



Effect of post-harvest ripening and drying methods on seed quality and storability in pumpkin cv Pusa Hybrid 1

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ABSTRACT

An investigation was carried out, to study the effect of post-harvest ripening and drying methods on the seed quality in pumpkin cv Pusa Hybrid 1, during summer 2008 and 2009 at Seed Production Unit, IARI, New Delhi. After harvesting, the fruits were allowed for post-harvest ripening (PHR) of zero days (P₀), 10 days (P₁) and 20 days (P₂) and seeds obtained from each of the PHR treatments were subjected to three methods of drying, viz. shade drying (D₁), sun drying (D₂) and mechanical drying (D₃). The results showed that seed obtained from 20 days PHR followed by shade drying (P₂D₁) had given superior quality seed with respect to germination (94.33 %), seedling length (34.30 cm), vigour index - I (3236.52) and electrical conductivity (17.30 μ mhos/cm/g) followed by P₂D₃ (20 days PHR and mechanical drying), while germination (%) was significantly lower in P₀D₂ during storage. In all treatments the seeds stored for 12 months showed maximum germination followed by reduction after eighteen months of storage. The germination percentage was maintained above the Indian minimum seed certification standards (IMSCS) of 60% up to eighteen months of storage in all treatments.

Key words: Drying method, Post-harvest ripening (PHR), Mechanical drying, Seed quality, Shade drying and Sun drying,

Pumpkin occupies a prominent place among vegetables owing to its high productivity, nutritive value, good storability thereby better transport potentialities. It is extensively grown during rainy and summer months in all parts of India.

Pumpkin fruit is commonly used as a vegetable both at immature and mature stage. The yellow and orange fleshed fruits are very rich in carotene (3332 IU), with fair quantities of vitamins B and C (Premnath *et al.* 1973). Pumpkin seeds are also a rich source of carbohydrates (22%), proteins (30%), oils (40-50%), minerals and vitamins (Singh 1998). India is the second largest producer of pumpkin in the world after China. Pumpkin, squash and gourd are grown in India over an area of 0.51 million ha with the production of 4.90million tonnes (FAO 2012). The average productivity of pumpkin, squashes and gourds is 9.60 tonnes/ha in India, which is lower than the world's average productivity of 13.41 tonnes/ha. The higher productivity in Israel and Netherlands is due to the coverage of maximum area under hybrids whereas lower productivity in India is due to occupation of major area by open pollinated varieties (OPV). The pumpkins are being cultivated by resource poor farmers who cannot afford high cost of hybrid seed. The quality of seed largely depends on the stage of harvest. Harvesting

either at an early or a late stage results in lower seed yield with poor quality. Generally, fruits harvested at physiological maturity produce high quality seeds in terms of viability and vigour compared to fruits harvested at an early or later stages of field maturity. The seeds obtained from fruits harvested even before attainment of physiological maturity but allowed for post-harvest fruit ripening for a few days may also produce good quality seeds since the seed development continues in fleshy fruits owing to the continuous supply of nutrients and food reserves from fruit to seed (Petrova *et al.* 1981). Apart from the time of fruit harvesting and post-harvest ripening period best quality of seeds could be maintained to a greater extent by adopting suitable drying methods. Seed moisture plays an important role in determining the longevity of seed in several vegetables including pumpkin. Most of the vegetable seed can withstand drying to extend their storage life with low moisture content. At the time of extraction of seeds from the fruits, seed moisture content varies generally from 40 to 45 per cent. It is required to be reduced to a safer level of 8 to 9 per cent by different drying methods, viz. sun, shade or mechanical drying to preserve the quality of seed during storage (Rajkumar 1973, Javaregowda *et al.* 1994, Gowda 1997). All kinds of drying methods are not equally effective in retaining high viability and vigour of seeds under given set of conditions. Drying of seed too rapidly or with high air temperature certainly causes injury to seed (Copeland 1976). Further, seed drying helps in arresting the activity and

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development of micro-organisms (Christensen and Kaufman 1965). Therefore, an attempt was made to find out the suitable period of PHR and practicable drying method to maintain high seed viability and vigour during storage in pumpkin.

MATERIALS AND METHODS

An experiment was conducted during summer season of 2008 and 2009 at Seed Production Unit (SPU), Division of Seed Science and Technology (DSST), Indian Agricultural Research Institute (IARI), New Delhi. The seed of parental lines of Pusa Hybrid 1 obtained from the Division of Vegetable Science, IARI, New Delhi were grown by adapting the good agricultural package of practices (GAP). The crossed fruits were obtained by following the hand pollination method (Vishwanath 2007). The crossed fruits harvested at vine drying stage were allowed for three different post-harvest ripening (PHR) periods, viz. zero days PHR (P_0), 10 days PHR (P_1), 20 days PHR (P_2). Seed obtained from each of them were having initial moisture content around 30-40% so these seeds were subjected to three different drying methods, viz. shade drying (D_1), sun drying (D_2) and mechanical drying (D_3) at 35°C temperature. The seeds were dried under shade (D_1) and direct sun light (D_2), every day from 9.00 am to 5.00 pm for 5-7 days till the seed attained 8-9 per cent moisture content. In mechanical drying, the seeds were dried in a mechanical seed drier at a constant temperature of 35°C for 5 hr. After drying seeds were packed in polythene bag (500 gauge) and stored under ambient conditions (28°C \pm 3°C temperature, 70% \pm 5% RH). The seed quality attributes such as germination (%), seedling length (cm), seedling dry weight (mg), vigour index – I, vigour index – II, moisture content (%) were conducted by adopting the ISTA procedure (Anon 2008) and electrical conductivity (μ mhos/cm/g) of seed leachate

was determined as per the procedure of Dadlani and Agrawal (1987). The seed storability was studied by conducting germination test at 3 months interval regularly upto 18 months. The data was statistically analyzed by following Randomized Complete Block (RCB) design in factorial concept using SAS statistical package version 9.2.

RESULTS AND DISCUSSION

Germination (%)

The results on the effect of post-harvest ripening and drying method and their interaction on germination (%) were presented in Table 1. Post-harvest ripening significantly influenced the germination %. Seed obtained from P_2 showed significantly higher germination (90.81%) followed by P_1 (90.67%). The lowest germination was recorded in P_0 (88.56%).

Among the different methods of seed drying, (D_1) recorded higher germination (93.44%) followed by D_3 (91.44%), while the lowest value was noticed in D_2 (87.56%). The interaction effect due to post harvest ripening and drying method also significantly influenced the germination (%). The higher germination (%) was recorded in P_2D_1 (94.33%) followed by P_2D_3 (93.33%) and P_1D_1 (93.33%) with lowest recording in P_0D_2 (83.67%).

Seedling length (cm)

The marked differences on seedling length were observed for post harvesting ripening and drying methods and their interaction (Table 1). The results revealed that seedling length was significantly higher in P_2 (33.34 cm) than in P_1 (32.51 cm) and P_0 (30.78 cm) irrespective of drying methods. Significant differences due to drying methods were noticed for seedling length. It was significantly maximum in D_1 (33.34 cm) followed by D_3 (32.03 cm) whereas D_2 recorded significantly minimum seedling length

Table 1 Effect of post-harvest ripening and drying methods in seed quality of pumpkin cv Pusa Hybrid 1

Post-harvest ripening	Drying methods											
	Germination (%)				Seedling length (cm)				Seedling dry weight (mg)			
	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean	D_1	D_2	D_3	Mean
P_0	92.67 (74.46)	83.67 (66.53)	89.33 (71.09)	88.56 (70.70)	32.07	29.48	30.79	30.78	43.03	46.69	50.18	46.63
P_1	93.33 (75.32)	87.00 (69.11)	91.67 (73.38)	90.67 (72.60)	33.64	31.70	32.18	32.51	47.58	50.27	52.24	50.03
P_2	94.33 (76.62)	92.00 (74.00)	93.33 (75.93)	90.81 (75.52)	34.30	32.59	33.13	33.34	48.13	51.93	54.75	51.60
Mean	93.44 (75.47)	87.56 (69.88)	91.44 (73.47)	93.63 (72.94)	33.34	31.26	32.03	32.21	46.25	49.63	52.39	49.42
	SEm \pm		HSD (5%)		SEm \pm		HSD (5%)		SEm \pm		HSD (5%)	
P	0.71		1.51		0.28		0.60		0.82		1.73	
D	0.71		1.51		0.28		0.60		0.82		1.73	
P \times D	1.45		3.67		0.56		NS		1.66		NS	

*Transformed (arc sin) value in parenthesis. P_0 - zero days Post-Harvest Ripening, P_1 - 10 Days Post-Harvest Ripening, P_2 - 20 Days Post-Harvest Ripening, D_1 - Shade drying, D_2 - Sun drying, D_3 - Mechanical drying, HSD – Tukey's Honest Significant Difference, NS – Non Significance

Table 2 Effect of post-harvest ripening and drying methods in seed quality of pumpkin cv. Pusa Hybrid 1

Post-harvest ripening	Drying methods											
	Vigour index - I				Vigour index - II				Electrical conductivity (μ mhos/cm/g)			
	D ₁	D ₂	D ₃	Mean	D ₁	D ₂	D ₃	Mean	D ₁	D ₂	D ₃	Mean
P ₀	2972.59	2521.07	2690.45	2728.04	3992.43	3898.63	4478.30	4123.12	30.30	37.38	34.95	34.21
P ₁	3141.16	2758.19	2948.81	2949.38	4441.52	4371.39	4786.22	4533.04	28.78	36.25	32.90	32.64
P ₂	3236.52	2998.10	3092.94	3109.19	4538.35	4777.44	5116.64	4810.81	17.30	25.28	21.80	21.46
Mean	3116.76	2759.12	2910.73	2928.87	4324.10	4349.15	4793.72	4488.99	25.46	32.97	29.88	29.44
	SEM \pm			HSD (5%)	SEM \pm			HSD (5%)	SEM \pm			HSD (5%)
P	25.75			54.20	66.50			139.9	1.38			2.92
D	25.75			54.20	66.50			139.9	1.38			2.92
P \times D	51.86			132.9	123.00			NS	2.78			NS

P₀- 0 Days post-harvest ripening, P₁- 10 Days post-harvest ripening, P₂- 20 Days post-harvest ripening, D₁- Shade drying, D₂- Sun drying, D₃- Mechanical drying, HSD – Tukey's Honest Significant Difference, NS – Non Significance

(31.26 cm). Non-significant differences were observed for P \times D interaction effect. However, more seedling length was noticed in P₂D₁ (34.30 cm) followed by P₁D₁ (33.64 cm) with lowest in P₀D₂ (29.48 cm) treatment combination.

Seedling dry weight (mg)

Significant variations on seedling dry weight due to post harvesting ripening and drying methods were observed with their interaction effect (Table 1). The results showed that, the P₂ recorded significantly highest seedling dry weight (51.60 mg), followed by P₁ (50.03 mg). The lowest seedling dry weight was observed in P₀ (46.63 mg). The mechanical drying method (D₃) recorded significantly maximum seedling dry weight (52.39 mg) as compared to other methods irrespective of post harvesting ripening followed by D₂ (49.63 mg) and minimum was in D₁ (46.25 mg).

Interaction effect of post-harvest ripening and drying methods (P \times D) was found non-significant for seedling dry weight with numerically higher seedling dry weight in P₂D₃ (54.75 mg) and lower in P₀D₁ (43.03 mg).

Vigour index - I

The highest and lowest vigour index - I was noticed in P₂ (3109.19) and P₀(2728.04), respectively over drying methods and the highest vigour index was recorded in D₁ (3116.76), followed by D₃ (2910.73) and lowest in D₂ (2759.12) over post harvesting ripening (Table 2). The significant differences were also observed for P \times D interaction effect. Highest vigour index was noticed in P₂D₁ (3236.52), followed by P₂D₃ (3092.94) and lowest in P₀D₂ (2521.07).

Vigour index - II

The seeds obtained from P₂ recorded significantly higher vigour index - II(4810.81) while, P₀ recorded lower value (4123.12). Drying methods produced significant effect on vigour index - II and found that mechanical drying(D₃) recorded significantly maximum vigour index - II (4793.72), while, it was minimum (4324.10) in shade drying (D₁)

(Table 2). The interaction effect due to post harvest ripening, drying methods showed non-significant differences in vigour index - II.

Electrical conductivity (μ mhos/cm/g)

The results showed that P₀ and P₂ recorded significantly higher (34.21) and lower (21.46) electrical conductivity irrespective of seed drying methods. The sun drying (D₂) recorded significantly highest electrical conductivity (32.97) of seed leachates while lowest electrical conductivity (25.46) was observed in D₁ irrespective of post harvesting ripening (Table 2).

Storability

The results revealed that germination percentage due to interaction between post-harvest ripening and drying methods differed significantly with the mean values of 26.67%, 83.48%, 87.63%, 90.15%, 91.63%, and 87.48% at zero, three, six, nine, twelve and eighteen months of storage period (Table 3). Germination percentage was found to increase with the advancement of storage period from zero (26.67%) to twelve months (91.63%) followed by reduction at eighteen months (87.48%) among all treatments. The initial germination (%) ranged from 11.00% in P₀D₂ to 48.33% in P₂D₁ at the beginning of storage period. The seed of all treatments after three months of storage showed sharp increase in germination percentage (83.48%) thereafter the increase was gradual.

Germination percentage was significantly higher (48.33%, 89.67 %, 92.67 %, 95.83 % and 97.00 %) in the seeds of P₂D₁, while it was significantly lower (11.00 %, 78.00 %, 82.67 %, 85 % and 87.67%) in seeds of P₀D₂ at zero, third, sixth, ninth and twelfth months of storage period, respectively. P₂D₁(92.33%) and P₂D₃ (93.00%) were at par with regard to germination percentage after eighteen months of storage period though marginally higher values were recorded in P₂D₃. The results revealed that the rate of reduction in germination percentage was slower in mechanical drying than in shade drying after eighteen

Table 3 Effect of post-harvest ripening and drying methods on germination (%) after different storage period in pumpkin cv Pusa Hybrid 1

Treatment	Storage period (months)					
	0	3	6	9	12	18
P ₀ D ₁	18.00 (25.1)	81.33 (64.4)	87.67 (69.4)	91.17 (72.7)	92.00 (73.6)	86.00 (68.0)
P ₀ D ₂	11.00 (19.3)	78.00 (62.0)	82.67 (65.4)	85.00 (67.2)	87.67 (69.4)	82.67 (65.4)
P ₀ D ₃	17.00 (24.3)	77.67 (61.8)	84.33 (66.7)	87.67 (69.4)	89.33 (70.9)	86.33 (68.3)
P ₁ D ₁	29.33 (32.8)	89.00 (70.6)	90.67 (72.2)	94.00 (75.8)	94.67 (76.6)	89.67 (71.2)
P ₁ D ₂	19.00 (25.8)	83.00 (65.6)	84.67 (66.9)	85.00 (67.2)	87.67 (69.4)	81.33 (64.4)
P ₁ D ₃	23.67 (29.1)	80.67 (63.9)	87.67 (69.4)	90.00 (71.6)	92.33 (73.9)	91.00 (72.5)
P ₂ D ₁	48.33 (44.0)	89.67 (71.2)	92.67 (74.3)	95.83 (78.2)	97.00 (80.0)	92.33 (73.9)
P ₂ D ₂	32.33 (34.6)	86.67 (68.6)	88.33 (70.0)	90.00 (71.6)	90.33 (71.9)	84.00 (66.4)
P ₂ D ₃	41.33 (40.0)	85.33 (67.5)	90.00 (71.6)	92.67 (74.3)	93.67 (75.4)	93.00 (74.3)
Mean	26.67 (31.1)	83.48 (66.0)	87.63 (69.4)	90.15 (71.7)	91.63 (73.2)	87.48 (69.3)
HSD at 5 %	7.93	4.34	6.10	5.66	4.82	4.40

Transformed (arc sin) value in parenthesis

months of storage. This was visible in P₂D₁ and P₂D₃ where the germination (%) declined from 97.00% at twelve months of storage to 92.33% at eighteen months in P₂D₁ with a reduction of 4.67%, whereas in P₂D₃, the germination fell from 93.67 to 93.00% with the decline of just 0.67%. The germination percentage above the minimum seed certification standards (IMSCS) of 60 % were maintained up to eighteen months of storage in all treatment combinations.

Post-harvest ripening showed significant effect on seed quality. The highest germination (90.81%), seedling length (33.34 cm), seedling dry weight (51.60 mg), vigour index – I (3109.19) and vigour index – II (4810.81) were observed at 20 days post-harvest ripening (P₂) which could be due to continued development of immature and matured embryos to attain physiological maturity of seed during post-harvest ripening which was evident by lower electrical conductivity of seed leachate (21.46 μ mhos/cm/g). The higher germination percentage in P₂ could be attributed to the increased growth potential of the embryo during post-harvest ripening, which enhanced the capability of radical to penetrate seed coat which is a physical barrier in seeds (Weston *et al.* 1992). Similar findings were reported in other cucurbits such as water melon (Alvarenga *et al.* 1984), cucumber (Barbedo *et al.* 1993, Nandeesh *et al.* 1995) as well as in non-cucurbits, viz. Indian chilli (Pandita and Nagarajan, 2001) and tomato (Dias *et al.* 2006).

The methods of drying had significant influence on seed quality parameters like seed germination, seedling length, seedling dry weight, vigour index - I, vigour index – II and electrical conductivity. Among, the three drying methods, shade drying of seeds (D₁) recorded significantly superior performance due to the possible minimum moisture stress effect owing to slow drying under constant temperature without exposure to continuous UV radiation effects. The high temperature in mechanical drying resulted in rapid loss of moisture thus inducing a severe moisture stress on embryo affecting the seed performance. The poor seed

quality in sun drying could be due to direct exposure of seed to high energy ultra violet radiation (UV rays) associated with faster rate of desiccation and seed deterioration (Harrington 1960, Singh and Ojha 1972). These results are in agreement with the findings of Javaregowda *et al.* (1994) in brinjal, Nascimento *et al.* (1994); Suryawanshi *et al.* (1996), Ravi kumar (2005) in cucumber, Nepane *et al.* (1993) in sweet pepper and Shantappa *et al.* (2006) in bitter gourd.

Post-harvest ripening and drying method interaction differed significantly with respect to germination and vigour index – I. Maximum germination and vigour index – I were recorded in P₂D₁ and it could be attributed to continued development of embryo with in seed during PHR and constant drying temperature during drying period resulting in better seed quality.

Good seed storage is a basic requirement in any seed production programme. The longevity of seed predominantly depends on the moisture content of seeds, temperature and RH of storage. Cucurbits, in general, have storability of 3 to 4 years and grouped under good storer. Under ambient conditions (28°C \pm 3°C temperature, 70% \pm 5% RH) in Delhi, the seeds of P₂D₁ showed significantly higher values of germination percentage compared to other treatment combinations up to twelve months of storage period. This superiority in P₂D₁ could be attributed to fully developed and vigorous embryo and the favourable effect of shade drying on seed quality in terms of germination. Similar findings were also reported in ash gourd (Ganar *et al.* 2004). The slower rate of reduction in germination percentage after eighteen months of storage in P₂D₃ is owed to the low moisture content in seeds.

CONCLUSION

It is concluded that the harvested fruits of pumpkin should be allowed for 20 days of post-harvest ripening before seed extraction and seeds should be dried under shade for getting higher seed quality.

REFERENCES

- Alvarenga E M, Silva R F and Aranjó E F. 1984. Influence of age and post harvest storage of watermelon on seed quality. *Horticultural Brasileria* **2**(2): 5–8.
- Barbedo C J, Coelho A S, Zanin A C W and Nakagawa J. 1993. Influence of age of cucumber fruits on seed quality. *Horticultura Brasileira*, **11**: 18–21.
- Christensen, C.M. and Kaufman, C.M. (1965). Deterioration of stored grains by fungi. *Annual Review of Phytopathology* **3**: 69–84.
- Copeland L O. 1976. *Principles of Seed Science and Technology*. Burgers Publication Co., Minnesoe.
- Dadlani M and Agrawal P K. 1987. *Techniques in Seed Science and Technology*, pp 103–4. South Asian Publishers, New Delhi.
- Dias D C F S, Ribeiro F P, Dias L A S, Silva D J H, Vidigal D S. 2006. Tomato seed quality in relation to fruit maturation and post-harvest storage. *Seed Science and Technology* **34**(3): 691–9.
- FAO database (2012). www.fao.org.
- Ganar H D, Kant K, Dadlani M, Sirohi P S and Tomar B S. 2004. Effect of after-ripening and seasons on seed quality of ash gourd (*Benincasa hispida* (Thunb.) Cogn.). *Seed Research* **32**: 145–8.
- Gowda H G. 1997. Effects of stages of harvesting and drying methods on seed quality in onion. M Sc (Agri.) thesis, University of Agricultural Sciences, Dharwad.
- Harrington J F. 1960. Drying, storing and packaging seed to maintain germination. *Seed Man's Digest*. **1**: 16–8.
- ISTA. 2008. Seed testing rules, Publ. *International Seed Testing Association* Barsserssorf, CH-Switzerland.
- Javaregowda S, Mahboob Ali Khan and Jagadish G V. 1994. Effect of drying methods on seed quality in brinjal (*Solanum melongena* L.). *Seed Technology News* **24**: 101–2.
- Nandeesh, Javaregowda S. and Ramegowd G. 1995. Studies on the stage of harvest and post harvest ripening on seed quality in cucumber (*Cucumis sativus* L.). *Seed Research* **23**(2): 113–5.
- Nascimento W M, Pessoa S V. and Silva J B C. 1994. Mucilage removal and its effect on seed quality in cucumbers and tomatoes. *Horticultural Brasileria* **12**(20): 169–72.
- Nepane P R, Ghimire A J. and Khanal R. 1993. Seed research on summer vegetable crops (sweet pepper and okra) at PAC. *PAC Technical paper Pakhribas Agriculture Centre* **144**: 12.
- Pandita V K. and Nagarajan S. 2001. Fruit maturity and post harvest ripening affecting chilli seed quality and field emergence. *Seed Research* **29**(1): 21–23.
- Petrova H R, Doikova M and Popova D. 1981. Studies on the quality of egg plant seed. *Acta Horticulturae* **111**: 275–80.
- Premnath Dutta, O P. and Vijay O P. 1973. Arka Chandan the carotene rich pumpkin. *Indian Horticulture* pp.19–20.
- Rajkumar 1973. Design, development and testing of a baffle type mode chilli drier. M Tech Thesis, Indian Institute of Technology, Khargapur.
- Ravikumar G H, Shekhar Gowda M, Vasudevan N, Basave Gowda and Mahadeva Reddy 2005. Influence of spacing, nipping and fruit retention on seed yield and seed quality in cucumber. *Seed Research*. **33**(1): 82–7.
- Shantappa T, Shekhargouda M, Meharwade M N. and Ravindra Mugle. 2006. Effects of stages of harvest and drying methods on seed quality in bitter gourd. *Seed Research* **34** (2): 146–9.
- Singh R S. and Ojha P. 1972. Drying characteristics of groundnut and chillies. *Journal of Agriculture* **9**(2): 50–61.
- Singh S P. 1998. Seed Production of Commercial Vegetables, pp 469–18.
- Suryawanshi Y B, Patil R B. and Pukar J K. 1996. Seed dormancy studies in cucumber (*Cucumis sativus* L.) cv. Himangi. *Seed Research* **24**: 160–2.
- Vishwanath 2007. 'Studies on floral attributes and methods of pollination on seed yield and quality in pumpkin (*Cucurbita moschata* Duch. exPoir.) cv Pusa hybrid-1.' MSc thesis, P G School, IARI, New Delhi.
- Weston L A, Geneve R L. and Staub J E. 1992. Seed dormancy in *Cucumis sativus* var. *hardwickii* (Royle) Alef. *Scientia Horticulturae* **50**: 35–46.