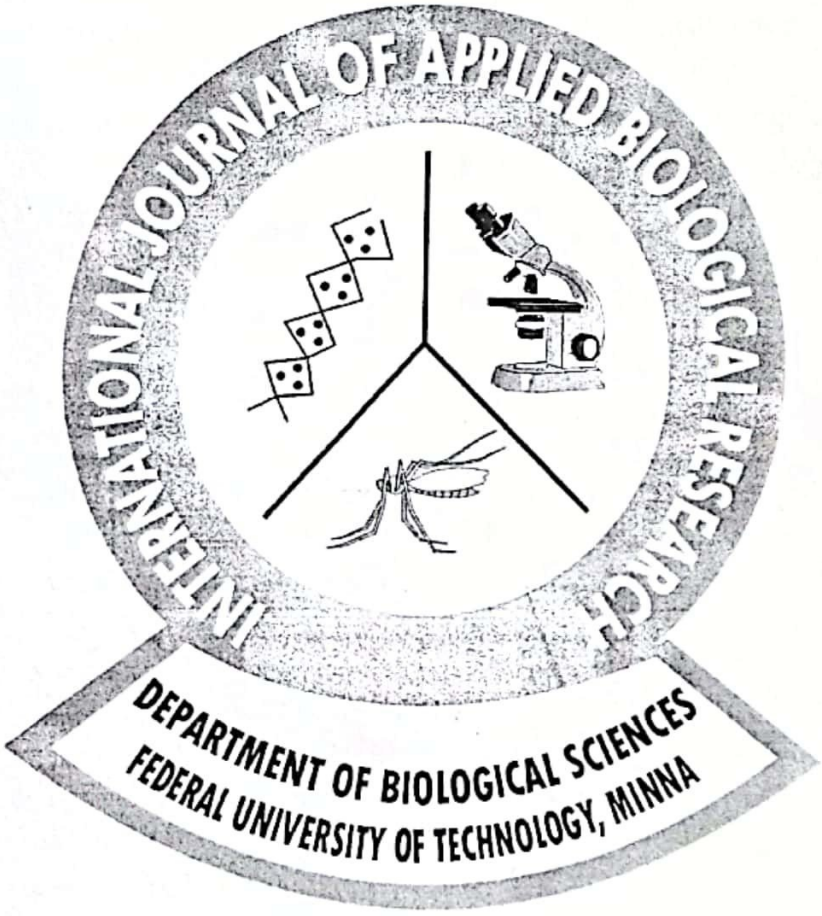
INTERNATIONAL JOURNAL OF APPLIED BIOLOGICAL RESEARCH

VOLUME 8, NUMBER 1, ISSUE 1, JUNE 2017



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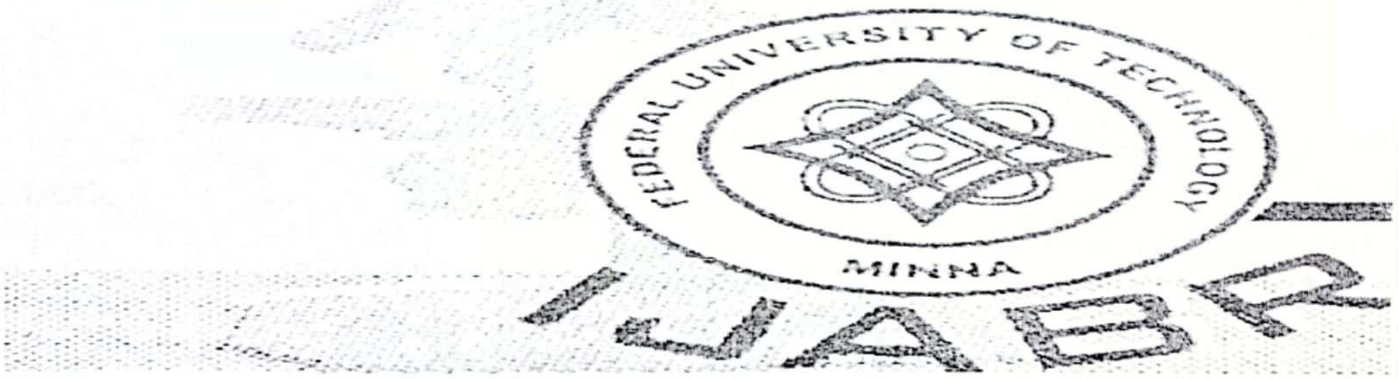

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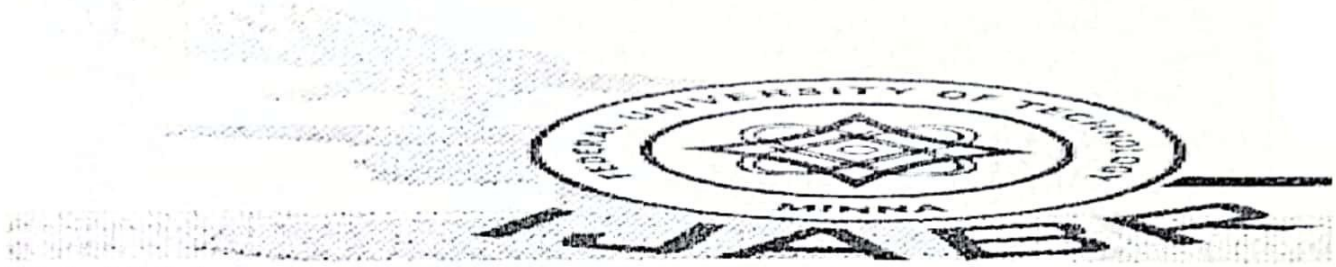

Original Article

DRYING PROCEDURES FOR OPTIMAL PEPPER (*Capsicum annuum L.*) SEED QUALITY

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Submitted: March, 2017; Accepted: April 2017; Published: June, 2017

ABSTRACT

This study was conducted at the Department of Crop Production, Federal University of Technology Minna, Niger State, Nigeria. The aim was to determine the effect of different processing methods (drying procedures) on seed quality of 'Tatashe' and 'Shombo' cultivars of pepper (*Capsicum annuum* L.). Red-ripe fruits of each cultivar were divided into ten lots with each lot processed differently tagged P1-P10: seeds of P1 and P2 were extracted from red-ripe freshly harvested fruits and were sun-dried or air dried for 16 days respectively. Seeds of P3 - P8 were extracted from fruits that were sun dried for 2, 4, 6, 8, 10 and 12 days followed by air-drying for the balance of 14, 12, 10, 8, 6 and 4 days respectively. Seeds of treatments P9 and P10 were extracted from fruits that had been sun- or air-dried respectively for 16 days. Results show that the moisture content of freshly extracted seeds varied between 43 and 49 %. Seeds of the two cultivars dried faster in the sun than under air-drying attaining moisture content of 2.2 and 2.1 % in 'Tatashe' and 'Shombo' respectively by 16 days of drying. Dried seeds were stored in open container at 37 °C and 90 % relative humidity to accelerate their age. Seed samples were drawn from the stored lots and tested to determine germination percentage (GP), germination rate (GR), germination rate index (GRI) and germination index (GI) at 0,10,20,40 and 60 days after storage. The study was a 2 x 10 factorial experiment and the arrangement was a completely randomised design (CDR). The data collected were subjected to analysis of variance using Minitab 17.0 version. Means were separated using Duncan Multiple Range Test (DMRT) when significant difference occurred among treatments. The results obtained showed that GP, GR, GRI and GI were greater in 'Shombo' than in 'Tatashe'. Seeds processed by the P1, P2 and P10 methods germinated significantly higher and faster and stored longer than those of other processing methods. Seed quality was poorer in seeds extracted from sun-dried fruits compared to those from air-dried fruits.

Keywords: Germination index, germination rate, germination rate index, seed

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INTRODUCTION

Pepper represents a diverse plant group of the family Solanaceae grown for its fruit which are rich in vitamins and mineral elements and consumed the world over. Mansur *et al.* (2015) referred to common pepper (*Capsicum annuum*) as one of the most important vegetables in the world. Most farmers in developing countries are resource-poor and therefore rely on farm-saved seeds which have been reported to be of poor quality (Ochieng *et al.*, 2011) with diminishing profitability (Santos, 2013). Daniel and Adetumbi (2004) reported that about 60 % of vegetable farmers in Southwestern Nigeria relied on seed that were saved from previous harvest. According to Dagnoko *et al.* (2013) good quality seed has high return per unit area as the genetic potentiality of the crop can be fully exploited. Inappropriately processed seeds will be of poor quality.

Seeds extracted from fleshy fruits are normally at high moisture content. Pepper seeds normally contain about 40 percent moisture at physiological maturity (Dagnoko *et al.*, 2013) and have to be dried to a safe moisture level. This demands that drying be done fast enough to a safe level to guard against fast quality deterioration associated with storage of seeds at high moisture level. Daniel and Adetumbi (2004) however warned that fast or excessive drying can reduce seed quality significantly. The adverse effect could be observed immediately after processing or following storage (latent effect) as described by Nagel and Borner (2010). Different methods have therefore been developed for extraction and drying of seeds from different wet fruits to ensure high quality. Seed extraction methods that have been used in tomato included natural pulp fermentation as well as the degradation of the gelatinous materials around the seed using H_2SO_4, HCl and sodium carbonate (Demir *et al.*, 2005). Fermentation for 24 hours with or without the use of acid combined with the use of various drying methods has also been found effective in obtaining high quality eggplant seed by Daniel and Adetumbi (2004) while Rahman *et al.* (2015) reported the superiority of wet seed extraction without fermentation over the dry seed extraction method in the same crop. Both wet extraction and sun-drying methods have been found adequate in *Capsicum annuum* (Probert *et al.*, 2009). There are however, conflicting information in respect of the drying method to adopt. Report by Chakradhar *et al.* (2016) revealed that maximum germination percentage and vigour were recorded in seeds that were shade-(air) dried following extraction from freshly harvested fruits followed by seeds extracted from air-dried fruits. The authors reported further that seeds from sun-dried and freeze-dried fruits were of significantly poorer quality than air-dried seeds. Both Ravi Hunje *et al.* (2007) and Christinal and Tholkcappian (2012) recorded lower germination percentage and poorer vigour in air-dried seeds than in sun and mechanically dried seeds of pepper due to slow-drying rate in the former.

In most developing countries with abundant supply of sunshine, farmers usually dry fruits/seeds in the open at no cost. Drying of chilli fruits too rapidly or with high air temperature can be injurious to seed and may kill the embryo (Ravi Hunje *et al.*, 2007). Recently, completed study in 'Tatashe' and 'Shombo' showed that seeds of the former were of poorer quality and that the seeds extracted from sun-dried fruits were poorer in quality compared to what was recorded in air-dried fruits (F. Kadiri, pers.comm.).

Most farmers that use self-saved seeds extract the quantity required for planting from previously sun-dried

fruits as the need arises rather than using the wet extraction method. This study was therefore conceived to determine the effect of different fruit-drying procedures on seed quality of 'Tatashe' and 'Shombo' cultivars of pepper (using percentage germination and vigour as indices).

MATERIALS AND METHODS

Fruits of two (2) cultivars of pepper ('Tatashe' and 'Shombo') harvested at red-ripe stage from Chanchaga irrigation farm were each divided into ten lots and processed using 10 different procedures (P1-P10) detailed as in Table 1. The Table shows the descriptions of the treatments the seeds and fruits used for study were subjected to. Seeds of P1 and P2 were extracted from red-ripe freshly harvested fruits and were sun-dried or air dried for 16 days respectively. Seeds of P3 - P8 were extracted from fruits that were placed on paper and su-dried for 2, 4, 6, 8, 10 and 12 days followed by air-drying for the balance of 14, 12, 10, 8, 6 and 4 days respectively. Seeds of treatments P9 and P10 were extracted from fruits that had been sun- or air-dried respectively for 16 days. The study was a 2 x 10 factorial experiment resulting in 20 treatment combinations; the arrangement was a completely randomised design (CRD).

Moisture content determination was done by the hot oven method at 130 ^{0}C for 60 minutes (ISTA, 2005), immediately seeds were extracted from fruits and after drying for 16 days. The percentage moisture content (on wet weight basis) was calculated as follows:

$$MC\ \% = \frac{\text{Weight of water lost}}{\text{Weight of wet seeds}} \times 100$$

To determine and monitor changes in seed quality over storage period, seeds were spread in a thin layer in flat open aluminium foil containers at 37 °C and 90% relative humidity to accelerate seed ageing.

Seed germination tests were conducted at 0, 10, 20, 40 and 60 days after storage using four replicates of 50 seeds each. The seeds were placed on distilled water-moistened filter paper placed in plastic Petri-dishes. Incubation was at 30 °C for 28 days and germination counts were taken daily. Data were collected on seed germination percentage, mean germination time (MGT), germination index (GI) and germination rate index (GRI). Seed germination percentage (GP) was determined by expressing the total number of the seeds that germinated at the end of the incubation period as a percentage of the 50 seeds per replicate.

The means were then determined for each treatment combination. Mean germination time (MGT) was calculated using the relationship described by Kader (2005): $MGT=\sum f.x/\sum f.$ Where: f=seeds germinated on day x.

Germination rate index (GRI) indicates the percentage germination per day. It spreads the percentage evenly across the time spread: GRI (%day) = G1/1 + G2/2 +...+ Gx/x: where: G1 = germination percentage at the first day after sowing, G2= germination percentage at the second day after sowing, ...Gx = germination percentage at the xth day after sowing (Kadar, 2005). Germination index (GI) is determined using the expression GI = (20xn1) + (19xn2) + ...+ (1xn20). where: n1, n2... n20 = No. of germinated seed on the first, second and subsequent days until (in the present study) the 20th day of germination; 20, 10 ... and 1 are weights given to the number of

germinated seeds on the first, second and subsequent days, respectively (Kader, 2005).

Table 1: Cultivar and drying procedures used in the study

Treatment per cultivar	Treatment Description	No. of days of drying	
		Sun	Air
P1	Extracted Seeds	0	16
P2	Extracted Seeds	16	0
P3	Fruit	2	14
P4	Fruit	4	12
P5	Fruit	6	10
P6	Fruit	8	8
P7	Fruit	10	6
P8	Fruit	12	4
P9	Fruit	16	0
P10	Fruit	0	16

Data analysis

Data generated from all parameters were subjected to analysis of variance (ANOVA) using Minitab 17.0 version. All values in percentages were transformed to arcsin values before statistical analysis. Means were separated by the least significant difference (LSD) method or Duncan Multiple Range Test (DMRT, 1955) where significant differences occured.

RESULTS

The moisture (MC) of freshly extracted seeds of 'Tatashe' and 'Shombo' were 43 and 49 % respectively and the difference was significant ($P<0.05$). Table 2 shows that after 16 days of drying seed MC had declined to 5.3 and 3.9 % for 'Tatashe' and 'Shombo' respectively; the difference was significant. The Table reveals further that seeds extracted from fruits that were air-dried for 16 days (P10) and those from fruits that were sun-dried for 2 and 4 days and then air-dried for 14 (P3) and 12 (P4) days had significantly higher MC (8.6, 8.6 and 7-2 % respectively) than seeds of all the other tretments with a range of 2.3 – 5.1 %. It is evident from Table 3 that the MC level attained by seeds of the different processing methods after 16 days of drying varied with cultivar. For example, whereas there was no significant difference between the MC levels of 'Tatashe' seeds extracted from fresh fruits followed by air-drying or sun-drying (C1P1/C1P2), (C2P1) air-dried 'Shombo' seeds were significantly higher in moisture content than those that were sun-dried (C2P2) with values of 4.7 and 2.1 % respectively. Futhermore, 'Tatashe' seeds extracted from fruits that were initially sun-dried for 8 – 12 days followed by air-drying for 8 – 4 days (C1P6 – C4P8) and those from fruits sun-dried for 16 days (C1P9) were generally significantly higher in moisture content than those of cultivar 'Shombo' of same tretments (C2P6 – C2P9). However, the MC of the seeds of the two cultivars extracted from fruits that were only sun-dried for 2 and 4 days followed by air-drying for 14 and 12 days respectively and those air-dried for 16 days were of similarly high values (7.2 – 9.7 %).

Table 4 shows that cultivar (C), processing procedure (P) and their interaction significantly affected germination percentage (GP) at all storage periods. 'Shombo' seeds

germinated significantly higher than 'Tatashe' seeds at all storage periods. At 0, 10, 20 and 40 days after storage (DAS), GP values were similarly high in seeds extracted from fresh fruits followed by air-drying (P1) or sun-drying (P2) and from those in which fruits were air-dried for 16 days (P10) and the values were significantly higher than in most of the other processing methods. However, by 60 DAS, the highest GP (70) which was recorded in P2 was not significantly different from those of most of the other processing treatments except P9 (47.5 %).

Though germination was generally significantly higher in 'Shombo' than in 'Tatashe', as reported above, it is evident from Table 5 that response to processing method varied with cultivar. Seeds of 'Tatashe' processed using the P1, P2, and P10 methods generally germinated equally highly and recorded percentages were significantly higher than those of other treatments from 0 – 40 DAS. There were no significant differences among 'Shombo' seeds of all processing procedures. GP of 'Tatashe' seeds increased up to about 20/40 DAS followed by declined at between 40 and 60 DAS. No appreciable increase in seed GP was recorded in 'Shombo'; a decrease in GP was recorded between 40 and 60 DAS in both cultivars.

Seed germination rate (GR) was significantly affected by cultivars, processing and their interaction (Table. 6). 'Shombo' seeds germinated significantly faster than 'Tatashe' seeds at all storage periods. At 0, 10, 20 and 40 DAS germination was generally significantly faster in seeds that were extracted from fruits air-dried for 16 days (P10) compared to all other processing procedures. However, at 60 DAS, though germination was still fastest in P10, it was not significantly better than P3, P6 and P7. The slowest germination was most often recorded in seeds extracted from fruits dried in the sun for 16 days (P9) throughout the study.

Table 7 shows that though GR was generally significantly faster in 'Shombo' seeds than in 'Tatashe' seeds, the adoption of P1, P2 and P10 processing methods for 'Tatashe' resulted in GR values that were generally similar to those of 'Shombo' of any of the processing methods. There was a general declined in seed germination rate of both cultivars at 60 DAS.

'Shombo' seeds recorded significantly higher germination rate index (GRI) than 'Tatashe' seeds at all storage periods (Table. 8). At 0 and 10 DAS seeds extracted from fruits and dried continuously in the shade for 16 days (P10) recorded significantly higher GRI than all other treatments. However, at 20 DAS, P10 value was not significantly different from those recorded for processig treatments P1, P2 and P3. At 40 and 60 DAS, there was no significant difference between P10 and P1 and between P10 and P7 respectively. Though germination was generally higher and faster in 'Shombo' than in 'Tatashe' as reported above, Table 9 shows that 'Tatashe' seeds obtained from fruits that were air-dried for 16 days had significantly higher GRI than most 'Shombo' treatments at 10 and 40 DAS. The GRI for 'Tatashe' seeds extracted from fruits dried for 16 days was at par with all 'Shombo' seeds of all processing procedures at 60 DAS.

Significantly higher germination index (GI) values were recorded in 'Shombo' than 'Tatashe' seeds at all storage periods (Table 10). Values were generally highest in P10 but they were not significantly greater than those of P1 at 0 DAS, P1 and P2 at 10 and 20 DAS and P1, P2, P5 and P8 at 40 DAS. Table 11 shows that though GI values were generally highest in 'Shombo' seeds compared to those of 'Tatashe', the P1,

P2 and P10 values for 'Tatashe' were mostly similar to those of 'Shombo' at 0-40 DAS. At 60 DAS, performances of 'Shombo' seeds were significantly better than those of 'Tatashe' except seeds of the latter that were extracted from fruits that were air-dried for 16 days (C1 P10).

Table 2: Percentage moisture content (MC) of seeds of 'Tatashe' and 'Shombo' at different drying period (days)

	Seed moisture content (MC)
Treatments	16
Cultivar (C)	
'Tatashe'	5.3a
'Shombo'	3.9b
Processing (P)	
P1	5.1b
P2	3.1c
P3	8.6a
P4	7.2a
P5	4.7b
P6	2.5c
P7	2.3c
P8	3.2c
P9	3.3c
P10	8.6a
Interaction	
C X P	*

Means of factors that share the same letter(s) within each column are not significantly different (P>0.05) using Duncan Multiple Range Test. * = Significant difference at P≤5%, SE± = Standard error of mean

Table 3: Interaction effect of cultivar and processing method on seed moisture content (MC) following 16 days of drying

	Seed moisture content (MC)
Cultivar (C) x Processing (P)	16
C1 X P1	4.7c
C1 X P2	4.0cd
C1 X P3	9.7a
C1 X P4	7.2ab
C1 X P5	5.2bc
C1 X P6	4.0cd
C1 X P7	2.2e
C1 X P8	4.3c
C1 X P9	4.6c
C1 X P10	9.6a
C2 X P1	4.7c
C2 X P2	2.1e
C2 X P3	7.6a
C2 X P4	8.0a
C2 X P5	4.3c
C2 X P6	2.1e

C2 X P7	3.4de
C2 X P8	2.3de
C2 X P9	2.2e
C2 X P10	(7.7a

Mean that share the same letter(s) within each column are not significantly different (P>0.05) using Duncan Multiple Range Test (DMRT). SE± = Standard error mean

Table 4: Germination percentage of seeds of 'Tatashe' and 'Shombo' at different storage periods (days)

	Storage period (days)				
Treatments	0	10	20	40	60
Cultivar (C)					
'Tatashe'	50.3b	68.8b	72.3b	72.5b	37.8b
'Shombo'	84.6a	89.0a	91.2a	92.4a	72.6a
Processing(P)					
P1	84.0a	92.5a	92.3a	91.6ab	51.1ab
P2	81.3ab	94.5a	95.9a	95.0a	70.0a
P3	61.3cd	70.8bc	79.4b	79.3cde	58.6ab
P4	69.0bc	72.6bc	76.0b	81.4cde	52.8ab
P5	67.0c	76.0bc	80.3b	84.8bcd	59.0ab
P6	63.0c	72.7bc	77.2b	75.0de	66.1ab
P7	52.8d	65.9c	59.5c	77.2cde	55.8ab
P8	60.8cd	77.4b	83.4b	85.6bc	59.0ab
P9	61.5cd	74.0bc	76.5b	73.5e	47.5b
P10	82.8a	92.1a	92.0a	91.2ab	63.6ab
SE±	1.6	1.5	1.5	1.6	2.5
Interaction					
C x P	*	*	*	*	*

Means of factors that share the same letter(s) within each column are not significant difference (P>0.05) using Duncan Multiple Range Test. * = Significant difference, SE± = Standard error mean

Table 5: Interaction effect of cultivar and processing on seed germination percentage at different storage period (days)

	Storage period (days)				
Cultivar (C) x Processing (P)	0	10	20	40	60
C1 X P1	79.5ab	91.5abc	91.5ab	90.0ab	25.0fg
C1 X P2	72.0b	92.5abc	95.5a	95.5a	63.0a-e
C1 X P3	42.5c	60.0efg	64.5cd	65.0cde	41.6efg
C1 X P4	47.5c	52.0efg	56.0d	62.5cde	20.5fg
C1 X P5	49.0c	63.5ef	69.5cd	75.0bc	37.0efg
C1 X P6	35.0cd	52.0efg	55.5d	52.0e	42.5d-g
C1 X P7	19.0d	43.5g	57.0cd	55.0de	34.0efg
C1 X P8	45.0c	69.5de	79.0bc	72.5cd	43.5c-g
C1 X P9	35.0cd	46.5fg	57.0cd	52.0de	18.5g
C1 X P10	78.0ab	92.5abc	93.5a	91.0ab	48.8b-f
C2 X P1	88.5a	93.5abc	93.0a	93.0a	77.0ab
C2 X P2	90.5a	96.0a	95.0a	94.0a	77.5ab
C2 X P3	80.0ab	81.5cd	88.5ab	91.0a	74.5abc
C2 X P4	90.5a	88.0abc	92.0a	94.5a	85.0a
C2 X P5	85.0ab	88.5abc	89.5ab	92.0a	79.5a
C2 X P6	91.0a	89.5abc	93.0a	92.0a	86.0a
C2 X P7	86.5ab	86.0abc	87.0ab	93.0a	76.5ab
C2 X P8	76.5ab	84.5bcd	87.0ab	93.5a	73.5a-d
C2 X P9	88.0ab	94.0ab	91.5ab	90.0ab	77.5ab
C2 X P10	87.5ab	90.5abc	90.0ab	91.0ab	77.5ab

Mean that share the same letter(s) within each column are not significantly different (P>0.05) using Duncan Multiple Range Test (DMRT), SE± = Standard error mean

Table 6:. Mean germination time (days) of seeds of 'Tatashe' and 'Shombo' at different storage period (days)

	Storage period (days)				
Treatments	0	10	20	40	60
Cultivar (C)					
'Tatashe'	8.4a	8.0a	7.3a	7.6a	10.5a
'Shombo'	5.7b	5.7b	5.9b	6.7b	8.2b
Processing (P)					
P1	5.7f	5.6d	5.8bc	7.0bcd	9.5ab
P2	6.0ef	6.3cd	6.3b	7.0bcd	9.7ab
P3	6.0ef	7.0bc	6.4b	7.3bcd	9.0bc
P4	8.6b	8.2ab	8.3a	9.4ab	9.7ab
P5	7.2cde	6.8cd	6.4b	6.9cd	9.8ab
P6	7.9bcd	6.8cd	6.7b	8.8abc	9.5bc
P7	8.3bc	7.5bc	6.7b	7.9bcd	9.0bc
P8	6.6bef	6.7cb	5.9bc	6.3d	9.2ab
P9	10.3a	9.2a	8.5a	10.7a	10.6a
P10	4.0g	4.2a	5.2c	4.5e	7.7c
Interaction					
C x P	*	*	*	*	*

Means of factors that share the same letter(s) within each column are not significantly different (P>0.05) using Duncan Multiple Range Test (DMRT). * = Significant different, SE± = Standard error mean

Table 7:. Interaction effect of cultivar and processing on mean germination time (days) of seeds of 'Tatashe' and 'Shombo' at different storage period (days)

	Storage period (days)				
Cultivar C) x Processing (P)	0	10	20	40	60
C1 X P1	6.2ef	5.1gh	5.5ef	6.9cde	10.3a-f
C1 X P2	6.3e	6.5d-g	6.3b-f	7.3cde	10.5a-e
C1 X P3	5.8efg	8.6bc	7.5bc	7.3cde	10.1a-f
C1 X P4	11.6b	10.5b	10.0a	9.4ab	11.5ab
C1 X P5	8.9cd	8.2cde	6.9b-e	6.9cde	11.4abc
C1 X P6	9.1cd	8.3cd	7.6b	8.8abc	10.0a-f
C1 X P7	10.8bc	9.1bc	7.4bcd	7.9bcd	11.2a-d
C1 X P8	7.4de	7.2c-f	6.2b-f	6.4def	9.3b-g
C1 X P9	14.6a	12.8a	10.6a	10.7a	12.2a
C1 X P10	3.9g	3.6h	4.9f	4.5f	4.4e-h
C2 X P1	5.2efg	6.3efg	6.1b-f	7.0cde	8.8e-h
C2 X P2	5.6efg	6.2efg	6.4b-f	6.7de	9.0c-h
C2 X P3	6.3e	5.4fgh	5.2ef	6.8cde	7.8fgh
C2 X P4	7.2efg	5.9fg	6.5b-f	6.6de	7.9fgh
C2 X P5	5.5efg	5.4fgh	5.8b-f	6.4edf	8.2e-h
C2 X P6	6.7e	5.3fgh	5.7c-f	7.0cde	9.0c-h
C2 X P7	5.8efg	5.9fg	6.1b-f	6.8cde	6.7h
C2 X P8	6.9efg	6.3d-g	5.6def	6.8cde	9.2b-g
C2 X P9	6.0efg	5.7fgh	6.5b-f	7.5bcd	8.9d-h
C2 X P10	4.0fg	4.7gh	5.4ef	5.3ef	7.0gh

Mean that share the same letter(s) within each column are not significantly different (P>0.05) using Duncan Multiple Range Test (DMRT). SE± = Standard error mean

Table 8: Germination rate index (% day^{-1}) of seeds of 'Tatashe' and 'Shombo' at different storage period (days)

	Storage period (days)				
Treatments	0	10	20	40	60
Cultivar (C)					
'Tatashe'	16.4b	19.4b	21.0b	20.0b	20.0b
'Shombo'	25.3a	25.2a	25.0a	23.5a	19.2a
Processing (P)					
P1	24.5b	25.9b	25.1ab	22.9a	13.7cd
P2	23.2bc	24.1bc	24.5ab	23.4b	16.3bc
P3	20.6cd	20.0d	24.2abc	21.bcd	15.9bc
P4	19.2de	19.9d	19.9e	20.2cde	14.6bcd
P5	20.4d	21.7cd	23.1bcd	22.6bc	15.1bcd
P6	18.4def	21.4cd	21.4cde	19.3e	15.9bc
P7	16.4f	18.9d	21.1de	20.0de	17.1ab
P8	19.5de	21.6cd	23.8bcd	23.3bcd	15.3bcd
P9	17.0ef	19.0d	19.4e	18.0e	12.7d
P10	29.5a	30.5a	27.0a	27.6a	19.5a
Interaction					
C x P	*	*	*	*	*

Means of factors that share the same letter(s) within each column are not significantly different (P>0.05) using Duncan Multiple Range Test (DMRT). * = Significant different, SE± = Standard error mean

Table 9: Interaction effect of cultivar and processing on germination rate index (% day^{-1}) at different storage period (days)

	Storage period (days)				
Cultivar (C) x Processing (P)	0	10	20	40	60
C1 X P1	23.0cd	27.4abc	25.4ab	23.0bcd	9.1fgh
C1 X P2	21.3de	23.8bcd	24.7abc	23.1bcd	14.4b-e
C1 X P3	17.1ef	16.9fg	22.1bcd	20.0def	12.4efg
C1 X P4	13.3fg	14.6fg	15.9ef	16.9efg	8.5gh
C1 X P5	15.5f	17.6efg	20.5cde	20.7def	10.8e-h
C1 X P6	13.0fg	16.2fg	17.3def	15.6g	12.6d-g
C1 X P7	8.3h	14.0fg	17.9def	16.5fg	13.5c-f
C1 X P8	15.6f	19.8def	22.8bc	21.7cd	13.5c-f
C1 X P9	9.3gh	11.9g	15.2f	14.3g	7.4h
C1 X P10	27.9ab	31.8a	27.8a	28.5a	18.2ab
C2 X P1	26.0bc	24.3bcd	24.9abc	22.7cd	18.3ab
C2 X P2	25.1bcd	24.5bcd	24.3abc	23.6bcd	18.2ab
C2 X P3	24.1bcd	23.0cde	26.4ab	23.5bcd	19.3a
C2 X P4	25.2bcd	25.1bcd	23.9abc	23.4bcd	20.6a
C2 X P5	25.3bcd	25.9abc	25.7ab	24.4bc	19.4a
C2 X P6	23.7bcd	26.6abc	25.2ab	23.0bcd	19.1a
C2 X P7	24.5bcd	23.8bcd	24.3abc	23.5bcd	20.8a
C2 X P8	23.3cd	23.5bcd	24.7abc	22.9bcd	17.1a-d
C2 X P9	24.7bcd	26.1abc	23.7abc	21.7cd	18.0abc
C2 X P10	31.0a	29.3ab	26.2ab	26.7ab	20.8a

Mean that share the same letter(s) within each column are not significantly different (P>0.05) using Duncan Multiple Range Test (DMRT), SE± = Standard error mean

Table 10: Germination index (GI) of seeds of 'Tatashe' and 'Shombo' at different storage period (days)

Treatments	Storage period (days) 0	10	20	40	60
Cultivar (C)					
'Tatashe'	336.0b	452.8b	506.2b	485.2b	214.9b
'Shombo'	663.2a	681.1a	681.9a	646.3a	500.3a
Processing (P)					
P1	643.3ab	710.9a	700.1ab	642.7abc	300.2cd
P2	615.4b	690.5a	698.3ab	661.4ab	397.7b
P3	458.5cd	505.4bc	582.5cd	544.1b-e	360.1bc
P4	459.3cd	471.6bc	486.4e	519.1cde	327.1bcd
P5	477.6c	549.4b	585.5cd	603.6a-d	344.1bcd
P6	429.8cde	516.8bc	533.8de	481.9de	376.0bc
P7	375.3e	445.3c	519.0de	435.2e	357.1bc
P8	444.4cde	553.4b	628.1bc	598.4a-d	345.4bcd
P9	386.5de	458.3c	478.9e	439.0e	274.9d
P10	706.1a	770.1a	727.6a	731.9a	493.3a
Interaction					
C x P	*	*	*	*	*

Means of factors that share the same letter(s) within each column are not significantly different (P>0.05) using Duncan Multiple Range Test (DMRT). * = Significant different, SE± = Standard error mean

Table 11 Interaction effect of cultivar and processing on germination index (GI) of seeds of 'Tatashe' and 'Shombo' at different storage period (days)

Cultivar (C) x Processing (P)	Storage period (days) 0	10	20	40	60
C1 X P1	587.8bc	729.8ab	707.3ab	633.5abc	133.7de
C1 X P2	533.8c	671.8b	703.0ab	648.5abc	332.0bc
C1 X P3	329.8d	375.5de	466.7cde	442.5cde	229.0cd
C1 X P4	223.8de	274.0ef	300.0f	360.0de	98.0e
C1 X P5	296.5d	406.2cd	492.8cd	533.8a-d	177.3de
C1 X P6	207.3de	329.5de	370.0ef	319.7de	233.5cd
C1 X P7	93.5e	260.5ef	388.5def	358.7de	165.5de
C1 X P8	306.8d	481.5c	586.5bc	533.5a-d	256.3cd
C1 X P9	112.0e	195.2f	295.0f	270.7e	81.0e
C1 X P10	669.3ab	804.0a	751.7a	751.0a	442.8ab
C2 X P1	698.8ab	692.0ab	693.0ab	652.0abc	466.7a
C2 X P2	697.0ab	709.3ab	693.5ab	674.2ab	463.5a
C2 X P3	587.3bc	635.2b	698.3ab	645.8abc	491.3a
C2 X P4	694.8ab	669.3b	672.8ab	678.3ab	556.2a
C2 X P5	658.8abc	692.5ab	678.3ab	673.5ab	511.0a
C2 X P6	652.3abc	704.0ab	697.5ab	644.0abc	518.5a
C2 X P7	657.0abc	630.0b	649.5ab	511.7bcd	548.8a
C2 X P8	582.0bc	625.3b	669.7ab	663.7abc	434.5ab
C2 X P9	661.0abc	721.3ab	662.8ab	607.2e	468.8a
C2 X P10	743.0a	736.3ab	703.5ab	712.8ab	543.7a

Mean that share the same letter(s) within each column are not significantly different (P>0.05) using Duncan Multiple Range Test (DMRT), SE± = Standard error mean

DISCUSSION

The moisture content of 43- 49 % recorded for 'Tatashe' and 'Shombo' in the present study is higher than 30 – 40 % reportd by Ravi *et al.* (2007). The fact that the cultivars evaluated in the current study are different from those of the authors cited above may be responsible for the difference in result.

All seed lots in this study attained moisture content levels of below 10 % which is deemed safe for pepper seed storage (Ravi *et al.*, 2007). The situations in the current study in which seed of cultivar 'Shombo' were significantly higher in germination percentage, faster in germination and had higher germination rate index and germination index than 'Tatashe' seeds has also been recorded in two different chilli varieties by Dagnoko *et al.* (2013). That differences in seed quality may vary with genotype even among varieties within same species have likewise been reported by various workers in other crops (Balesevi-Tubic *et al.*, 2011; Suma *et al.*, 2013). Probert *et al.* (2009) and Nagel and Borner (2010) also reported that seed longevity may vary among species and seed lots of the same species.

Contrary to the report of Ravi *et al.* (2007) and Christianal and Tholkkappian (2012) seeds obtained from air-dried fruits in the current study were of significantly higher quality than those from sun-dried fruits. The authors argued that the poor quality recorded in shade-dried fruits might have resulted from microbial infection. No such infection was recorded in the current study. Greater effective moisture diffusivity has been reported for chilli fruits dried at high temperature compared to drying at lower levels (Kaleemullah and Kailappan, 2005; Vega *et al.*, 2007). However, the low seed quality recorded in sun-dried fruits of 'Tatashe' in the current study even following only two days of exposure may be attributed to high temperature effect despite the faster drying compared to what was obtained in air-drying. The differential response of seeds of 'Tatashe' and 'Shombo' to sun-drying recorded in the current study was also recorded by Dagnoko *et al.* (2013) which they opined to be an indication of variability in heat tolerance between genotypes. FAO (2014) stressed that the potential for physiological ageing can be reduced by lower drying temperature. The lower germination percentage, germination rate index and germination index as well as slower germination recorded in fresher seeds in this study followed by an increase as storage progressed are in agreement with the reports of Nascimento *et al.* (2006) and Caixeta *et al.* (2014) in pepper. The increase in the various indices is explained to be due to the presence of dormancy in freshly harvested seeds which is lost as storage progressed. This has also been reported by Rithichai *et al.* (2009) in coriander. Subsequent decreased in seed quality agrees with the result of Woltz and TeKrony (2001) and Rithichai *et al.* (2009), a trend that was explained to be due to deterioration sequel to degradation and inactivation of enzymes, reduction of respiratory activity and loss of integrity of cellular membranes.

In conclusion, results from this work show that quality of seeds of cultivar 'Shombo' was significantly greater than that of 'Tatashe'. Furthermore, 'Shombo' seed quality was not significantly influenced by processing procedure whereas exposure of 'Tatashe' fruits to as short as two days of sun-drying resulted in significant reduction in seed quality. Therefore, to obtain 'Tatashe' seeds of high quality, seeds should either be extracted from freshly harvested fruits and then sun- or air-dried or they may be extracted from air-dried fruits. It is recommended that seeds of 'Tatashe' should be extracted from freshly harvested red-ripe fruits before air- or sun-drying. Alternatively, good quality seed may be obtained from air-dried fruits. Any of the processing

procedures may be adopted for 'Shombo'.

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