Original Research Article

Standardisation of Harvesting Stages for Dehydration in Okra (*Abelmoschus esculentus* L. Moench)

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A B S T R A C T

The study was conducted to know the suitability of variety and harvesting stage for dehydration of okra (*Abelmoschus esculentus* L. Moench). The experiment consists of three varieties (ArkaNikhita, ArkaAnamika and Hiriyur Local) and three harvesting stages (4 Days after Anthesis, 6 Days after Anthesis and 8 Days After Anthesis) in all possible combinations were assessed for physico-chemical characters. Among different varieties and harvesting stages, V_1 (ArkaNikhita) variety and H_1 (4Days After Anthesis) harvesting stage recorded maximum pod weight, dry matter, rehydration ratio and recorded minimum dehydration ratio. Interaction of varieties and harvesting stages were found significant with respect to physico-chemical characters. The treatment combination V_1H_1 (ArkaNikhita harvested at 4 Days after Anthesis) recorded significantly higher values with respect to pod weight (26.80 g), dry matter (12.95%) and rehydration ratio (6.53). The results of Sensory evaluation of dehydrated okra shown that V_1H_1 (ArkaNikhita harvested at 4 Days after Anthesis) treatment combination received highest score (3.75) for overall acceptance.

Introduction

Okra (*Abelmoschus esculentus*) is one of the most widely known and utilized species of the family Malvaceae and an economically important vegetable crop grown in tropical and sub-tropical parts of the world (Saifullahand Rabbani, 2009). The plant was previously included in the genus *Hibiscus*. Later, it was designated to *Abelmoschus,* which is distinguished from the genus *Hibiscus* (Aladele *et al.,* 2008). Okra originated in Ethiopia and was then propagated in North Africa and in India by the 12th century BC.

The fruits are a green capsule containing numerous white seeds when immature. It is a popular ingredient of soups and stews where a highly viscous consistency is desired (Baxter and Waters, 1990). Okra seeds are a source of oil, protein and are also used as a coffee

substitute, while ground-up okra seeds have been used as a substitute for aluminium salts in water purification. The appropriate age of harvest for okra is important not only for internal consumption but also for export point of view. As soon as the fruit reaches the edible quality, it has to be harvested because it deteriorates in quality (physical and chemical) at a very fast rate. Due to high rate of respiration suffers huge post-harvest losses and there is a trend of market glut in *Kharif* and late *Kharif* and lean availability in *Rabi*. So drying of fresh pods is probably the best alternative to cope up with market glut during peak production season.

A proper screening and selection of suitable cultivar and harvesting stage for dehydration is essential to meet the international standard quality at the competitive prices. At the same time in order to increase its appearance and retention of nutrients various pre-treatments are required to be tested for dehydration of okra. Hence the experiment was conducted to study the optimum stage of harvesting of okra fruits for dehydration.

Materials and Methods

The present experiment was carried out at ICAR-KrishiVignana Kendra, Babbur Farm, Hiriyur, Chitrdurga during *Kharif* season of 2019-2020.The experiment was laid out in Factorial Randomised Block Design (FRCBD) with three replications in the experiment. The treatments in each replication were allotted randomly based on random number table. The seeds of okra were sown in each replication with 3.0 m × 1.5 m plot size at 45 cm × 30cm spacing. The crop was raised by following the recommended package of practices of University of Horticultural Sciences, Bagalkot.

Three cultivars (ArkaNikhita, ArkaAnamika and Hiriyur Local) with three harvesting

stages (4 Days After Anthesis, 6 Days After Anthesis and 8 Days After Anthesis) in all possible combination was taken to know the suitability of variety and harvesting stage for dehydration of okra. Observations were recorded on five randomly selected plants in each replication for different traits *Viz.,* pod length, pod diameter, pod weight, dehydration ratio, rehydration ratio, dry matter, crude protein, crude fibre and scores of sensory evaluations.

The data obtained in respect of various characters were analysed statistically by analysis of variance method suggested by Panse and Sukhatme (1967). The observational treatment effects were real from chance effects. The null hypothesis was tested by P test of significance where the test revealed the significance of treatment effects. The appropriate standard error (S.E.) for each factor was worked out to compare two treatments means, critical difference (C. D.) at 5 per cent level of significance was also worked out.

Results and Discussion

Analysis of variance showed significant difference among the varieties, harvesting stage and interaction of both varieties and harvesting stage. The effect of variety and harvesting stage on pod length, pod diameter and pod weight were presented in Table 1.

The variety V_1 (ArkaNikhita) has recorded maximum pod length (13.36 cm). The variation in the pod length is due to the varietal character and it also influenced by pest and disease attack. The H_3 (8 Days After Anthesis) harvesting stage has recorded maximum pod length (17.36 cm). The length of okra fruit increased from 9.09 cm to 17.36 cm during maturation from 4 to 8 DAA. With respect to interaction there is a significant difference among different treatment

combination, V_3H_3 (Hiriyur Local harvested at 8 Days After Anthesis) had the maximum length (17.57 cm) which was statistically on par (17.53 cm) with V_1H_3 (ArkaNikhita harvested at 8 DAA) and the lowest was observed in V_2H_3 (ArkaAnamika harvested at 8 Days After Anthesis) (Table 1). Similar findings were reported by Petropoulos *et al.,* (2018)and Shen *et al.,* (2019).

The pod diameter varied significantly among the different varieties and harvesting stage. The highest pod diameter (1.87 cm) was noticed in V_3 (Hiriyur Local) variety. The increased diameter in pod could be attributed to the varietal characteristics. The highest pod diameter (2.11 cm) was noticed in H_3 (8 Days After Anthesis) harvesting stage. While, lowest pod diameter (1.53 cm) was recorded in H_3 (8 Days After Anthesis) harvesting stage.Among the treatment combinations, pod diameter was maximum (2.19 cm) in V_3H_3 (Hiriyur Local harvested at 8 Days After Anthesis) treatment combination (Table 1). These results are in agreement with Nasrin *et al.,* (2010), Biswas *et al.,* (2016) and Shen *et al.,* (2019).

Table.1 Effect of variety and harvesting stage on pod length, pod diameter and pod weight of okra

Treatment	Pod length (cm)	Pod diameter (cm)	Pod weight (g)
Variety			
V_1(ArkaNikhita)	13.36	1.80	17.28
V_2(ArkaAnamika)	13.12	1.76	14.79
V_3(Hiriyur Local)	13.17	1.87	16.05
S.Em±	0.032	0.002	0.064
C.D. (P=0.05)	0.096	0.006	0.194
Harvesting stage (Days After Anthesis)			
H_1(4 DAA)	9.09	1.53	7.91
H_2(6 DAA)	13.20	1.79	15.85
H_3(8 DAA)	17.36	2.11	24.36
S.Em±	0.032	0.002	0.064
C.D. (P=0.05)	0.096	0.006	0.194
Interaction (V×H)			
T_1-V_1H_1	8.89	1.53	8.03
T_2-V_1H_2	13.65	1.78	17.00
T_3-V_1H_3	17.53	2.11	26.80
T_4-V_2H_1	9.40	1.52	7.89
T_5-V_2H_2	13.00	1.71	13.67
T_6-V_2H_3	16.97	2.03	22.80
T_7-V_3H_1	8.99	1.54	7.80
T_8-V_3H_2	12.95	1.87	16.87
T_9-V_3H_3	17.57	2.19	23.47
S.Em±	0.055	0.003	0.111
C.D. (P=0.05)	0.166	0.010	0.337

Table.2 Effect of variety and harvesting stage on dehydration ratio, rehydration ratio and dry matter content of dehydrated okra

Treatment	Dehydration ratio	Rehydration ratio	Dry matter (%)
Variety			
V_1(ArkaNikhita)	17.70	5.24	10.99
V_2(ArkaAnamika)	18.33	4.86	10.82
V_3(Hiriyur Local)	18.98	3.53	10.22
S.Em±	0.030	0.011	0.013
C.D. (P=0.05)	0.092	0.032	0.041
Harvesting stage (Days After Anthesis)			
H_1(4 DAA)	14.34	5.54	12.5
H_2(6 DAA)	17.11	4.20	10.23
H_3(8 DAA)	23.56	3.79	9.31
S.Em±	0.030	0.011	0.013
C.D. (P=0.05)	0.092	0.032	0.041
Interaction (V×H)			
T_1-V_1H_1	12.70	6.53	12.95
T_2-V_1H_2	16.99	5.10	10.52
T_3-V_1H_3	23.42	4.10	9.55
T_4-V_2H_1	14.77	6.07	12.89
T_5-V_2H_2	17.50	4.40	10.06
T_6-V_2H_3	22.73	4.10	9.44
T_7-V_3H_1	15.56	4.33	11.60
T_8-V_3H_2	16.86	3.10	10.09
T_9-V_3H_3	24.52	3.17	8.94
S.Em±	0.053	0.018	0.023
C.D. (P=0.05)	0.159	0.056	0.070

Table.3 Effect of variety and harvesting stage on Sensory evaluation of dehydrated okra

Treatment	Colour	Mouth feel	Smell or odour	Texture	Fibreness	Overall acceptability
Variety						
V_1 (ArkaNikhita)	3.41	3.00	2.98	3.25	3.08	3.37
V_2 (ArkaAnamika)	2.83	3.00	3.55	3.83	2.80	3.33
V_3 (Hiriyur Local)	2.91	3.00	3.22	3.17	3.50	3.00
S.Em±	0.004	0.003	0.004	0.004	0.004	0.002
CD (P=0.05)	0.013	NS	NS	NS	0.013	0.006
Harvesting stage (Days After Anthesis)						
H_1(4 DAA)	3.08	3.00	3.32	3.33	2.80	3.42
H_2(6 DAA)	2.92	2.75	3.11	3.17	3.08	2.96
H_3(8 DAA)	2.83	3.25	3.33	3.75	3.50	3.33
S.Em±	0.004	0.003	0.004	0.004	0.004	0.002

CD (P=0.05)	0.013	NS	NS	NS	0.013	0.006
Interaction (V×H)						
T₁-V₁H₁	3.25	3.25	3.3	3.25	2.50	3.75
T₂-V₁H₂	3.50	2.75	3.00	3.00	3.00	3.00
T₃-V₁H₃	3.50	3.00	2.65	3.50	3.75	3.25
T₄-V₂H₁	3.25	3.00	4.00	3.75	2.65	3.50
T₅-V₂H₂	3.00	3.00	3.33	3.75	3.00	3.12
T₆-V₂H₃	2.25	3.00	3.33	4.00	2.75	3.50
T₇-V₃H₁	2.75	2.75	2.66	3.00	3.25	3.00
T₈-V₃H₂	3.25	2.5	3.00	2.75	3.25	2.75
T₉-V₃H₃	2.75	3.75	4.00	3.75	4.00	3.25
S.Em±	0.007	0.006	0.008	0.006	0.007	0.004
CD (P=0.05)	0.022	NS	NS	NS	0.022	0.014

The highest pod weight (17.28 g) was noticed in V_1 (ArkaNikhita) variety. While, lowest pod weight (14.79 g) was recorded in V_2 (ArkaAnamika) variety. The variation might be due to differences in the vegetative growth of varieties which leads to the variation in photosynthesis and ultimately pod weight. The highest pod weight (24.36 g) was noticed in H_3 (8 Days After Anthesis) harvesting stage. The pod weight was maximum (26.80 g) in treatment combination V_1H_3 (ArkaNikhita harvested at 8 Days After Anthesis) while the minimum was observed at V_3H_1 (Hiriyur Local harvested at 4 DAA) treatment combination (Table 1). These results are in agreement with Singla *et al.,* (2018).

The V_1 (ArkaNikhita) variety recorded the lowest dehydration ratio(17.70). The H_3 (8 Days After Anthesis) harvesting stage recorded significantly highest dehydration ratio(23.56). This might be due to significant tissue structure modification and overall volume shrinkage and the extent of shrinkage differ from variety to variety. The lower shrinkage ratio is more desirable by industry for dehydration (Table 2). These results are well supported by the previous findings of the results quoted by Bawaand Saini (1986) in cauliflower and Gandavvagol *et al.,* (2018).

The rehydration ratio was found to be maximum (5.24) in V_1 (ArkaNikhita) variety and the minimum rehydration ratio (3.53) in V_3 (Hiriyur Local) variety. The maximum rehydration ratio of pods was recorded in H_1 (4 Days After Anthesis) harvesting stage as compared to all the harvesting stage (Table 2). These results are in conformity with the results quoted by Javed *et al.,* (1995) in onion, the quick and high rehydration capacity of dried commodities indicated their better quality (Rajeshwari *et al.,* 2011) in case of leafy vegetables, and Gandavvagol *et al.,* (2018).

Dehydration and rehydration ratio varied significantly for variety and harvesting stage interaction. Among treatment combination, V_3H_3 (Hiriyur Local harvested at 8 Days After Anthesis) treatment combination recorded maximum dehydration ratio (24.52). Whereas, V_1H_1 (ArkaNikhita harvested at 4 Days After Anthesis) treatment combination recorded the minimum dehydration ratio(12.70). Whenever the recovery was found higher, dehydration ratio was lower, which indicates the inverse relation between the per cent recovery and its dehydration ratio (Table 2).

In the present study, variety and harvesting stage had a profound and significant effect on dry matter of pods. The highest dry matter (10.99%) is recorded in V_1 (ArkaNikhita) variety, while the lowest dry matter content (10.22%) recorded in V_3 (Hiriyur Local) variety.

The highest dry matter (12.50%) is recorded in H_1 (4 Days After Anthesis) harvesting stage, while the lowest dry matter content (9.31%) recorded in H_3 (8 Days After Anthesis) harvesting stage. For processing purposes, the pods should have a high dry matter content (Reshmika *et al.,* 2016). Environmental condition had exhibited significant effect on dry matter content (Riya *et al.,* 2016). These results are in line with the observations made by them (Table 2).

The highest dry matter (12.95%) per cent was observed in V_1H_1 (ArkaNikhita harvested at 4 DAA) treatment combination. Whereas the lowest dry matter (8.94%) content was recorded in V_3H_3 (Hiriyur Local harvested at 8Days After Anthesis) treatment combination. This may be due to the reason that in immature cells the vacuoles are very small having small quantity of water. Whereas, dry matter is lesser due to higher quantity of water up to a certain limit (Table 2). The results were agreeing with Nasrin *et al.,* (2010).

Sensory evaluation of dehydrated okra was done in comparison with fresh okra to know the consumer preferences. Colour of fresh okra was significantly better than dried okra. The colour ratings was highest in V_1H_2 (ArkaNikhita harvested at 6 Days After Anthesis) and V_1H_2 (ArkaNikhita harvested at 8 Days After Anthesis) treatment combination. Expectedly, the aroma of the fresh okra was significantly better than the processed okra. ArkaNikhita harvested at 4

Days After Anthesis received highest ratings. Poor rating may be due to loss of volatile aroma components during drying. Moreover, Hiriyur Local harvested at 8 Days After Anthesis received lowest ratings in terms of taste. With respect to fiberness, V_3H_3 (Hiriyur Local harvested at 8 Days After Anthesis) treatment combination received the highest ratings. While, V_1H_1 (ArkaNikhita harvested at 4 Days After Anthesis) treatment combination received lowest ratings. Fiberness is non-preferred in terms of consumer acceptance. In terms of overall acceptability by the panelist there was significant difference among treatment combination. The V_1H_1 (ArkaNikhita harvested at 4 Days After Anthesis) treatment combination received highest scores (Table 3). Similar results are found by Falade *et al.,* (2010) and Arise *et al.,* (2012).

In conclusion based on sensory evaluation, dry matter content, dehydration ratio, rehydration ratio and retention of nutrients and minerals after dehydration, V_1 (ArkaNikhita) variety was found to be suitable for dehydration. Among different harvesting stages, H_1 (4 Days After Anthesis) was found to be optimum with respect to physico-chemical characteristics and the same harvesting stage received highest ratings in terms of overall acceptability. With respect to interaction, harvesting of ArkaNikhita at 4 days after anthesis was found to be optimum for dehydration of okra. The same treatment obtained highest ratings in terms of overall acceptance, which is preferred over other treatments.

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