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A Bharathkumar
Dept. of Post-Harvest Technology, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

SL Jagadeesh
Dept. of Post-Harvest Technology, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

Netravati
Dept. of Post-Harvest Technology, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

Veenith Hegde
Dept. of Post-Harvest Technology, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

G Bhuvaneshwari
Dept. of Post-Harvest Technology, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

H Bindu
Dept. of Post-Harvest Technology, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

Correspondence
A Bharathkumar
Dept. of Post-Harvest Technology, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot, Karnataka, India

A study on fruit preparation on quality of fig fruits (cv. Bellary) osmotic-dehydrated under solar tunnel dryer

A Bharathkumar, SL Jagadeesh, Netravati, Veenith Hegde, G Bhuvaneshwari and H Bindu

Abstract
Dehydration of fruit and vegetables is one of the oldest techniques known to man and consists primarily of sun drying or artificial dehydration of fruits and vegetables. Fig fruits are climacteric, highly perishable, and higher in respiration rate and ethylene production. Fresh figs cannot be stored for longer period at ambient condition but the dried figs can be stored for 6–8 months. The fig varieties grown locally on a large scale (Bellary fig in Karnataka) are not yielding acceptable colour and taste in dried fig. This is partly due to natural low TSS (9˚Brix) in these figs as compared to exotic fig varieties. Therefore, this study was conducted to improve quality of dehydrated fig by imposing pre-drying treatments to whole fig fruit, pricked whole fig fruit, or fruits cut as halves and quarters. The common pre-treatment was blanching (4 minutes) + 0.2% KMS (Potassium metabisulfite) + steeping in 40ºB sugar solution containing 0.25% citric acid for 24 hours. The pre-treated fruits were dried by employing solar tunnel dryer and analysed for physico-chemical and sensory attributes. The fruits cut to quarter shape showed maximum dried fruit recovery (23.52%) with minimum time taken for dehydration (83.70hours). The same treatment recorded higher *L**(40.15), lower *a**(9.06) and *b**(19.05) value with acceptable organoleptic properties.

Keywords: *Ficus carica*, osmotic-dehydrated fig, physical properties, organoleptic qualities

1. Introduction

The common fig (*Ficus carica* L.), is deciduous tree belonging to the Moraceae family, commonly known as “Anjir” in India. Fig is one of the earliest cultivated fruit trees and an important crop worldwide for both fresh and dry consumption [1]. Figs are found to be a rich source of amino acids. They are also free of fat and cholesterol [1, 2, 3, 4]. Both fresh and dried figs have high amounts of fiber and polyphenols [5, 6]. In India, fig is considered to be a minor fruit crop and the commercial cultivation of common (edible) fig is mostly confined to Western Parts of Maharashtra, Gujarat, Uttar Pradesh (Lucknow and Saharanpur), Karnataka (Bellary, Chitradurga and Srirangapatna) and Tamil Nadu (Coimbatore). Figs are also very popular as dried fruit, since drying increases their shelf life [7]. Dried figs are reported to be a good source of carbohydrates, sugars, minerals, vitamins, organic acids and phenolic compounds [2, 3]. The dried figs are used as a food supplement by diabetics and because of the high amount of sugars in it; it is consumed as a sweet [2]. Alkaloids, flavonoids, coumarins, saponins and terpenes have also been reported in aqueous extract of the ripe dried fruit of *Ficus carica* [7]. Being highly perishable, fig fruits cannot be stored for longer period at ambient condition but the dried figs can be stored for 6–8 months [8].

At present, sun drying is the main processing method used in tropical regions. However, drying of fig fruits is not a popular practice in India. The fig varieties grown locally (Bellary fig in Karnataka) on a large scale are not yielding acceptable colour and taste in dried fig. This is partly due to natural low TSS content in these figs as compared to exotic fig varieties. Farmers are thus forced to sell fresh fruits which often cause loss to them due to highly perishable nature of the fruit. In fact, cold storage of fresh figs is a challenge in rural areas. Hence, there is a great scope and need for drying of local figs to produce dried fig with optimum quality. Osmotic dehydration has received greater attention in recent years as an effective method for preservation of fruits. Being a simple process, it facilitates processing of tropical fruits, retention of initial fruit characteristics viz., colour, aroma and nutritional compounds [9]. It has potential advantages for the processing industry to maintain the food quality and to preserve the wholesomeness of the food. Osmotic-dehydration involves dehydration of fruit slices in two stages, removal of water using as an osmotic agent and subsequent dehydration in a dryer where moisture content is further reduced to make the product shelf stable. Osmotic dehydration is considered as more as a pre-concentration than a dehydration step due to that water losss decreased after the first 3 hours of steeping. Osmotic treatment helps in improving the quality and also increases the drying rate of fruits. To avoid wastage and economic loss to farmers, to stabilize the prices, to protect the nutrients and to encourage fig fruit cultivation, the surplus fig produced needs to be processed and preserved properly. The present investigation will be focusing on imposing pre-drying treatments to fig fruit as whole fruit, pricked whole fig, halves and quarters in osmotic agent and drying by employing solar tunnel dryer.

2. Materials and Methods

Fig fruits harvested at optimum maturity were brought to the laboratory of the Department of Post-Harvest Technology, Bagalkot in CFB boxes. The damaged, bruised, punctured and infected fruits were discarded manually fruits stalks were manually removed using a sharp knife and care was addressed not to damage the fruits. Then the fruits were thoroughly washed in order to clean the latex exuded after cutting the stalks. Syrup was prepared by mixing known quantity of sugar in gentle boiling water to get a final total soluble solid content of 40˚B.

Fig fruits of uniform size, colour and shape of were selected and were then subjected to different pre-treatments. Blanching: Fruits of one kg were tied in muslin cloth and placed in boiling water at a temperature ranging 90-95˚C for 4 minutes with 5 replications. Fruit preparation: After blanching, whole fig (T_1), fig fruits were whole fig pricked (18-20 holes) with help of tooth pick (T_2), cut into halves (T_3) and quarters (T_4) using knife. After fruit preparation, fruits were steeped in sugar syrup of 40 ˚B (osmotic solution) containing 0.2% Potassium metabisulfite and 0.25% citric acid under ambient condition. Drying: Pre-treated figs were placed on clean stainless steel trays (dimension of 80 x 60 x 5 cm) and kept for drying in a solar tunnel dryer at a temperature of 56 ˚C till reaching a safe moisture level. Pressing: The dried fig fruits were taken out from solar dryer when moisture was reduced to 32±3 per cent and pressed carefully. Pressing was manually done using papad press. The stage of pressing was carefully maintained in order to avoid any oozing out of inside matter of the fruit while pressing. Drying: After pressing fig fruits were further dried in a solar tunnel dryer to reach safe moisture level of 23-27 per cent.

1.1 Physical parameters

2.1.1 Weight reduction (%)

The weights of fresh fig and after steeping in osmotic solution were noted and weight reduction was calculated using the formula:

$$\text{Weight reduction (\%)} = \frac{(w_i - w_f)}{w_i} \times 100$$

Where, w_i and w_f are the initial and final sample (24 hours after steeping in osmotic solution) weights in grams (g) respectively.

2.1.2 Dried fruit recovery (%)

The weight of fresh fig fruits before drying and the weight at the end of drying from each treatment were noted and dried recovery was calculated using the formula:

$$\text{Dried recovery (\%)} = \frac{W_2}{W_1} \times 100$$

Where, W_2: Weight of dried fig (g), W_1: Weight of fresh fig (g)

2.1.3 Time taken (hours)

The total time taken by the fig fruits for reaching a safe moisture level of 24-27 per cent was recorded in hours.

2.1.4 Colour (*L**, *a**, *b**)

Colour of the samples was measured using Colour Flex EZ colorimeter (Model: CFEZ 1919, Hunter associates laboratory. Inc., Reston) fitted with 45 mm diameter aperture. The instrument was calibrated using black and white tiles provided. Colour was expressed in *L** (lightness/darkness), *a** (redness/greenness) and *b** (yellowness/blueness).

2.2 Organoleptic evaluation of dried fig

Organoleptic evaluation of fruits was carried out by a panel of 10 semi-trained judges. The sensory characters like skin colour as well as colour and appearance, taste, flavour, texture and overall acceptability were evaluated on a 9 point Hedonic scale.

Statistical analysis

Statistical analysis was performed using Web Agri Stat Package (WASP) Version 2.0 (Jangam and Thali, 2010) [10]. All data the collected were analysed by one-way analysis of variance (ANOVA). Significant differences among means at $P \leq 0.05$ were determined by post hoc tests using Duncan's multiple range test.

3. Results and Discussion

The data pertaining to weight reduction, dried fruit recovery and drying time as influenced by pre-treatments drying under solar tunnel dryer on physical properties of dehydrated fig is presented in Table 1.

Table 1: Effect of fruit pre-treatment on weight reduction, dried recovery and drying time of dried figs. Similar alphabets within the column represents non-significant differences at (p<0.05)

Treatments	Weight reduction (%) after steeping in osmotic solution	Dried fruit recovery (%)	Drying time (Hours)
T_1-Whole fig	8.84^c	20.52^d	108.60^a
T_2-Pricked whole fig	7.07^d	21.84^c	104.40^b
T_3-Halves	10.31^b	22.69^b	87.80^c
T_4-Quarters	13.75^a	23.52^a	83.70^d
Mean	9.99	22.14	96.10
SEm±	1.13	0.25	0.37
CD@5%	3.40	0.70	1.12

The results on weight reduction as influenced by pre-treatments, the maximum weight reduction was recorded in T_4 (13.75 %), whereas, significantly minimum weight reduction was observed in T_2 (7.07 %). Osmotic solution concentration was the most important effect on weight reduction. This might be due to osmotic process (mainly between water loss and solids gain). Similar results were reported by El-Aouar *et al*, (2006) [11] in osmotic dehydrated papaya. The data revealed on dried fruit recovery showed significant differences among various pre-treatments. Maximum dried fruit recovery was recorded in T_4 (23.52 %) and minimum recovery was recorded in T_1 (20.52 %). The increase in yield in pre-treatment T_4-quarters steeping in sugar solution may be attributed to penetration of solution in to intercellular spaces, due to density of differences between the syrup and the entrapped air in intercellular spaces (Mavroudis *et al.*, 1998 [12] and Khan and Vincent, 1990) [13] and Similar results obtained by Kaggodi (2007) [14] and Abhay (2004) [15].

Pre-treatments have a positive influence on the drying time of the product. Significantly lowest time taken for drying was recorded in T_4 (83.70 hours) followed by T_3 (87.80 hours). Significantly maximum drying was found in T_1 (108.60 hours). This might be due to higher cut surface and also due to osmotic process (13.75% weight reduction) during steeping. Similar results obtained by Borah *et al*. (2015) [16] in turmeric.

Table 2: Effect of pre-treatment on instrumental colour (*L*, a* and b**) value of dried figs. Similar alphabets within the column represents non-significant differences at (p<0.05)

Treatments	Instrumental Colour values		
	L*	***a****	***b****
T_1-Whole fig	36.06^b	13.42^a	19.04
T_2-Pricked whole fig	36.65^b	13.33^a	19.38
T_3-Halves	36.83^b	11.47^a	19.40
T_4-Quarters	40.75^a	9.06^b	19.05
Mean	37.57	11.82	19.22
SEm±	0.78	13.42	0.98
CD@5%	2.34	2.01	NS

The data pertaining instrumental colour values (*L*, a* and b) of dehydrated fig as influenced by pre-treatments drying under solar tunnel dryer is presented in Table 2.**

Irrespective of treatments significantly maximum *L** value was found in T_4 (Quarters) (40.75) and minimum in T_1 (Whole fig) (36.06). Maximum *a** value was found in T_1 (13.42) and minimum in T_4 (9.1). This value indicates light colour (less browning) and this may be due to faster drying rate with less non-enzymatic browning. The loss of intercellular air caused by sugar impregnation might increase the light reaction (Lambard *et al.*, 2008) [17]. Addition of citric acid and potassium metabisulfite in sugar syrup, they act as an anti-darkening and presence of sulfur and sulfite compounds prevent discolouration. The results showed no significant differences among treatments with respect to *b** value. However, the maximum mean *b** value was noticed in T_2 and T_3 (19.40) Similar results were reported by Anusree (2017) [18] in fig.

Table 3: Effect of pre-treatments on organoleptic parameters (colour and appearance, flavour, texture and consistency, taste and overall acceptability) of dried figs. Similar alphabets within the column represents non-significant differences at (p<0.05)

Treatment	Colour and appearance	Flavour	Taste	Texture and consistency	Overall acceptability
T_1-Whole fig	7.60^{ab}	7.70^a	7.28^b	7.14^{ab}	7.40^{ab}
T_2-Pricked whole fig	7.35^b	7.13^b	7.01^b	6.48^b	7.00^b
T_3-Halves	7.44^b	7.63^{ab}	7.60^{ab}	7.54^{ab}	7.60^a
T_4-Quarters	8.02^a	8.09^a	8.21^a	8.14^a	8.00^a
Mean	7.60	7.64	7.53	7.53	7.50
SEm±	0.16	0.17	0.23	0.38	0.22
CD@5%	0.47	0.51	0.69	1.12	0.65

The data pertaining on organoleptic properties of dehydrated fig as influenced by pre-treatments drying under solar tunnel dryer is presented in Table 3

It was evident from Table 3 that the pre-treatments have affected the colour and appearance characteristic of dried figs significantly. Maximum score for colour and appearance was recorded in T_4 (8.02) and minimum score was recorded in T_2 (7.35) and T_3 (7.44), they are on par with each other. Pre-treatment T_4 (quarters) has better effect on colour and appearance property than any other pre-treatment. The blanching + KMS + citric acid developed light colour of dried figs whereas T_2 (pricked whole fig) developed the brown colour. Faster drying rate reduces the browning during drying. Taste: Significant difference was found between the taste characteristic among the treatments. The figs subjected to pre-treatment T_4 (8.21) were mostly liked by the panel members because of its sweetness followed by figs subjected by pretreatment T_3 (7.60). Lowest score was recorded in T_2 (7.01) and it was on par with T_1 (7.28). Flavour: Significant difference was observed within the treatments. Maximum score for flavour was recorded in T_4 (8.09) and it was on par with T_1 (7.70) and minimum score was recorded in T_2 (7.13). Texture: The pre-treatments have profound significantly influence on the textural characteristic of dried figs. The texture of figs subjected to pre-treatment T_4 (8.14) was found to be better than all other samples. The texture of sample subjected to pre-treatment T_3 (7.54) was on par with the sample subjected to treatment T_1 (7.14). Overall acceptability: The dried figs subjected to pre-treatment T_4 (8.00) assigned highest value of sensory score and were liked by the panel members followed by T_3 (7.60). T_2 (7.00) sample was proved to be moderately liked by the panel members.

4. Conclusion

The fruits cut to quarter shape showed maximum weight reduction (13.75%) after steeping in osmotic solution, dried fruit recovery (23.52%) with minimum time taken for dehydration (83.70 hours). The same treatment recorded higher *L** (40.15), lower *a** (9.06) and *b** (19.05) value with acceptable organoleptic properties.

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