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Standardization of Drying Methods of different Fruit Types on Storability of Chilli Seed

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ABSTRACT

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The effect of seed drying methods on storability for chilli of different fruit types was studied in Completely Randomized Design (CRD) in four replications with five treatments. The chilli fruits were grouped like slender, moderate and fleshy as per the fleshiness index and are exposed to different drying methods such as sun-drying, shade drying, freeze drying, oven drying of fruits and hand extracted seeds on the day of harvest followed by shade drying. Seeds were stored for 10 months and observations were recorded on germination percentage, vigour index in a regular interval of 2 months. Results revealed that fleshy fruit types showed highest germination percentage in shade drying after 2 months of storage (79.14%) & reduced gradually whereas lowest found in freeze drying method after 10 months after storage (12.26%) followed by medium and slender fruit types. After 2 months of storage, shade dried fleshy fruit types of chilli exhibited highest vigour index (943.553) followed by slender & medium fruit types whereas lowest vigour index found in freeze dried slender fruit types of chilli after 10 months of storage (50.99). Hence both shade drying and hand extracted seeds on the day of harvesting is recommended for drying of chilli seeds.

Introduction

Chilli (*Capsicum annuum* L.; 2N=24) is a member of the Solanaceae family. Nearly 30 species were identified under the genus *Capsicum*. Out of it, only five species *C. annuum* L., *C. baccatum* L.; *C. chinense*

Jacq.; *C. frutescens* L. and *C. pubescens* Ruiz & Pavonand are mostly cultivated and are recognized by International Bureau of Plant Genetic Resources. Among all, *C. annuum* L. is the widely cultivated and most explored species. It is an indispensable spice essentially used in every Indian cuisine due to its

pungency, taste, appealing colour and flavour. Pungency of chilli is due to a crystalline acrid volatile alkaloid called 'capsaicin', present in the placenta of fruit which has diverse prophylactic and therapeutic uses in allopathic and ayurvedic medicine.

Chilli seeds exhibit peculiar behavior in storage requirement. These seeds lose viability quickly after being removed from fruit. Seeds maintain viability for a longer period when they are in fruits than the seeds extracted and stored.

Seeds reported to maintain a higher germination value up to 6 months, when retained in fruits and stored under ambient conditions (RadheSham *et al.*, 1996; Nagaraja *et al.*, 1998b; Sahoo, 2014).

The quality of chilli seeds can be maintained for a long period by adopting different drying methods and also extraction methods.

Chilli, unlike brinjal and tomato, the other members of Solanaceae family where seeds are mostly extracted at ripened stage using fermentation method, chilli seed extraction is mostly done after drying of the ripened fruits. However it is reported that chilli seeds express maximum vigour at physiological maturity stage (Sahoo, 2014).

Hence chilli drying is very crucial from seed viability and vigour point of view, as seeds extracted from fruits at physiological maturity is supposed to express maximum vigour.

So for understanding the viability and vigour of chilli seeds, both inside the fruit and extracted at the day of harvest for the entire storage period is a matter of study.

Keeping these propositions in mind, the present experiment was designed to evaluate the drying methods like shade drying, sun-

drying, freeze drying, oven drying of chilli with fruits harvested at physiological maturity and hand extraction of seeds on the day of harvest followed by shade drying for identifying suitable drying methods.

Materials and Methods

Categorization of fruit types in chilli genotypes using fleshiness index

Chilli fruits were categorized into three types based on their shape characteristics and drying requirements for standardization of drying time, method and storage potential in ambient condition and their effect on seed viability and vigour.

A fleshiness index was developed for this study to categorize different chilli fruit types. The indicators used were the fruit shape (ratio of fruit width and length) and fleshiness (Pericarp thickness). This index is useful in estimating indirectly the fruit cavity volume, which in turn affects the total heat absorption and retention by the fruit, deciding the seed life in terms of viability and vigour during and after drying.

Fleshiness index

Fleshiness index is a characteristic of both

Fruit Shape (Ratio of fruit width and length)

Fleshiness (Pericarp thickness)

Fleshiness Index = (Ratio of fruit width and length) × Pericarp thickness

$$FI = (W/L) \times P$$

Where FI = Fleshiness Index

W= Width of the fruit at the widest point

L = Fruit length excluding the stalk

P = Pericarp thickness

For this experiment the varieties were categorized in to three groups based on the range of the Fleshiness Index

Slender fruit type (i.e. FI = 0-0.3)

Medium fruit type (i.e. FI = 0.3-0.6)

Fleshy fruit type (i.e. FI > 0.6)

Seed quality attributes in different fruit types with respect to drying and storage condition

For studying the effect of fruit types and drying method on storage potential, 26 treatments were taken including control wherein the genotypes were exposed to 5 drying methods and 5 storage durations.

M1 :	Shade Drying	D1 :	2 Months
M2 :	Hand Extracted	D2 :	4 Months
M3 :	Sundried	D3 :	6 Months
M4 :	Freeze Drying	D4 :	8 Months
M5:	Oven Drying	D5 :	10 Months

Chilli of different fruit types were exposed to 5 types of drying methods. Harvested fruits were dried under shade, sun, freeze and oven.

Some seeds were extracted manually from the fruits on the day of harvest, washed thoroughly and dried in shade for 2 days and in the sun for 3 days for drying. After drying seeds were stored on air-tight steel container, germination and vigour testing was done at an interval of 2 months.

Seed quality attributes studied

Germination percentage

The germination test was carried out using germination papers by the between paper (BP) method (ISTA, 1965) for all the stages. Four such settings for four replications of fruit types of chilli were placed in a germination chamber at 25±10C in an upright position. The final count was taken on 14th day and germination (%) was calculated as percentage of number of normal seedlings divided by no of seeds used for germination test. Separate observations were recorded for different treatments.

Seed Vigour Index (SVI)

Vigour index was determined for the stages where only germination took place following Abdul-Baki and Anderson, 1973.

Vigour index (VI)= Avg. length of seedlings (cm) × Germination (%)

Results and Discussion

Standardisation of drying method

Standardization of drying methods of chilli was done with fruits harvested at physiological maturity. Methods used for drying chilli are shade drying, sun drying, freeze drying and oven drying. Besides above treatments another was hand extraction of seeds on the day of harvest followed by shade drying.

All the 27 studied genotypes of chilli exhibited varying fruit types differing significantly in fruit size, shape, weight and fruit cavity with different pericarp thickness were grouped in to three categories like slender fruit type, medium fruit type and fleshy fruit type using the value of fleshiness

index and subjected to different treatments as dried fruits are the main source for seed extraction. The dried fruits and seeds of all treatments were subjected to ambient storage condition packed in polythene in sealed container and using destructive sampling.

Germination percentage

In the category of fleshy fruit type the average germination percentage of chilli seed was found highest in shade drying method (79.139%) followed by hand extracted seed (77.292) and lowest in freeze drying method (56.569%) after 2 months of storage. The shade dried fruits had a relative advantage over sun-drying, freeze drying and oven drying with general germination of 22.416%, 36.633%, 4.019% respectively. After 4 months of storage, highest germination percentage was found in shade dried seed (71.028%) followed by oven dried seed (70.111%) and hand extracted seed (69.694%) however germination capacity was similar between oven dried and hand extracted seed and lowest was found in freeze dried seed (52.278%). After 4 months of storage, the relative advantage of shade dried fruits over sun-drying, freeze-drying and oven drying were 20.899%, 35.866 % and 1.308%. After 6 months of storage, the trend as like as 4 months after storage was observed. But after 8 and 10 months after storage, hand extracted seeds had shown the highest germination percentage than that of other drying methods i.e. 55.250% and 33.250% respectively. In the category of medium fleshy type of fruit, the highest germination was found in hand extracted seed (75.556%) followed by shade dried seed (73.986%) and lowest in freeze dried seed (56.847%) after 2 months of storage. The shade dried fruits had relative advantage over sun-drying, freeze drying and oven drying were 18.484%, 30.149% and 2.363% respectively.

This trend was followed in the seed after 4 months of storage and 6 months of storage and the shade dried fruits had relative advantage over sun-drying, freeze drying and oven drying were 18.569%, 31.359%, 0.041% and 32.220%, 48.552%, 0.533% respectively. But after 8 and 10 months of storage, hand extracted seeds had highest germination percentage followed by shade dried seed the shade dried fruits had relative advantage over sun-drying, freeze drying and oven drying were 22.914%, 74.524%, -14.523% and 24.456%, 139.792%, -8.980% respectively.

In the category of slender type of fruit, the highest germination was found in hand extracted seed (73.478%) followed by shade dried seed (72.156%) and lowest in freeze dried seed (57.122%) after 2 months of storage. The shade dried fruits had relative advantage over sun-drying, freeze drying and oven drying were 16.631%, 26.319% and 1.899% respectively. This trend was followed in the seed after 4, 8 and 10 months of storage and the shade dried fruits had relative advantage over sun-drying, freeze drying and oven drying were 16.932%, 29.065%, -1.210% (4 months after storage), 19.097%, 73.732%, -14.579% (8 months after storage) and 10.583%, 134.085%, -9.359 (10 months after storage). But after 6 months of storage, shade dried seeds had highest germination percentage (65.211%) followed by hand extracted seed (64.656%) and the shade dried fruits had relative advantage over sun-drying, freeze drying and oven drying were 29.472%, 47.240%, -0.862% after 6 months of storage.

In most of the cases like shade dried seed, hand extracted seed, sun dried seed and oven dried seed showed more germination percentage in fleshy fruit type in compared to medium and slender type of fruit, but in freeze dried seed, the slender type of fruit showed maximum germination percentage followed by medium and fleshy fruit type (Fig. 1 and 2; Table 1–3).

Table.1 Different fruit types in chilli genotypes based on fleshiness index

Fruit Type	Landraces	% of total samples
Slender	V7, V8, V9, V10, V11, V12, V14, V15, V16, V17, V19, V20, V21, V23, V27	55.6%
Medium	V2, V3, V4, V5, V18, V22	22.2%
Fleshy	V1, V6, V13, V24, V25, V26	22.2%

Table.2 Seed germination percentage of chilli (*Capsicum annum L.*) dried under different conditions in ambient storage

Drying methods & Storage duration combination	Germination % Mean		
	Slender	Medium	Fleshy
M0D0 (Contol)	77.056	78.083	82.444
M1D1 (Shade Dried+ stored for 2 Months)	73.478	75.556	79.139
M1D2 (Shade Dried+ stored for 4 Months)	67.989	69.000	71.028
M1D3 (Shade Dried+ stored for 6 Months)	65.211	65.486	66.181
M1D4 (Shade Dried+ stored for 8 Months)	49.611	48.722	48.917
M1D5 (Shade Dried+ stored for 10 Months)	32.278	31.806	32.333
M2D1 (Hand Extracted + stored for 2 Months)	72.156	73.986	77.292
M2D2 (Hand Extracted + stored for 4 Months)	68.178	68.972	69.694
M2D3 (Hand Extracted + stored for 6 Months)	64.656	64.667	65.222
M2D4 (Hand Extracted + stored for 8 Months)	55.511	53.889	55.250
M2D5 (Hand Extracted + stored for 10 Months)	32.767	32.472	33.250
M3D1 (Sundried+ stored for 2 Months)	61.867	62.444	63.139
M3D2 (Sundried+ stored for 4 Months)	58.144	58.194	58.750
M3D3 (Sundried+ stored for 6 Months)	50.367	49.528	50.472
M3D4 (Sundried+ stored for 8 Months)	41.656	39.639	39.500
M3D5 (Sundried+ stored for 10 Months)	29.189	25.556	24.250
M4D1 (Freeze Dried+ stored for 2 Months)	57.122	56.847	56.569
M4D2 (Freeze Dried+ stored for 4 Months)	52.678	52.528	52.278
M4D3 (Freeze Dried+ stored for 6Months)	44.289	44.083	44.028
M4D4 (Freeze Dried + stored for 8Months)	28.556	27.917	26.556
M4D5 (Freeze Dried + stored for 10Months)	13.789	13.264	12.264
M5D1(Oven Dried + stored for 2Months)	70.811	72.278	74.306
M5D2 (Oven Dried + stored for 4Months)	68.822	68.972	70.111
M5D3 (Oven Dried + stored for 6 Months)	65.778	65.139	66.167
M5D4 (Oven Dried + stored for 8 Months)	58.078	57.000	58.056
M5D5 (Oven Dried + stored for 10Months)	35.611	34.944	35.389
SE(m)	0.315	0.366	0.326
CD(0.05%)	0.896	1.041	0.928
CD(0.01%)	1.190	1.382	1.233
CV%	1.02	1.19	1.04

Methods of Drying		Duration of Storage after drying	
M1 :	Shade Dried	D1 :	2 Months
M2 :	Hand Extracted	D2 :	4 Months
M3 :	Sundried	D3 :	6 Months
M4 :	Freeze Dried	D4 :	8 Months
M5:	Oven Dried	D5 :	10 Months

Table.3 Seed Vigour index of chilli (*Capsicum annum* L.) dried under different conditions in ambient storage

Drying methods & Storage duration combination	Vigour Index Mean		
	Slender	Medium	Fleshy
M1D1 (Shade Dried+ stored for 2 Months)	922.169	1020.203	1099.250
M1D2 (Shade Dried+ stored for 4 Months)	842.787	810.631	943.553
M1D3 (Shade Dried+ stored for 6 Months)	718.669	878.325	856.436
M1D4 (Shade Dried+ stored for 8 Months)	662.957	727.190	851.451
M1D5 (Shade Dried+ stored for 10 Months)	381.657	449.839	558.292
M2D1 (Hand Extracted + stored for 2 Months)	266.831	282.022	281.504
M2D2 (Hand Extracted + stored for 4 Months)	724.270	863.394	532.810
M2D3 (Hand Extracted + stored for 6 Months)	808.473	749.783	656.697
M2D4 (Hand Extracted + stored for 8 Months)	655.222	653.150	686.001
M2D5 (Hand Extracted + stored for 10 Months)	475.247	499.408	581.600
M3D1 (Sundried + stored for 2 Months)	239.200	203.331	192.356
M3D2 (Sundried + stored for 4 Months)	556.887	636.475	578.763
M3D3 (Sundried + stored for 6 Months)	517.317	531.406	489.619
M3D4 (Sundried + stored for 8 Months)	401.426	475.419	485.298
M3D5 (Sundried + stored for 10 Months)	299.453	286.792	325.976
M4D1 (Freeze Dried + stored for 2 Months)	156.088	143.472	137.182
M4D2 (Freeze Dried + stored for 4 Months)	485.506	419.044	423.860
M4D3 (Freeze Dried + stored for 6Months)	333.954	420.681	415.939
M4D4 (Freeze Dried + stored for 8Months)	308.618	368.692	315.208
M4D5 (Freeze Dried + stored for 10Months)	162.880	161.661	175.949
M5D1(Oven Dried + stored for 2Months)	50.990	73.992	62.300
M5D2 (Oven Dried + stored for 4Months)	757.991	667.458	847.258
M5D3 (Oven Dried + stored for 6 Months)	751.821	733.725	797.347
M5D4 (Oven Dried + stored for 8 Months)	666.490	649.433	738.350
M5D5 (Oven Dried + stored for 10Months)	492.062	414.511	562.206
SE(m)	273.590	293.656	298.333
CD(0.05%)	26.057	44.667	42.469
CD(0.01%)	74.058	126.949	120.702
CV%	98.375	168.633	160.335

Fig.1 Seed germination percentage of chilli (*Capsicum annuum* L.) dried under different conditions and stored for different durations

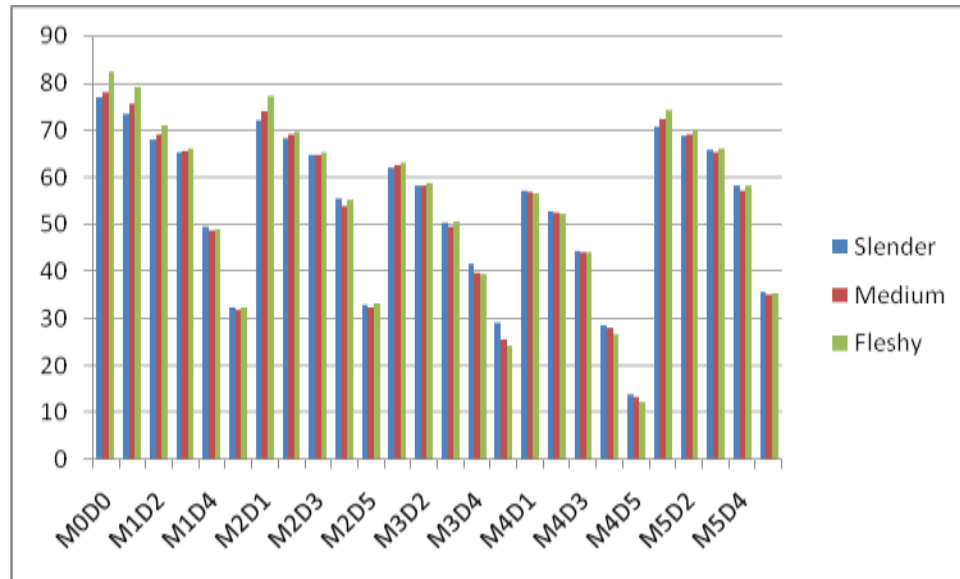
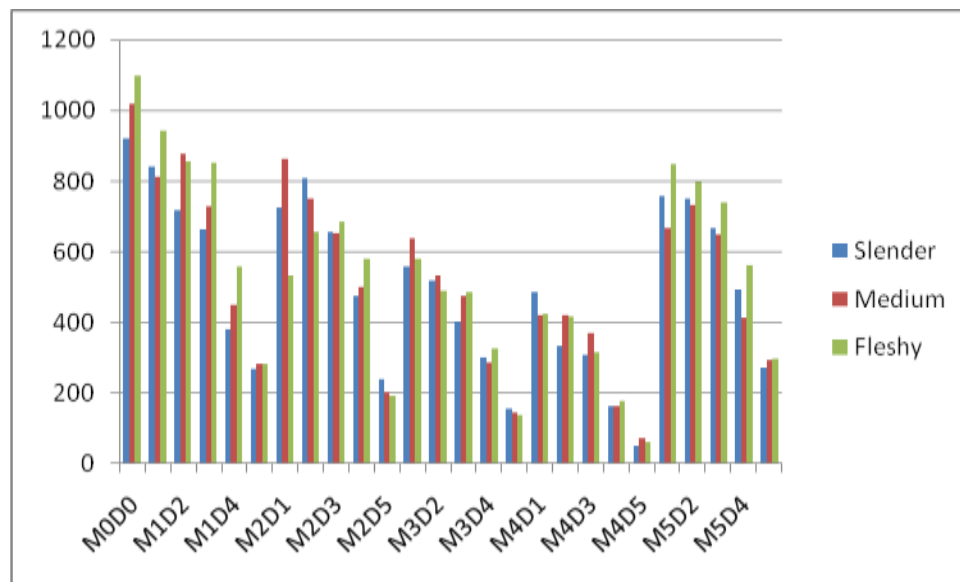


Fig.2 Vigour index of chilli (*Capsicum annuum* L.) dried under different conditions and stored for different durations



Vigour index

In the category of fleshy fruit type, shade dried seeds had highest vigour index (943.553) followed by oven dried seeds (581.600) followed by oven dried seed (847.258) and sundried seeds (578.763) and lowest in freeze dried seeds (423.860) after 2

months of storage. This same trend was observed in seeds after 4 and 6 months after storage. But after 8 months of storage, highest vigour index observed in hand extracted seed (562.206) and shade dried seed (558.292) and after 10 months of storage highest vigour

index found in oven dried seed (298.333) followed by shade dried seed (281.504). In the category of medium fleshy fruit type, hand extracted seeds had highest vigour index (863.394) followed by shade dried seeds (810.631) and oven dried seeds (667.458) and lowest in freeze dried seeds (419.044) after 2 months of storage and this same trend was observed in seeds after 8 months of storage.

But after 4 and 6 months of storage highest vigour index observed in shade dried seed (878.325 and 727.190 respectively) followed by hand extracted seed (749.783 and 653.150 respectively) and after 10 months of storage highest vigour index found in oven dried seed (293.656) followed by shade dried seed (282.022). In the category of slender fruit type, shade dried seeds had highest vigour index (842.787) followed by oven dried seeds (757.991) and hand extracted seeds (724.270) and lowest in freeze dried seeds (485.506) after 2 months of storage and this same trend was observed in seeds after 4 months of storage.

Drying methods and fleshiness index played very important role in seed quality in the present experiment. Results can be better interpreted by understanding the fact that, chilli seed attains physiological and functional maturity at high seed moisture content of 39-40% and the rate of moisture migration from center to surface of the seed is influenced by temperature, pericarp thickness, chemical composition of seed and seed coat permeability. The rate of moisture removal from the surface of seed is influenced by degree of surface saturation, thickness of the pericarp or fleshiness of the fruit, relative humidity and temperature of drying air. If evaporation from the seed surface occurs too rapidly it can damage the embryo, therefore seed should be dried carefully to arrest stress damage due to heat. In contrast, if moisture elimination takes place too slowly it may

favour invasion of pathogens (Harrington, 1972). In the present experiment shade drying of chilli fruits harvested at red maturity or physiological maturity was found to be the most effective method of drying in all the three types of fruit i.e. slender, medium and fleshy. Seeds extracted and shade dried on the day of harvest was also effective for a certain period in all fruit types (Patra *et al.*, 2016). Sun drying was less effective for seed purpose. Similar results were reported by Thiagarajan (1983) in chillies.

These results are in agreement with the findings of Dhanelappagol *et al.*, (1988) in chillies, Javaregowda *et al.*, (1990) in tomato and Shivahre *et al.*, (1995) in chillies. Heat tolerance of seed varies with the species. For drying of vegetable seed, temperature not exceeding 35°C has been advocated by Harrington (1972). This variation in seed quality parameters among different fruit types may be due to existence of variability and storability for different duration of storage.

Drying requirements of chilli seed was found to be very peculiar and depends on thickness of the pericarp or fleshiness index, type of fruits in a view to get good quality of chilli seeds along with it plays an important role in storability of chilli seeds. The present experiment evaluated all these aspects and revealed that shade drying of chilli fruits harvested at physiological maturity or seeds extracted on the same day of harvest followed by shade drying are useful for maintaining seed viability and vigour up to 6 months duration of safe storage. After that, its quality got drastically reduced in all fruit types of chilli such as slender, medium and fleshy.

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