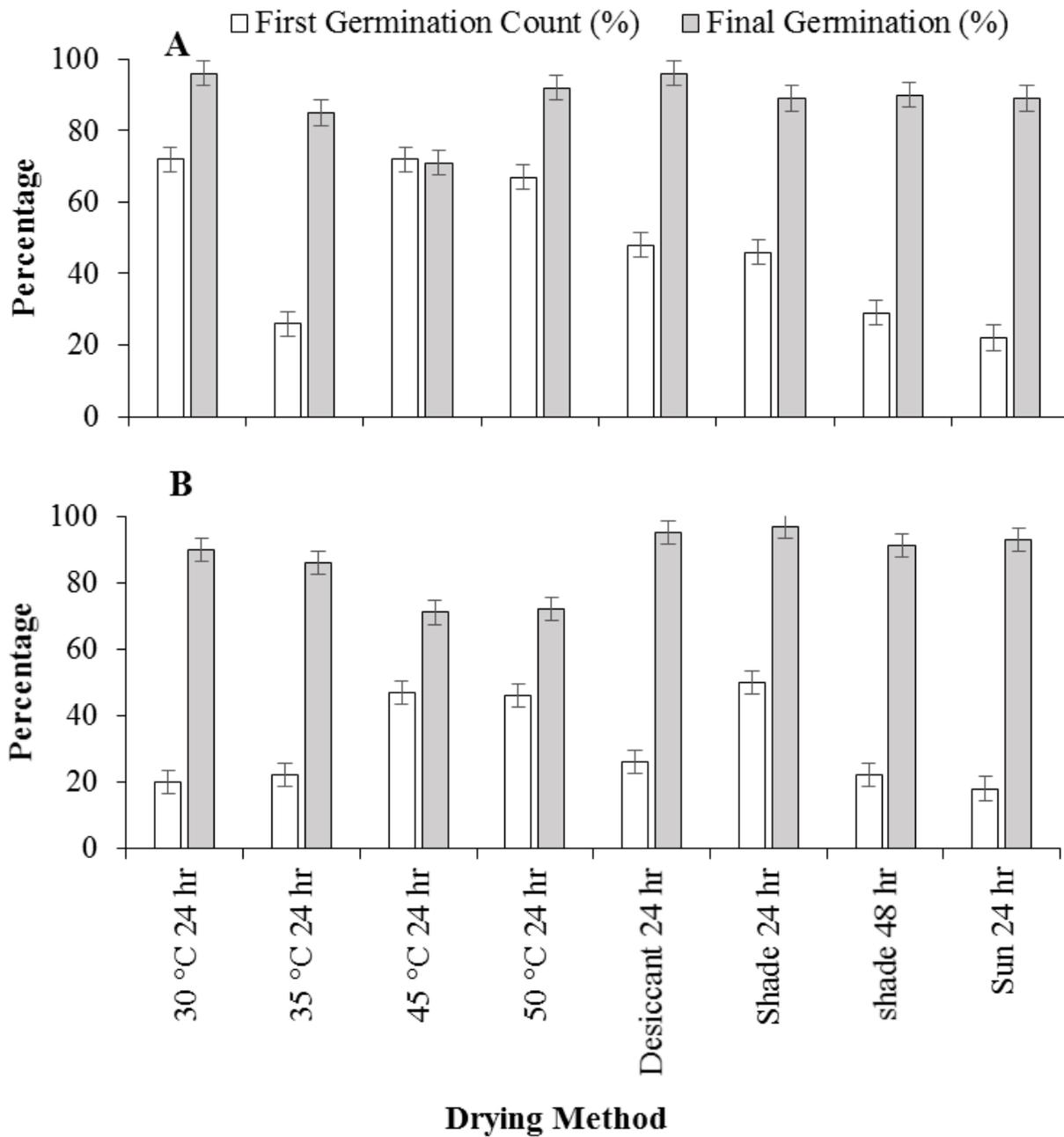


Figure 3. First germination count (%) and final germination (%) of *cv. Oforiwa* (A) and *cv. Kpando* (B) African eggplant seeds subjected to different methods of drying.

recommended by Harrington (1972).

In the present study, drying at 30°C for 24 h is recommended.

Conclusion

African eggplant seeds do not require natural fermentation

during extraction for enhanced seed germination. Fermentation for up to 12 h can however improve seed vigour. All drying methods were able to reduce seed moisture content for storage and maintained seed physiological quality. Oven drying methods however, is recommended for drying seeds meant as it was able to reduce moisture to the recommended moisture level (6%) for long term storage of seeds. It is recommended that

the latent effect of these two important methods on the seed physiological quality are studied.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

- Almekinders CJM, Louwaars NP (1999). Harvesting Processing and Storage. Intermediate Technology Publication Ltd, pp.112-118.
- Araújo EF, Silva RF, Corrêa PC (2000). Efeitos imediatos e latentes da temperatura e da umidade relativa do ar de secagem na qualidade fisiológica de sementes de milho-doce, cultivar BR 400. *Revista Brasileira de Sementes* 22(2):21-30.
- Brasil (2009) Ministério da Agricultura, Pecuária e Abastecimento. Regras para análise de sementes. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. Brasília, DF: MAPA/ACS P 395.
- Babiker AZ, Dulloo ME, El Balla MAM, El Tahir I (2010). Effects of low cost drying methods on seed quality of *Sorghum bicolor* (L.) Monech. *African Journal of Plant Science* 4(9):339-345.
- Botey HM, Ochuodho JO, Ngode L, Dwamena H, Osei-Tutu I (2021a). Temperature and Light effects on germination behaviour of African eggplant (*Solanum aethiopicum* L.) seeds. *Indian Journal of Agricultural Research* (in press).
- Botey HM, Ochuodho JO, Ngode L (2021b). Fruit and Seed Physiological quality changes during seed development and maturation in African Eggplant (*Solanum aethiopicum* L.). *Scientia Horticulturae* (in press).
- Cardoso GD, Tavares JC, Ferreira RLF, Câmara FAA, Carmo GA (2001). Desenvolvimento de mudas de maracujazeiro-amarelo obtidas de sementes extraídas por fermentação. *Revista Brasileira de Fruticultura* 23(3):639-642.
- Chethan HN, Devaraju PJ, Dinesh HB, Shantharaja CS, Dhananjaya P, Satheesh Naik SJ (2013). Influence of different methods of seed extraction on seed quality in cucumber [*Cucumis sativus* (L.)] cv. Hassan Local. *International Journal of Agricultural Sciences* 9(1):323-325.
- Demir I, Samit Y (2001). Quality of tomato seed as affected by fruit maturity and seed extraction method. *Gartenbauwissenschaft* 66(4):199-202.
- Ells JE, Bass LN, Whiting D (2020). Storing Vegetable and Flower Seeds. Fact Sheet 7.221. <https://extension.colostate.edu/docs/pubs/garden/07221.pdf>.
- França LV, Croda MD, Nascimento WM, Freitas RA (2013). Physiological quality of eggplant seeds with different extraction and drying methods. *Journal of Seed Science* 35(1):51-55.
- George RAT (2000). Vegetable seed production. London: Longman Inc., 2.ed.328 p.
- Harrington JF (1972). Seed storage longevity. In: Kozlowski T.T., editor. *Seed Biology*. Volume 3. Academic Press, New York pp. 145-245.
- Hartmann-Filho FCP, Goneli ALD, Masetto TE, Martins EAS, Oba GC (2016). The effect of drying temperatures and storage of seeds on the growth of soybean seedlings. *Journal of Seed Science* 38(4):287-295. <https://doi.org/10.1590/2317-1545v38n4161866>
- Horna D, Timpo S, Gruère G (2007). Marketing Underutilized Crops: The Case of the African Garden Egg (*Solanum aethiopicum*) Global Facilitation Unit for Underutilized Species (GFU), DOI: 10.13140/2.1.3409.7608.
- Lopes KP, Bruno RLA, Bruno GB, Azeredo GA (2001). Comportamento de sementes de romã (*Punica granatum* L.) submetidas à fermentação e secagem. *Revista Brasileira de Fruticultura* 23(2):369-372. <https://doi.org/10.1590/S0100-29452001000200034>
- Marcos-Filho J (2005). *Fisiologia de sementes de plantas cultivadas*. Piracicaba: FEALQ, 495 p.
- Ogbonna PE, Odo LC (2011). Efficiency of seed extraction methods in the control of loss and low seed quality in egusi melon (*Colocynthis citrullus* L.). *Journal of Horticulture and Forestry* 3(2):58-62.
- Osei MK, Banful B1, Osei CK, Oluoch MO (2010). Characterization of African Eggplant for Morphological Characteristics. *Journal of Agricultural Science and Technology* 4(3):33-37.
- Rahman MB, Hossain MM, Haque MM, Ivy NA, Ahmad S (2015). Physiological Quality of Eggplant Seed as Influenced by Extraction Method. *Advances in Crop Science and Technology*.
- Ravi Hunje B, Vyakarnahal S, Jagadeesh RC (2007). Influence of Drying Methods of Fruits on Seed Quality in Chilli (*Capsicum annuum* L.). *Karnataka Journal of Agricultural Sciences* 20(2):269-271.
- Resende O, Almeida DP, Costa LM, Mendes UC, Sales JF (2012). Adzuki beans (*Vigna angularis*) seed quality under several drying conditions. *Ciência e Tecnologia de Alimentos* 32(1):151-155. <https://doi.org/10.1590/S0101-20612012005000013>
- Sabongari SB, Aliero L (2004). Effects of soaking duration on germination and seedling growth of tomato (*Lycopersicon esculentum* Mill). *African Journal of Biotechnology* 3(1):47-51
- Silva RF, Koch RB, Moore EL (1982). Effect of extraction procedures on tomato seed germination and vigour. *Seed Science and Technology* 10:187-191.
- Siddique AB, 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 Sciences* 2:978-982.
- Ullmann R, Resende O, Chaves TH, Oliveira DEC, Costa LM (2015). Qualidade fisiológica das sementes de sorgo sacarino submetidas à secagem em diferentes condições de ar. *Revista Brasileira de Engenharia Agrícola e Ambiental* 19(1):64-69. <https://doi.org/10.1590/1807-1929/agriambi.v19n1p64-69>
- Wang XF, Jing XM, Zheng GH (2001). Effect of seed moisture content on seed storage longevity. *Acta Botanica Sinica* 43(6):551-555.