

Effect of harvesting stage and method of drying on quality of fennel seed (*Foeniculum vulgare* L.)

M. B. Patel^{1*}, N. R. Patel², G. S. Patel³ and H.N. Leua⁴

¹ College of Horticulture, S. D. Agricultural University, Jagudan, Gujarat, India

^{2,3} and ⁴ Seed Spices Research Station, S. D. Agricultural University, Jagudan, Gujarat, India

Abstract

The present investigation was carried out with the aim of finding out the effect on quality of fennel CV.GF-12 harvested at different maturity stages i.e. premature - H1 (veins are not visible on the grain; grain is small and dark green in colour), mature - H2 (veins are visible on outer side of the grain, grain is small and green in colour) and post-mature - H3 (veins are clearly visible on outer side of the grain, grain is bold and light green to yellow in colour) and dried under different methods of drying i.e. Open-sun drying - D1 (drying in open environment on a cemented floor); Low-cost poly-solar dryer - D2 (a tunnel dryer with semi-cylindrical frame structure covered with UV stabilized polythene sheet having dimensions 10 m as length, height 2.25 m at center and base area 27.3 m²) and shade drying - D3 (shade of thatch roof). The highest volatile oil contents (1.480 %) and maximum economic return (₹ 3.18 lakh.ha⁻¹) found in fennel harvested at pre-mature stage and dried in shade drying method.

Key words: Drying and economic return, fennel, harvesting, maturity stage, quality.

Introduction

Fennel (*Foeniculum vulgare*), generally known as saunf in hindi, belongs to Apiaceae family, which is mainly cultivated in Gujarat, Rajasthan and Uttar Pradesh. It is used as condiment and culinary spice. The estimated acreage and production of fennel for the year 2016-17 in Gujarat alone was 40900 ha and 0.88 MT, respectively (Spice Board of India). There is need to maintain the quality of fennel through adopting proper harvest and post harvest technological measures i.e. harvesting stage and drying method. Appropriate harvesting stage is more important for maintaining quality and production (Bharadwaj *et al.*, 2013). Previous work regarding the stage of harvest and method of drying (for fennel) is limited. However, work has been done to study the effect of different sowing times and harvesting stages on the yield and composition of essential oil in fennel by (Stefanini *et al.*, 2006). The treatments consisted of four times of plantation and three stages of harvest: green seeds (intense green color), mature seeds (yellow color) and dry seeds (straw yellow color). The best results for productivity of fruits, content and yield of essential oil were observed at the time of plantation of January, and in the harvested green fruits. (Bhati *et al.*, 1989). studied effect of the three stages of fennel umbel picking (half length seed, full length green seed and fully grown seed turning to yellow colour). They found that, the highest

seed yield and highest volatile oil content was obtained when umbels were picked at full length size of fruits with green colour. (Abdalla, 1999) also studied the effect of the stage of anise seed development on the oil content, found highly significant difference seed oil content from different stages of seed maturity. The higher values of oil content were recorded from the dry ripe seed followed by the yellowish seed and the green seed stage. The essential oil content of fruits were 1.31, 1.18, and 1.26 %, at pasty, waxy and full ripening stages, respectively. The main oil components at different fruit maturity stages were found to be trans-anethol (84.1 - 86.1 %), fenchone (7.13 - 8.86 %), limonene (3.0 - 3.3 %), and methyl chavicol (2.5 - 2.7 %) (Mohammad and Amene, 2011). Bharadwaj *et al.*, 2013) reported that fennel umbels which were harvested at post maturity stage were superior to rest of the harvesting stages and recorded maximum sensory scores, seed dimensions and highest yield, maximum market rate and B:C ratio. This study has also concluded that drying of fennel umbels in modified locally made structures gave better quality of seed over other structures. Drying of fennel in shade has been found to have least adverse effect on quality instead of that dried in open sun or in presence forced-air (Reddy *et al.*, 2012). This study showed that extract of shade-dried stems was found to contain high phenol and flavonoid content and their least

concentrations were found in extracts of hot air oven dried roots. All the shade-dried parts showed better activity compared to sun-dried and hot air oven-dried parts. Drying had a significant effect on the antioxidant activity of the fennel plant. Too early harvesting stage will result into lesser yield. Late harvesting will cause increase in fibers and loss of volatile oil. Thus, it will deteriorate the quality. The different methods of drying include drying in open-sun on a cemented floor and drying in a tunnel-type greenhouse dryer. The former method is deemed unhygienic as crops dried in open sun are liable to environmental deterioration; whereas the latter method is detrimental to the quality as temperature in greenhouse tunnel is difficult to regulate and higher temperature leads to loss of green colour in fennel thereby affecting its market price. Therefore, it is important to find out proper harvesting stage that maintains the quality and in turn more economic return, The present study was planned with a view to find out an appropriate stage of harvesting and the drying method of fennel which gives best quality fennel and give higher economic return.

Material and methods

An experiment was conducted at Centre for Research on Seed Spices (CRSS), SDAU, Jagudan (Mehsana) to determine the influence of different harvesting stages and methods of drying on quality of fennel. The CRSS is located in the village Jagudan situated at longitude 74°.43 E, Latitude 23°.53 N and altitude 90.6 m ASL. The soil of the farm is sandy loam, good in fertility and water holding capacity, having pH 7.3 - 7.9, EC 0.25 DSm⁻¹, available N 250.5 kg ha⁻¹ (Low), P₂O₅ 49.5 kg ha⁻¹ (Medium) K₂O 436.8 kg ha⁻¹ (High), sulphur 12.30 ppm, organic carbon 0.33, Mn, 12.690 ppm, Fe 4.476 ppm, Zn

1.292 ppm. The annual rainfall of this region ranges from 170 mm to 1308 mm with an average precipitation of 865 mm. The research station falls in North Gujarat Agro-climatic zone – IV. The climatic condition of the area represents the tropical conditions with semi arid climate. The Kharif crop variety Gujarat Fennel - 2 was transplanted in August 2013 and harvested in Feb-March/ 2014. The crop was harvested in three stages: premature - H1 (veins are not visible on the grain; grain is small and dark green in colour), mature - H2 (veins are visible on outer side of the grain, grain is small and green in colour) and post-mature - H3 (veins are clearly visible on outer side of the grain, grain is bold and light green to yellow in colour), with three replications. The experiment was laid out with three harvesting stages and in each stage of harvesting there were three replications which was consisted of equal number of forty fennel plants. From all these plants fennel yield collected at different stages of harvesting. The crop was subjected to same agronomic practices during the whole crop period.

Green umbels harvested from each replication were weighed individually and the mass was recorded for each treatments and replication wise. The yield obtained from each maturity stages were then divided in nine equal parts and three-three part was allotted to different methods of drying: open-sun drying - D1 (drying in open environment on a cemented floor); low-cost poly-solar dryer - D2 (a tunnel dryer with semi-cylindrical frame structure covered with UV stabilized polythene sheet having dimensions 10 m as length, height 2.25 m at center and base area 27.3 m²); and shade drying - D3 (shade of thatch roof having size 4 X 3 X 2.5 m with a supporting structure made from bamboo and covered by locally available jute straw material) (Fig. 1).

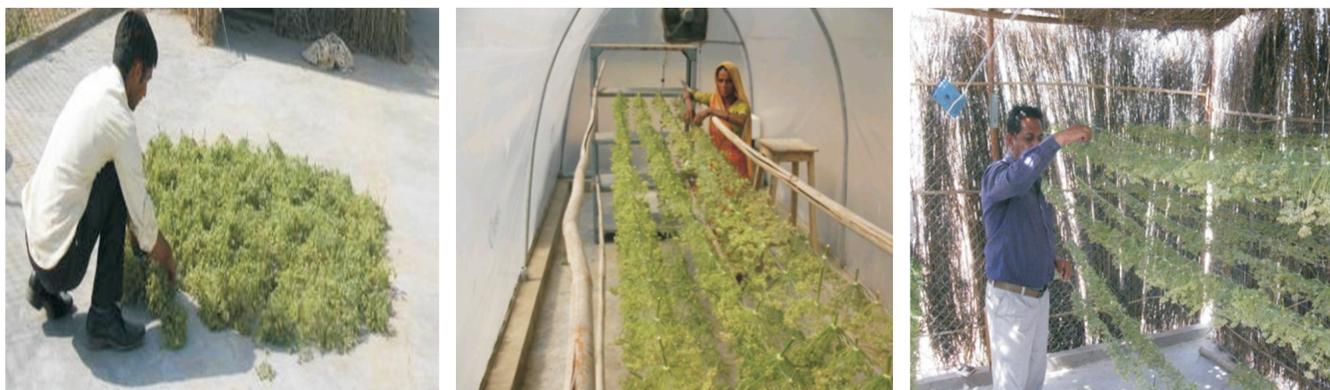


Fig. 1. Methods of drying. (Cemented floor, a low-cost poly solar dryer and a shade structure)

The umbels obtained after drying were threshed manually to obtain grain yield for each combination. The grains thus obtained from each treatment combination were graded separately in an air-screen cleaner-cum-grader (Model: AGROSAW Air-screen Cleaner-cum-Grader, capacity 25 kg hr⁻¹) to finally obtain two types of grains - Bold (BG) and Fine (FG). The percentage of the essential oil content of these clean ungraded seed was determined by water distillation using the Clevenger apparatus described according to (FSSAI, 2015) The percentage composition of the bold, fine and rejection with respect to clean ungraded grain weight was determined. The final yield thus obtained for each treatment combination in the form of bold and fine grains were packed in locally available plastic packets and tagged accordingly. As colour of fennel seeds play a vital role in determination of their market price, to ascertain the market price of grains from each combination, three randomly selected traders from APMC, Unjha (Mehsana) market yard were shown these packets and were asked to determine the market price based on colour and other visual characteristics. Yield of grains per hectare was determined based on yield per treatment. The prices fixed by the traders were then used to determine the value of grains (bold and fine as well as total), the economic return for each combination and value-addition w.r.t post-mature harvesting and open-sun drying.

In order to check the viability of the fennel seeds after harvesting, test of germination percentage was done on seeds obtained under post-mature harvesting and dried in all three methods. Hundred seeds from each combination were taken and pre-treated seeds were kept in the respective petri-dishes. For accuracy and precaution

against germination failure, each combination had been allotted two petri dishes. The dishes were monitored daily and the germination percentage was determined by counting the germinated seeds daily.

Results and discussion

Table 1 shows the weight of green umbels harvested on each stages. It can be seen that the total production obtained in case of fennel harvested at pre-mature (H1) and mature (H2) stages is almost similar whereas that obtained at post-mature stage (H3) is comparatively less. More yield in pre-mature stage harvesting might be due to more speedy growth in remaining flowering. Data in table also shows that the total dried weight of grains obtained for mature stage (H2) and post-mature stage (H3) treatments was higher than that obtained from pre-mature stage (H1). Similar result has been reported by Bharadwaj (2013). This might be due to more moisture in pre-mature harvested grain.

Appraisal of table 2 revealed that the harvesting stages (H) and drying methods (D) significantly effected on volatile oil contents in fennel seeds. A decreasing trends in volatile oil content was noticed with advancement of maturity, the highest value (1.43 %) in pre-mature stage (H1) and lowest value (1.193 %) in post mature stage (H3). The drying methods also showed variation in volatile oil contents with highest (1.363 %) in shade drying (D3) and lowest (1.289 %) in open sun drying (D1). The obtained results are also conformity with the findings of Bhati et al. (1989) for fennel crop. Mohammad and Amene (2011) also reported the essential oil content of fennel were 1.31, 1.18, and 1.26 %, at pasty, waxy and full ripening stages, respectively.

Table 1. Weight of fresh umbels and dried grains (ungraded)

Treatment	Fresh weight of Umbels, kg	Open-sun drying (D1)	Low-cost poly-solar drying (D2)	Shade drying (D3)	Dried Yield, kg
H1	125.062	6.509	6.426	6.34	19.275
H2	125.403	7.569	7.63	7.553	22.752
H3	86.141	7.225	7.235	7.292	21.752

Table 2. Effect of drying method and harvesting stages on volatile oil contents (%)

Treatment	Open-sun drying (D1)	Low-cost poly-solar drying (D2)	Shade drying (D3)	Mean
H1	1.397	1.430	1.480	1.436
H2	1.327	1.343	1.377	1.349
H3	1.143	1.203	1.233	1.193
Mean	1.289	1.326	1.363	
	H	D	H x D	
Sem	0.008	0.008	0.014	
CD	0.024	0.024	NS	

Mature (H2) ,Post-mature (H3),Pre-mature (H1)

Open-sun drying (D1), Low-cost poly-solar drying (D2), Shade drying (D3)

Data Data of seed weight obtained after grading in a cleaner-cum-grader machine was given in Table 3. Table also shows the portion of weight in bold grain, fine grains and rejection (which includes dirt and other particles) for each harvesting stage and each drying method. Weight of bold grains was obtained minimum in pre-mature harvesting while it was higher in both mature and post-mature harvesting. On the other hand, the weight of fine grains obtained is maximum in pre-mature as compared to mature and post-mature harvesting. This result is similar to that obtained by Stefanini (2006).

Table 3 shows the yield (kg ha-1) as calculated both in terms of bold and fine grains - for each harvesting stages and drying methods wise. As the market prices were obtained from three randomly selected market traders, the average value of these market prices were taken to calculate the economic return for grains obtained for each combination as-well-as those obtained after grading. Table 4 shows this calculation as well. It is clear that the highest value generated is under H1D3 (pre-mature harvesting and dried under shade) followed by H2D3 (mature harvesting and dried under shade). Similar trend has been reported by Bharadwaj (2013).

Table 4 showed the value addition, in terms of ` ha-1, obtained in fennel seeds due to stage of harvesting and method of drying. It revealed from the data presented in table 5 that due to maintain green colour of fennel grain in shade drying method fetches higher price (` 3.18 lakh ha-1) as compared to other drying methods. It also showed that higher market price was obtained for fine grain of fennel, dried in shade drying followed by poly solar drying, open floor sun drying respectively.

Table 6 showed the results of germination tests conducted on post-mature fennel seeds dried under all three methods. The germination percentage of seed dried in open sun and shade drying were almost same whereas it was low in seed dried under low cost poly solar dryer. The higher temperature in low cost poly solar drier might be damaged the seed embryo resulting in low germination of seed.

Conclusion

The study concluded that for obtaining higher return from fennel cultivation, it should be harvested at pre-mature or

Table 3. Weight of grains obtained after grading.

Treatment	Total ungraded dry grain weight, kg			Fine grain, kg			Bold grain, kg			Rejection, kg			
	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	total
H1	6.51	6.43	6.34	0.15	0.16	0.14	5.41	5.41	5.32	0.96	0.86	0.88	2.70
H2	7.57	7.63	7.55	0.13	0.14	0.15	6.24	6.26	6.29	1.20	1.23	1.11	3.54
H3	7.23	7.24	7.29	0.10	0.10	0.09	6.06	6.05	6.05	1.06	1.09	1.15	3.30
Total dry grain weight				63.779			Total fine grain 1.153	Total bold grain		53.088	Total rejection		9.537

Table 4. Yield and Economic Return for each harvesting stage and drying methods.

TREATMENT	Yield/treatment, kg		Yield, kg ha ⁻¹		Rate (₹ 20 kg ⁻¹)		Value, ₹ ha ⁻¹ (Lakh)		Total Value, ₹ ha ⁻¹ (Lakh)
	BG	FG	BG	FG	BG	FG	BG	FG	
H1D1	5.405	0.146	2502.32	67.89	1833.33	1533.33	2.29	0.052	2.34
H2D1	6.236	0.133	2887.02	61.80	1583.33	1433.33	2.28	0.044	2.32
H3D1	6.061	0.103	2806.07	47.87	1583.33	1350.00	2.22	0.032	2.25
H1D2	5.414	0.155	2506.67	71.81	2000.00	1583.33	2.50	0.056	2.56
H2D2	6.257	0.143	2896.59	66.58	1700.00	1466.67	2.46	0.048	2.51
H3D2	6.053	0.094	2802.16	43.95	1600.00	1416.67	2.24	0.031	2.27
H1D3	5.320	0.136	2463.15	63.10	2516.67	2700.00	3.09	0.085	3.18
H2D3	6.290	0.150	2911.82	69.63	2100.00	2433.33	3.05	0.084	3.14
H3D3	6.053	0.089	2802.16	41.34	1833.33	1916.67	2.56	0.039	2.60

Table 5. Value addition due to harvesting stage w.r.t. post-mature harvesting and method of drying w.r.t. open floor sun drying, (Value in lakh ₹ ha⁻¹)

Treatment combination	Open floor sun drying (D1)	Low cost poly solar drying (D2)	Shade drying (D3)	Total	Mean
Pre-mature harvesting (H1)	2.356	2.56	3.18	8.09	2.70
Mature harvesting (H2)	2.33	2.51	3.14	7.98	2.66
Post-mature harvesting (H3)	2.25	2.27	2.61	7.13	2.38
Total	6.93	7.35	8.94		
Mean	2.31	2.45	2.98		

Percent value addition due to harvesting stage w.r.t. H3

Pre-mature harvesting	13.44
Mature harvesting	11.89
Post-mature harvesting	Control

Percent value addition due to drying method w.r.t. Open

Open floor sun drying	Control
Low cost poly solar drying	6.03
Shade drying	28.94

Table 6. Germination test on post-mature fennel seeds.

Combination	Dish	DAS												
		6	7	8	12	13	14	15	16	18	19	20	21	22
H3 OPEN	1	-	7	17	43	69	86	95	97	100	100	100	100	100
	2	-	19	51	85	87	92	94	95	97	97	98	98	98
H3 SOLAR	1	-	5	18	60	79	89	91	92	94	94	96	96	96
	2	-	10	30	44	52	59	63	65	67	69	71	71	71
H3 SHADE	1	-	12	46	66	74	88	93	93	94	94	95	96	96
	2	-	6	6	21	32	43	54	59	79	82	94	96	97

mature stage and shade drying method is followed for drying fresh umbels of fennel for maintenance of green colour. As fennel seeds are consumed directly as Mukhwas, it is advisable to go for cleaning and grading operations after threshing to obtain bold and fine grains separately. The bold grains can be used both for seed purpose as well as Mukhwas and fine grains can fetch higher price in the market due to its sweet taste.

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