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Enhancement of the shelf life of bhendi by pre and postharvest application with hexanal containing aqueous formulation

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Abstract
The present study was undertaken to determine the effects of a nanoemulsion carrying hexanal, an Enhanced freshness formulation (EFF), as a pre harvest spray and post-harvest dip technology to minimize the post-harvest losses and to extend the shelf life of bhendi. Bhendi fruits were exposed to the pre harvest spray of 1% and 2% EFF solution one day before harvest. The bhendi were harvested at the harvest maturity stage and was treated with EFF (1.0 and 2.0 per cent for 1 min) and stored under ambient (28 °C ± 2 °C, RH 60 ± 10%) condition and evaluated for physical and biochemical parameters. The EFF at 1.0% concentration has recorded a lower physiological loss in weight (30.84%) on the 6th day of storage, higher firmness (2.8 N/mm), higher chlorophyll (40.2%) with increased shelf life (8 days) under ambient storage condition. The treated fruit had low total soluble solids (8.30 °Brix) and ascorbic acid content of 34.20 mg/ 100g of fruits indicating improved fruit quality during storage, in addition to an extended shelf life (8 days). Overall, the results indicated that the ripening process of the pre harvest EFF sprayed bhendi fruits was delayed and had an extended shelf life. Pre harvest spray and post-harvest dips using hexanal formulation is a potential technology that could be adopted in pack houses for domestic and export markets.

Keywords: Bhendi, Co-4, shelf life, enhanced freshness formulation (EFF), Pre harvest spray, post harvest dip technology

Introduction

Bhendi (*Abelmoschus esculentus* L. Moench) is a traditional vegetable belongs to Malvaceae family. In several countries of the world, it is considered a basic food of great socioeconomic and nutritional importance for populations. Okra fruits and seeds are edible; the immature fruits present medicinal, therapeutic, and nutritional properties and offer human nutrition dietary fibre, carbohydrates, vitamin B, calcium, iron, mineral salts and antioxidant substances. Among the relevant aspects of okra cultivation, its post-harvest management stands out as one of the main ones. After harvesting, vegetables become quite perishable owing to their high water content (90%) and intense metabolism that is characterized by high respiratory rate (Mota *et al*., 2010) [7]. These factors, which are the biggest problem in the storage of bhendi, lead to an extremely short storage period, mainly in poor storage conditions such as high temperature and low relative humidity, because these conditions accelerate the loss of water and darkening of fruits, thus, depreciating its commercial value for consumption in nature (Mota *et al*., 2010) [7]. Bhendi is being sold in markets and supermarkets and stored without temperature or humidity control, enabling the occurrence of wilting and water loss and depreciating the commercial value of the fruit (Finger *et al*., 2008) [5]. Post-harvest research focused more on low temperature storage in postharvest handling. However, below 10 °C to 12.5 °C chilling injury (CI) symptoms occurred which include brown or black surface discolouration, surface pitting and high levels of decay. Moreover, it is usually stored at room temperature in India which limits the strategy of low temperature storage. As it is a summer season vegetable, it continues to ripen after harvest and produces a high amount of ethylene. Hexanal is a naturally occurring six-carbon aldehyde compound produced in the lipoxygenase pathway and released from plants during tissue damage. It is an important precursor for the formation of six carbon alcohols and esters, which plays an important role in extending fruit freshness by inhibiting the enzyme phospholipase-D (Jandus *et al*., 1997) [6]. It is generally recognized as safe (GRAS) and has been observed to be a strong inhibitor of phospholipase D, and so technologies for its application to enhance shelf life and the quality of fruit, vegetables, and flowers are currently under development. Several studies have been carried out to enhance the shelf life and post-harvest quality of fruits, vegetables and flowers (Paliyath and Murr, 2008) [8]. Hence, the hexanal based formulations have been found to enhance the shelf life of many crops *viz*., guava, mango, grapes, apple, pear, peach, sweet cherry and strawberry (Paliyath and Murr, 2008; Spotts *et al*., 2007; Corbo *et al*., 2000) [8, 11, 3]. Keeping the above in view, an attempt was made to investigate the effect of hexanal formulation (EFF) on post harvest quality and shelf life enhancement in bhendi CO 4 hybrid.

Materials and Methods

The present investigation was carried out at the Department of Vegetable Science, Horticultural College and Research Institute for Women, TNAU, Trichy, during 2021-2022. The experiment was laid out in Completely Randomized Design (CRD) with five treatments and five replications. Bhendi fruits were treated with EFF both as pre harvest spray and post harvest dip. The fruits were exposed to the pre harvest spray of 1% and 2% EFF solution one day before harvest. The fresh bhendi fruits were harvested at harvest maturity and maximum efforts were made to select uniform sized fruit that was free from injuries and diseases. Fruits were treated with EFF at 1.0 and 2.0 per cent for 1 minute and then air dried. The untreated fruits dipped in water for 1 minute and then air-dried served as control. Three kg of fruits for each replication of each treatment were stored under ambient (28 °C ± 2 °C, RH 60 ± 10%) condition. The observations like physiological loss in weight, firmness and shelf life were recorded and fruit biochemical parameters *viz*., chlorophyll content, total soluble solids (TSS), ascorbic acid content (mg/100g), firmness (N/mm) and titrable acidity (%) were determined by adopting the AOAC (1990) method.

Physiological loss in weight

The PLW was calculated by subtracting the final weight from the initial weight of the fruit and then expressed as per cent weight loss with reference to the initial weight as recommended by the Association of Office Analytical Chemists (2001) using the following formula till the produce became unmarketable which is estimated by visual scoring: PLW (%) = ((Initial weight − Final weight) / Initial weight) × 100.

Titrable acidity

The titrable acidity was estimated by titration of the juice against 0.1 N KOH using phenolphthalein as an indicator and expressed as citric acid (Srivastava and Kumar 1993) [12].

Fruit firmness

The fruit firmness was measured using a digital penetrometer with a reading range between 5 and 200 Newton (N), with a 3 mm tip was used for the determination of rupture force and the readings were expressed as N/mm.

Shelf life: The shelf life of the fruit was determined by recording the number of days the fruits remained in marketable condition without spoilage in each replication during storage and expressed in days.

Total Soluble Solids

The total soluble solids of the fruits were determined with the help of an Erma hand refractometer with a range of 0-32 per cent and the values were expressed in degree brix after making the temperature correction at 20 °C.

Result and Discussion

The least physiological loss in weight was observed in 1% EFF as a preharvest spray on the 2nd, 3rd, 4th, 5th and 6th day after storage as 7.67, 14.99, 22.07, 26.80 and 30.84% respectively. This might be due to the hexanal which maintains the cell structure and integrity because of reduced catabolic process. This result is consistent with that of Yaptenco *et al*. (2007) [14] that Hexanal slows down the lipogenase in the skin of fruit delaying the ripening process and lowering the Physiological loss in weight (PLW). Higher fruit firmness was observed in preharvest spray EFF 1% in bhendi due to the presence of hexanal in the aqueous formulation which slows down the cell wall softening enzymes. This result is in accordance with Sharma *et al*. (2010) [9] who reported that Hexanal lowers the PLW and coincides with the retention of fruit firmness and changes due to increased cell wall biosynthesis and membrane preservation, slows down cell wall softening enzymes.

The lowest TSS (8.30 °B) was observed in preharvest EFF 1% in bhendi on 5th day due to delayed ripening and the highest TSS (10.40 °B) was observed in untreated fruits. This result is by Esteves *et al*. (1982) [4] who reported that untreated fruits showed an increase in TSS due to the conversion of starch to sugar whereas hexanal treated fruits showed a slight increase in TSS and hence delayed ripening in Guava. Higher ascorbic acid (34.20 mg/100g) was observed in preharvest spray EFF 1% in bhendi. This result is consistent with Singh and Rao (2005) [10] who reported that a decrease in ascorbic acid is due to the conversion of ascorbic acid into dehydroascorbic acid by the enzyme ascorbic acid oxidase, whereas hexanal treated fruits showed decreased oxidation and an increase in ascorbic acid in Mango. Higher acid content was observed in preharvest spray EFF 1% in bhendi. This result is consistent with Gill *et al*. (2016) [15] who reported that high acid content causes curtailment of respiratory rate and slow ripening of cherry. Maximum chlorophyll content (40.2%), high firmness (2.8 N/mm) and longer shelf life of 8 days was observed in preharvest spray EFF 1% in bhendi. The reduction of chlorophyll in the untreated fruits was faster than the EFF treated fruits and this reduction in chlorophyll might be due to high ethylene production which regulates the de-novo synthesis of the enzyme chlorophyllase in peel during ripening (Trebitsh *et al*. 1993) [13]. These results are in corroboration with Amarjeet *et al*. (2016) [2] reported that hexanal treated fruits showed an increase in shelf life, higher firmness and minimum PLW in sapota.

Table 1: Effect of EFF on Physiological loss in weight (%) of bhendi under ambient storage condition

Treatments	PLW (%)				
	Day2	Day3	Day4	Day5	Day6
T_1 – Pre harvest spray 1% EFF	7.67	14.99	22.07	26.80	30.84
T_2 – Pre harvest spray 2% EFF	8.70	16.75	24.42	29.74	34.74
T_3 – Post harvest dip1% EFF	7.73	16.49	24.85	34.85	42.99
T_4 – Post harvest dip 1% EFF	9.70	20.00	28.76	38.88	47.21
T_5 – Control	11.40	23.26	33.49	45.49	53.95
SEd	0.115	0.238	0.982	0.463	0.552
CD(0.05%)	0.241	0.508	2.04	0.98	1.17

Table 2: Effect of EFF on biochemical characters and shelf life of bhendi under ambient storage condition

Treatments	Chlorophyll content (%)	TSS (°B)	Firmness (N/mm)	Ascorbic acid (mg/100g)	Shelf life (days)
T_1 – Pre harvest spray 1% EFF	**40.2**	**8.30**	**2.8**	**34.20**	**8.00**
T_2 – Pre harvest spray 2% EFF	36.8	9.10	2.6	32.50	7.00
T_3 – Post harvest dip 1% EFF	32.1	9.50	2.4	33.90	6.00
T_4 – Post harvest dip 1% EFF	38.5	9.70	2.3	33.90	6.00
T5 – Control	25.0	10.40	0.5	30.30	5.00
SEd	0.4509	0.1291	0.036	0.425	0.0908
CD (0.05%)	0.9612	0.2752	0.0778	0.907	0.1936

Conclusion

Based on the research findings, it can be concluded that pre harvest spray of bhendi fruits with EFF @ 1% was found effective in increasing the shelf life with minimum physiological loss in weight and maximum fruit firmness. The fruit biochemical parameters revealed that EFF treated fruits had less total soluble solids, high ascorbic acid content, high Titrable acidity and higher firmness indicating a minimum decrease in the quality of fruit during storage compared to control at ambient storage condition.

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