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Post-storage Seed Quality in Cucumber (*Cucumis sativus* L.) as Impacted by Variable Fruit Age and *in-situ* Storage Durations

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ABSTRACT: The contribution of fruit pulp reserves to seed development and post-harvest seed quality in cucurbits remains inadequately explored, despite the widespread practice of *in-situ* fruit storage prior to seed extraction. The present investigation examined the combined influence of fruit harvest stage and *in-situ* storage duration of harvested fruits on seed quality and longevity in cucumber (*Cucumis sativus* L.). Fruits were harvested at three developmental stages, namely 30, 40 and 50 days after anthesis (DAA), and subjected to four *in-situ* storage durations (0, 5, 10, and 15 days). Seeds extracted from each treatment were stored for eight months, during which germination percentage and seedling vigour index-I were assessed at two-month intervals. Biochemical constituents, including total soluble sugars, starch, total soluble proteins, oil content, and total soluble amino acids, were quantified immediately after seed extraction and after eight months of storage. Seed germination percentage and vigour index-I increased progressively with advancement in fruit maturity from 30 to 50 DAA and with longer *in-situ* storage duration from 0 to 15 days. Seeds extracted from fruits harvested at 30 and 40 DAA exhibited an increase in germination up to four months of storage, whereas those harvested at 50 DAA showed improvement up to six months, followed by a gradual decline. Storage reserves such as sugars, starch, proteins, and oil content declined with prolonged seed storage, accompanied by an increase in total soluble amino acids. Seeds harvested at 50 DAA and extracted after 10 days of *in-situ* fruit storage consistently exhibited superior seed quality and storability after eight months of storage. The study highlights the critical role of fruit maturity and post-harvest fruit handling in optimizing seed quality and provides practical recommendations for improving cucumber seed longevity under typical storage conditions.

Keywords: Germination, Seed longevity, Starch, Storage, Vigour

INTRODUCTION

Seed longevity, defined as the ability of seeds to remain viable during short- or long-term storage, determines the practical lifespan of seeds and is a critical component of seed quality [1]. The storability of seeds encompasses both dormant and non-dormant phases and is governed by intrinsic factors such as genetic makeup, seed composition, physiological maturity at harvest, and biochemical status, as well as extrinsic factors including storage temperature and seed moisture content. Based on their tolerance to desiccation, seeds are broadly categorized as orthodox or recalcitrant. Recalcitrant seeds, including those of mango, coconut, rubber, and cocoa, rapidly lose viability and cannot withstand drying below 20–30% moisture content, whereas orthodox seeds—comprising most field and vegetable crops—can be safely dried to low moisture levels and stored for extended periods [2]. Cucurbitaceous vegetables, including cucumber, produce orthodox seeds with comparatively long storage potential when maintained at optimal moisture contents ranging from 4% to 8%, depending on the species.

Despite their inherent storability, freshly harvested cucurbit seeds frequently exhibit poor germination during the initial months of storage. This has been attributed to post-harvest dormancy, largely associated with the presence of abscisic acid (ABA) in immature or freshly harvested seeds [3, 4]. Consequently, a period of dry storage or physiological after-ripening is often required to overcome dormancy and realize the full germination potential of the seed lot. However, prolonged storage beyond the optimal period results in seed deterioration or ageing, characterized by progressive loss of viability and vigour [5]. Even under favourable storage conditions, seeds undergo inevitable biochemical and structural degradation, including lipid peroxidation, membrane destabilization, and solute leakage, ultimately impairing germination and seedling establishment [3, 4, 6]. The rate and extent of these changes vary widely among species and cultivars [7].

Cucumis sativus L. (cucumber), a warm-season vegetable crop belonging to the family Cucurbitaceae, is propagated exclusively through seed. The crop is monoecious, with female flowering extending over several weeks, resulting in fruits of varying developmental stages on the same plant [8]. For seed production, fruits are commonly harvested after complete senescence of the vines, a practice that often leads to suboptimal seed yield and poor germination. Seeds extracted from either immature or over-mature fruits in cucurbits such as cucumber, melon, watermelon, and squash have consistently been reported to be inferior in quality, underscoring the importance of harvesting fruits at the appropriate developmental stage [9].

A growing body of evidence highlights the significance of post-harvest ripening or *in-situ* storage of harvested fruits in improving seed quality in cucurbits by facilitating continued translocation of assimilates from the fruit pulp to the developing seeds [3, 10]. Improvements in seed germination and vigour following *in-situ* storage of harvested fruits have been reported in ash gourd, pumpkin, and other cucurbit species, with the optimal duration varying across crops and environments [11, 12]. These studies collectively emphasize that seed quality in cucurbits is not solely determined at harvest but continues to be influenced by post-harvest fruit handling practices prior to seed extraction.

From a practical standpoint, seed producers and farmers often rely on visually senesced fruits for seed extraction, with limited scientific guidance on the optimal fruit maturity stage and duration of *in-situ* storage required to maximize seed quality. In Punjab, cucumber is sown during February, and fruits intended for seed extraction are harvested during the last fortnight of June or the first fortnight of July. The extracted seeds are typically stored for about eight months before sowing in the subsequent season, during which a substantial decline in seed viability and vigour is frequently observed. Such losses not only reduce planting value but also increase seed replacement costs and compromise field establishment, particularly under suboptimal sowing conditions. Standardizing fruit harvest maturity and *in-situ* storage duration therefore holds direct relevance for seed producers, enabling the production of high-quality seed with improved storability using simple, low-cost post-harvest interventions.

In this context, the present study was undertaken to standardize the ideal fruit harvest stage in combination with the *in-situ* storage period of harvested fruits to optimize seed quality and longevity in the cucumber variety Punjab Naveen under Punjab agro-climatic conditions. By integrating physiological and biochemical assessments of seed quality during storage, the study aims to generate actionable recommendations for seed producers and farmers, thereby enhancing seed longevity, ensuring better crop establishment, and contributing to sustainable cucumber seed production systems.

MATERIALS AND METHODS

Experimental site and crop husbandry

The experiment was conducted on *Cucumis sativus* L. cv. Punjab Naveen at the Research Farm, Punjab Agricultural University, Ludhiana. Crop was raised following the recommended Package of Practices for cucurbits [13]. Harvesting of fruits commenced in the last week of April and continued until the second week of June.

Experimental design and treatments

The experiment was laid out in a factorial completely randomized design (CRD) to evaluate the effects of fruit harvest stage and *in-situ* storage duration of harvested fruits on seed quality. Female flowers were tagged at anthesis to precisely monitor fruit age. Two factors were studied:

- Factor I: Stage of fruit harvest
  - H_1 : 30 days after anthesis (DAA)
  - H_2 : 40 DAA
  - H_3 : 50 DAA
- Factor II: *In-situ* storage duration of harvested fruits prior to seed extraction
  - S_0 : Immediate seed extraction (0 days)
  - S_1 : 5 days after harvest
  - S_2 : 10 days after harvest
  - S_3 : 15 days after harvest

The factorial combination resulted in 12 treatment combinations, each replicated three times.

Seed extraction, drying and storage

Fruits were manually cut open, and seeds were extracted, thoroughly washed with water to remove adhering pulp, and shade-dried to approximately 8% moisture content. Seeds from each treatment were stored for eight months under ambient room temperature in high-density polyethylene (HDPE) bags. Seed quality parameters were evaluated at bi-monthly intervals.

Germination test

Germination was assessed using four replicates of 100 seeds per treatment following the between-paper method at 25°C in darkness [14]. Germination percentage was calculated as:

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds}} \times 100$$

Seedling vigour index – I

Seedling vigour index-I (SVI-I) was computed on the 8th day after germination. Seedling length was measured using a centimeter scale, and vigour index was calculated as described by [15]:

SVI-I = Germination (%) × Average seedling length (cm)

Biochemical analysis

Seed biochemical constituents were quantified immediately after seed extraction and again after eight months of storage. Total soluble sugars were extracted in 80% ethanol and estimated using the phenol–sulfuric acid method at 490 nm [16]. Total soluble proteins were determined following extraction with NaOH and colorimetric estimation at 520 nm [17]. Total free amino acids were quantified using ninhydrin reagent with absorbance recorded at 570 nm [18]. Starch content was estimated using the Clegg method [19] following perchloric acid extraction and phenol–sulfuric acid estimation [16]. Oil content (%) was estimated by Soxhlet extraction using petroleum ether as per AOCS protocols [20]. All biochemical parameters were quantified using appropriate standard curves.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) for factorial CRD using CPCS-1 statistical software, following the procedure outlined by Cochran and Cox [21]. Treatment means were compared at the 5% level of significance.

RESULTS AND DISCUSSION

Germination and seedling vigour

Seed germination increased significantly with advancement in fruit harvest stage from 30 to 50 DAA and with extension of *in-situ* storage duration from 0 to 15 days. This trend was consistent across all storage intervals from two to eight months. Seeds extracted from fruits harvested at 50 DAA showed progressive improvement in germination up to six months of storage, followed by a gradual decline, whereas seeds from fruits harvested at 30 and 40 DAA showed improvement only up to four months, after which germination declined.

The interaction between fruit harvest stage and *in-situ* storage duration was significant at all storage periods, indicating that seed quality was jointly influenced by both factors. Seeds extracted immediately from immature fruits harvested at 30 DAA or after only 5 days of *in-situ* storage consistently failed to meet the Indian Minimum Seed Certification Standards (IMSCS) of 60% germination. In contrast, seeds from fruits harvested at 30 DAA with 10–15 days of *in-situ* storage achieved germination exceeding 60% throughout the storage period. Seeds from fruits harvested at 40 and 50 DAA with 5–15 days of *in-situ* storage consistently exhibited germination well above IMSCS standards, with germination exceeding 90% after eight months of storage in treatments involving 10–15 days of *in-situ* storage (Table 1).

Seedling vigour index-I followed trends similar to germination. Vigour increased with advancement in fruit harvest stage and longer *in-situ* storage duration, reaching a maximum after four months of seed storage and declining thereafter. After eight months, SVI-I values were statistically at par for seeds extracted from fruits harvested at 40 DAA with 15 days of *in-situ* storage and those harvested at 50 DAA with 10 days of *in-situ* storage (Table 2).

These findings corroborate earlier reports in bottle gourd [3], ash gourd [11], and cucumber [22], where post-harvest fruit storage enhanced seed germination and longevity. Improvement in seed quality following short-term storage has been attributed to completion of seed maturation, acquisition of desiccation tolerance, and reduction in germination inhibitors such as ABA during *in-situ* fruit ripening [3, 4]. Conversely, the decline in

Table 1. Effect of fruit harvest stage and *in-situ* storage duration of harvested fruits on germination (%) of *Cucumis sativus* L. (cv. Punjab Naveen) after different storage periods

Treatments	Duration of seed storage (Months)			
	2	4	6	8
Stage of fruit harvest (DAA)				
30 (H_1)	60.08	64.58	60.08	54.66
40 (H_2)	83.83	87.58	85.16	83.00
50 (H_3)	89.67	93.50	94.91	91.41
SE(m)±	0.45	0.70	0.59	0.56
LSD (p=0.05)	1.32	2.07	1.79	1.67
***In-situ* storage duration of harvested fruits (Days)**				
0 (S_0)	62.89	70.22	66.89	62.66
5 (S_1)	71.78	76.11	74.11	72.44
10 (S_2)	86.22	87.89	87.33	82.44
15 (S_3)	90.56	93.33	91.88	87.88
SE(m)±	0.52	0.81	0.68	0.65
LSD (p=0.05)	1.52	2.39	2.07	1.93
Interaction (H x S)				
H_1S_0	40.66	46.67	40.33	36.66
H_1S_1	47.00	54.33	51.00	48.66
H_1S_2	72.33	73.00	70.00	61.66
H_1S_3	80.33	84.33	79.00	71.66
H_2S_0	69.67	78.66	71.66	67.00
H_2S_1	80.33	82.33	78.00	78.66
H_2S_2	90.67	92.66	94.00	90.66
H_2S_3	94.66	96.67	97.00	95.66
H_3S_0	78.33	85.33	88.66	84.33
H_3S_1	88.00	91.66	93.33	90.00
H_3S_2	95.66	98.00	98.00	95.00
H_3S_3	96.67	99.00	99.66	96.33
SE(m)±	0.90	1.40	1.17	1.13
LSD (p=0.05)	2.64	4.15	3.58	3.35

Table 2. Effect of fruit harvest stage and *in-situ* storage of harvested fruits on seedling vigour index - I in *Cucumis sativus* L. (cv. Punjab Naveen) after different storage periods

Treatments	Duration of seed storage (Months)			
	2	4	6	8
Stage of fruit harvest (DAA)				
30 (H_1)	2119	2405	2026	1709
40 (H_2)	3349	3737	3471	3231
50 (H_3)	3957	4237	4164	3900
SE(m)±	21.71	32.64	25.07	22.20
LSD (p=0.05)	64.1	96.4	74.0	65.5
***In-situ* storage duration of harvested fruits (Days)**				
0 (S_0)	2280	2764	2466	2208
5 (S_1)	2831	3141	2883	2673
10 (S_2)	3561	3800	3601	3285
15 (S_3)	3893	4134	3931	3621
SE(m)±	25.07	37.70	28.95	25.63
LSD (p=0.05)	74.01	111.3	85.4	75.7
Interaction (H x S)				
H_1S_0	1281	1551	1209	1020
H_1S_1	1570	1907	1652	1455
H_1S_2	2568	2791	2396	1961
H_1S_3	3055	3371	2845	2398
H_2S_0	2399	3160	2701	2313
H_2S_1	3100	3467	2969	2835
H_2S_2	3721	3994	3926	3686
H_2S_3	4174	4327	4286	4088
H_3S_0	3160	3581	3488	3291
H_3S_1	3824	4049	4028	3728
H_3S_2	4394	4614	4482	4206
H_3S_3	4450	4704	4660	4376
SE(m)±	43.43	65.29	50.14	44.40
LSD (p=0.05)	128.2	192.7	148.0	131.0

germination during prolonged storage is associated with membrane deterioration, lipid peroxidation, and increased solute leakage [3, 4]. Poor germinability of seeds from early harvested fruits can also be ascribed to immature embryos and a higher proportion of unfilled seeds [9]. Enhanced seedling vigour at later harvest stages and longer *in-situ* storage likely reflects improved assimilate accumulation through continued translocation from fruit pulp to developing seeds.

Biochemical changes during seed storage

Total soluble sugars and starch

Total soluble sugar content decreased with delayed fruit harvest and increased *in-situ* storage duration, whereas starch accumulation exhibited the opposite trend. The interaction between fruit harvest stage and *in-situ* storage duration was significant at all storage intervals (Table 3). Both total soluble sugars and starch declined progressively with increasing seed storage duration, reflecting their utilization as respiratory substrates. After eight months, sugar and starch contents were statistically at par in seeds harvested at 40 DAA with 10–15 days of *in-situ* storage and those harvested at 50 DAA with 5–10 days of *in-situ* storage.

Total soluble proteins and free amino acids

Total soluble protein content increased with fruit maturity and *in-situ* storage duration but declined with prolonged seed storage, whereas total free amino acids increased during storage. The significant interaction between

Table 3. Effect of fruit harvest stage and *in-situ* storage of harvested fruits on content of total soluble sugars and starch in seeds of *Cucumis sativus* L. (cv. Punjab Naveen) after different storage periods

Treatments	Duration of seed storage (Months)			
	0	8	0	8
	Total soluble sugars ($mg\ g^{-1}$ seeds)		Starch ($mg\ g^{-1}$ seeds)	
Stage of fruit harvest (DAA)				
30 (H_1)	45.78	37.53	4.77	3.40
40 (H_2)	42.56	35.71	5.97	4.56
50 (H_3)	38.38	34.34	6.50	5.28
SE(m) ±	0.10	0.07	0.04	0.04
LSD (p=0.05)	0.30	0.22	0.11	0.13
***In-situ* storage duration of harvested fruits (Days)**				
0 (S_0)	45.00	38.11	4.69	3.38
5 (S_1)	43.40	36.53	5.60	4.24
10 (S_2)	41.05	34.85	6.19	4.83
15 (S_3)	39.51	33.94	6.50	5.21
SE(m) ±	0.18	0.08	0.04	0.05
LSD (p=0.05)	0.34	0.25	0.13	0.15
Interaction (H x S)				
H_1S_0	49.05	39.63	4.09	2.81
H_1S_1	47.47	38.43	4.55	3.12
H_1S_2	44.97	36.60	5.01	3.66
H_1S_3	41.61	35.46	5.43	4.02
H_2S_0	44.72	37.74	4.57	3.30
H_2S_1	43.32	36.20	5.88	4.34
H_2S_2	41.59	34.89	6.51	4.56
H_2S_3	40.61	34.00	6.91	5.65
H_3S_0	41.24	36.97	5.41	4.03
H_3S_1	39.39	34.95	6.39	5.26
H_3S_2	36.58	33.06	7.04	5.88
H_3S_3	36.32	32.37	7.15	5.96
SE(m) ±	0.20	0.15	0.07	0.09
LSD (p=0.05)	0.60	0.43	0.22	0.26

Table 4. Effect of fruit harvest stage and *in-situ* storage of harvested fruits on content of total soluble proteins and total amino acids in seeds of *Cucumis sativus* L. (cv. Punjab Naveen) after different storage periods

Treatments	Duration of seed storage (Months)			
	0	8	0	8
	Total soluble proteins ($mg\ g^{-1}$ seeds)		Total amino acids ($mg\ g^{-1}$ seeds)	
Stage of fruit harvest (DAA)				
30 DAA (H_1)	214.66	161.11	5.78	6.65
40 DAA (H_2)	240.26	194.76	8.07	8.74
50 DAA (H_3)	266.35	224.23	10.51	11.11
SE(m) ±	0.62	0.96	0.04	0.04
LSD (p=0.05)	1.83	2.84	0.11	0.11
***In-situ* storage duration of harvested fruits (Days)**				
0 (S_0)	212.63	166.77	6.96	5.96
5 (S_1)	233.02	184.76	7.77	8.49
10 (S_2)	254.74	205.57	8.59	9.26
15 (S_3)	261.30	216.37	9.16	9.93
SE(m) ±	0.72	1.11	0.04	0.04
LSD (p=0.05)	2.12	3.28	0.13	0.13
Interaction (H x S)				
H_1S_0	177.78	131.00	5.13	5.96
H_1S_1	208.68	154.07	5.48	6.31
H_1S_2	233.65	176.08	5.98	6.85
H_1S_3	238.52	183.28	6.53	7.48
H_2S_0	217.57	171.85	6.30	6.91
H_2S_1	235.56	185.40	7.65	8.32
H_2S_2	248.68	200.42	8.67	9.26
H_2S_3	261.16	221.37	9.67	10.66
H_3S_0	242.54	197.46	9.44	10.09
H_3S_1	256.72	214.81	10.18	10.84
H_3S_2	281.90	240.21	11.12	11.67
H_3S_3	284.23	244.44	11.28	11.85
SE(m) ±	1.24	1.93	0.08	0.07
LSD (p=0.05)	3.67	5.69	0.23	0.22

harvest stage and *in-situ* storage duration indicates coordinated regulation of protein metabolism (Table 4). The increase in amino acids during storage is attributed to proteolytic degradation of storage proteins [23].

Oil content

Oil content declined with advancing fruit harvest stage and increased *in-situ* storage duration, both immediately after extraction and after eight months of storage (Table 5). This decline likely reflects metabolic conversion and utilization of lipids during seed maturation and storage.

Overall, deterioration of seed reserves during storage was accompanied by increased amino acid content and reduced germination, consistent with reports in cucumber [24] and watermelon [25]. Seed ageing involves membrane disruption, oxidative stress, and metabolic imbalance, ultimately impairing seed viability.

CONCLUSION

The study clearly demonstrates that seed quality and longevity in *Cucumis sativus* L. cv. Punjab Naveen are strongly influenced by fruit harvest stage and *in-situ* storage duration of harvested fruits prior to seed extraction. Seeds extracted from fruits harvested at advanced maturity (40–50 DAA) combined with *in-situ* storage of 10–15 days consistently exhibited superior

Table 5. Effect of fruit harvest stage and *in-situ* storage of harvested fruits on oil content (%) in seeds of *Cucumis sativus* L. (cv. Punjab Naveen) after different storage periods

Treatments	Duration of seed storage (Months)	
	0	8
Stage of fruit harvest (DAA)		
30 (H_1)	30.11	28.57
40 (H_2)	29.52	26.57
50 (H_3)	27.33	24.97
SE(m)±	0.24	0.16
LSD (p=0.05)	0.70	0.46
***In-situ* storage duration of harvested fruits (Days)**		
0 (S_0)	31.51	28.60
5 (S_1)	30.13	26.89
10 (S_2)	28.39	25.64
15 (S_3)	25.93	25.68
SE(m)±	0.27	0.18
LSD (p=0.05)	0.81	0.53
Interaction (H x S)		
H_1S_0	32.20	30.25
H_1S_1	30.95	27.91
H_1S_2	29.52	27.08
H_1S_3	27.78	29.05
H_2S_0	34.49	28.37
H_2S_1	30.34	27.38
H_2S_2	29.30	25.68
H_2S_3	26.93	24.85
H_3S_0	30.83	27.18
H_3S_1	29.10	25.40
H_3S_2	26.33	24.17
H_3S_3	23.07	23.14
SE(m)±	0.48	0.31
LSD (p=0.05)	1.40	0.92

germination, higher seedling vigour, and better retention of seed quality during eight months of ambient storage. Among the treatments, seeds harvested at 50 DAA with 10 days of *in-situ* storage emerged as the most optimal combination.

Biochemical analyses revealed a progressive decline in carbohydrates, proteins, and oil content during storage, accompanied by an increase in free amino acids, reflecting metabolic degradation associated with seed ageing. These physiological and biochemical changes explain the observed decline in germination after extended storage.

From a practical perspective, the findings provide clear, actionable guidance for seed producers and farmers. Harvesting cucumber fruits at 40–50 DAA followed by 10–15 days of *in-situ* storage before seed extraction can substantially improve seed quality, ensure compliance with seed certification standards, and minimize viability losses during short-term storage. Adoption of this simple post-harvest management strategy can enhance seed longevity, reduce economic losses, and strengthen cucumber seed production systems under Punjab agro-climatic conditions and similar environments.

REFERENCES

1. RAJJOU L AND I DEBEAUJON (2008). Seed longevity: survival and maintenance of high germination ability of dry seeds. *Comptes Rendus Biologies,* **331**: 796-805.
2. NERSON H (2007). Seed production and germinability of cucurbit crops. *Seed Science and Biotechnology,* **1**: 1-10.
3. MARUTHI K, SR DODDAGOUDAR, SN VASUDEVAN, G KHIDRAPURE AND D HANUMANTHAPPA (2014). Effect of post harvest ripening duration on seed quality during storage in bottle gourd (*Lagenaria siceraria*). *The Ecoscan,* **6**: 209-215.
4. NERSON H (2001). Effect of seed maturity, extraction practices and storage duration on germinability in watermelon. *Scientia Horticulturae,* **93**: 245-256.
5. COOLBEAR P (1995). Mechanisms of seed deterioration. In: BASRA AS (ed) *Seed quality: basic mechanisms and agricultural implications,* pp. 223-227. Food Products Press, New York.
6. TAYLOR AG (1997). Seed storage, germination and quality. In: WIEN HC (ed) *The Physiology of Vegetable Crops*, pp. 1-36. CAB International, United Kingdom.
7. PRIESTLEY DA (1986). *Seed ageing: implications for seed storage and persistence in the soil*. Comstock Publishing Associates, Ithaca, London.
8. ACHIGAN-DAKO EG, F FAGBEMISSI, HT AVOHOU, RS VODOUHE AND OCA AHANCHEDE (2008). Importance and practices of Egusi crops (*Citrullus lanatus* (Thunb.) Matsum & Nakai, *Cucumeropsis mannii* Naudin and *Lagenaria siceraria* (Molina) Standl. Cv. 'Aklamkpa') in sociolinguistic areas in Benin. *Biotechnologie Agronomie Societe et Environnement,* **12**: 393-403.
9. NERSON H AND HS PARIS (1988). Effects of fruit age, fermentation and storage on germination of cucurbits seeds. *Scientia Horticulturae,* **35**: 15-26.
10. MURUGESAN P AND K VANANGAMUDI (2005). Effect of post harvest fruit storage on seed quality in ash gourd (*Benincasa hispida* (Thunb.) Cogn.). *Seed Research,* **33**: 160-164.
11. GANAR HD, K KANT AND M DADLANI (2004). Study on physiological maturity in ash gourd (*Benincasa hispida*). *Seed Research,* **32**: 145-148.
12. KUMAR DD (2015). Standardization of quality seeds production technology in bottle gourd (*Lagenaria siceraria* (Molina) Standl) var. ABG-1. M.Sc. thesis, Anand Agricultural University, Anand, Gujarat, India.
13. ANONYMOUS (2018). *Package of Practices for Cultivation of Vegetables*. Punjab Agricultural University, Ludhiana, Punjab, India
14. ISTA (2008). *International rules for Seed Testing*. International Seed Testing Association, Barsserssorf, Switzerland.
15. ABDUL-BAKI AS AND JD ANDERSON (1973). Vigour determination in soybean by multiple criteria. *Crop Science,* **13**: 630-633.

16. DUBOIS M, KA GILES, JK HAMILTON, PA RETERS AND F SMITH (1956). Colorimetric method for the determination of sugars and related substances. *Analytical Chemistry,* **28**: 350-360.

17. LOWRY OH, NJ ROSEBROUGH, AK FARR AND RJ RANDALL (1951). Protein measurement with the folin phenol reagent. *Journal of Biological Chemistry,* **193**: 265-275.

18. LEE PY AND T TAKAHASHI (1966). An improved colorimetric determination of amino acids with the use of ninhydrin. *Analytical Biochemistry,* **14**: 71-77.

19. CLEGG KM (1956). The application of the anthrone reagent to the estimation of starch in cereals. *Journal of Sciences and Food Agriculture,* **7**: 40-44.

20. AOCS (1993). *Official Methods and Recommended Practices of the American Oil Chemists Society* (4^{th} ed.). AOCS Press, Champaign, Illinois, USA.

21. COCHRAN WG AND GM COX (1966). *Experimental Designs*. Wiley, New York, USA.

22. BARBEDO CJ, ASC BARBEDO, J NAKAGAWA AND O SATO (1999). Effect of fruit age and post harvest period of cucumber on stored seeds. *Pesquisa Agropecuaria Brasileira,* **34**: 839-847.

23. KALPANA R AND MKV RAO (1995). On the ageing mechanism in pigeonpea (*Cajanus cajan* (L.) Mill sp.) seeds. *Seed Science and Technology,* **23**: 1-9.

24. AYYAPPAN V, G ANDY, S NATESAN, CW CHOI AND M MARKANDAN (2010). Changes in L-isoaspartylmethyltransferase, storage components and anti-oxidant enzymes activities during accelerated ageing in cucumber (*Cucumis sativus* L.) seeds. *Journal of Plant Sciences,* **5**: 309-320.

25. RASHED MM, M SHALLAN, M FATHY AND AI ISMAIL (2010). Changes in biochemical and isozymes components of watermelon seeds during accelerated ageing technique. *Journal of American Science,* **6**: 979-985.