Original Research Article

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

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ABSTRACT

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, V1 (ArkaNikhita) variety and H1 (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 V1H1 (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 V1H1 (ArkaNikhita harvested at 4 Days after Anthesis) treatment combination received highest score (3.75) for overall acceptance.

Keywords
Okra, Dehydration, Harvesting stage, Cultivars, ArkaNikhita, ArkaAnamika

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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 (Saifullah and 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, Chitradurga 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 × 30 cm 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 V₁ (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 H₃ (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, V₃H₃ (Hiriyur Local harvested at 8 Days After Anthesis) had the maximum length (17.57 cm) which was statistically on par (17.53 cm) with V₁H₃ (ArkaNikhita harvested at 8 DAA) and the lowest was observed in V₂H₃ (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 V₃ (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 H₃ (8 Days After Anthesis) harvesting stage. While, lowest pod diameter (1.53 cm) was recorded in H₃ (8 Days After Anthesis) harvesting stage. Among the treatment combinations, pod diameter was maximum (2.19 cm) in V₃H₃ (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).

![Image of Table 1]

**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**                |                 |                   |               |
| V₁(ArkaNikhita)           | 13.36           | 1.80              | 17.28         |
| V₂(ArkaAnamika)           | 13.12           | 1.76              | 14.79         |
| V₃(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)** |                 |                   |               |
| H₁(4 DAA)                 | 9.09            | 1.53              | 7.91          |
| H₂(6 DAA)                 | 13.20           | 1.79              | 15.85         |
| H₃(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)**     |                 |                   |               |
| T₁-V₁H₁                   | 8.89            | 1.53              | 8.03          |
| T₂-V₁H₂                   | 13.65           | 1.78              | 17.00         |
| T₃-V₁H₃                   | 17.53           | 2.11              | 26.80         |
| T₄-V₂H₁                   | 9.40            | 1.52              | 7.89          |
| T₅-V₂H₂                   | 13.00           | 1.71              | 13.67         |
| T₆-V₂H₃                   | 16.97           | 2.03              | 22.80         |
| T₇-V₃H₁                   | 8.99            | 1.54              | 7.80          |
| T₈-V₃H₂                   | 12.95           | 1.87              | 16.87         |
| T₉-V₃H₃                   | 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**     |                   |                   |                |
| V₁ (ArkaNikhita)| 17.70             | 5.24              | 10.99          |
| V₂ (ArkaAnamika)| 18.33             | 4.86              | 10.82          |
| V₃ (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)** |                   |                   |                |
| H₁ (4 DAA)      | 14.34             | 5.54              | 12.5           |
| H₂ (6 DAA)      | 17.11             | 4.20              | 10.23          |
| H₃ (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)** |                   |                   |                |
| T₁-V₁H₁        | 12.70             | 6.53              | 12.95          |
| T₂-V₁H₂        | 16.99             | 5.10              | 10.52          |
| T₃-V₁H₃        | 23.42             | 4.10              | 9.55           |
| T₄-V₂H₁        | 14.77             | 6.07              | 12.89          |
| T₅-V₂H₂        | 17.50             | 4.40              | 10.06          |
| T₆-V₂H₃        | 22.73             | 4.10              | 9.44           |
| T₇-V₃H₁        | 15.56             | 4.33              | 11.60          |
| T₈-V₃H₂        | 16.86             | 3.10              | 10.09          |
| T₉-V₃H₃        | 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**     |        |            |                |         |           |                       |
| V₁ (ArkaNikhita)| 3.41   | 3.00       | 2.98           | 3.25    | 3.08      | 3.37                  |
| V₂ (ArkaAnamika)| 2.83   | 3.00       | 3.55           | 3.83    | 2.80      | 3.33                  |
| V₃ (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)** |        |            |                |         |           |                       |
| H₁ (4 DAA)      | 3.08   | 3.00       | 3.32           | 3.33    | 2.80      | 3.42                  |
| H₂ (6 DAA)      | 2.92   | 2.75       | 3.11           | 3.17    | 3.08      | 2.96                  |
| H₃ (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                 |
The highest pod weight (17.28 g) was noticed in V₁ (ArkaNikhita) variety. While, lowest pod weight (14.79 g) was recorded in V₂ (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 H₃ (8 Days After Anthesis) harvesting stage. The pod weight was maximum (26.80 g) in treatment combination V₁H₃ (ArkaNikhita harvested at 8 Days After Anthesis) while the minimum was observed at V₂H₁ (ArkaNikhita harvested at 4 DAA) treatment combination (Table 1). These results are in agreement with Singla et al., (2018).

The V₁ (ArkaNikhita) variety recorded the lowest dehydration ratio(17.70). The H₃ (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).

Dehydration and rehydration ratio varied significantly for variety and harvesting stage interaction. Among treatment combination, V₂H₃ (Hiriyur Local harvested at 8 Days After Anthesis) treatment combination recorded maximum dehydration ratio (24.52). Whereas, V₁H₁ (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 V₁ (ArkaNikhita) variety, while the lowest dry matter content (10.22%) recorded in V₃ (Hiriyur Local) variety.

The highest dry matter (12.50%) is recorded in H₁ (4 Days After Anthesis) harvesting stage, while the lowest dry matter content (9.31%) recorded in H₃ (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 V₁H₁ (ArkaNikhita harvested at 4 DAA) treatment combination. Whereas the lowest dry matter (8.94%) content was recorded in V₂H₃ (Hiriyur Local harvested at 8 Days 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 V₁H₂ (ArkaNikhita harvested at 6 Days After Anthesis) and V₁H₂ (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, V₁H₃ (Hiriyur Local harvested at 8 Days After Anthesis) treatment combination received the highest ratings. While, V₁H₁ (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 V₁H₁ (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, V₁ (ArkaNikhita) variety was found to be suitable for dehydration. Among different harvesting stages, H₁ (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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