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Effect of different pre-treatments on dehydration of fig fruits under electric tray dryer

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Abstract
Fig (*Ficus carica* L.) is considered as a minor fruit crop in India. Being highly perishable, fig cannot be stored for longer period at ambient condition. Figs after drying can be stored for about 6–8 months. Hence, there is a great scope and need for drying of figs with appropriate pre-treatment to get a product with optimum quality. The present investigation aims at studying the behaviour of figs as influenced by different pre-treatments. Among different pre-treatments, blanching (4 minutes) + 0.2% KMS + steeping in 40^{o}B sugar solution containing 0.5% citric acid for 24 hours was found to be the best on the basis of sensory evaluation.

Keywords: fig (*Ficus carica* L.), pre-treatment, drying

Introduction

Fig *(Ficus carica* L.), belonging to family Moraceae, is a moderately important fruit crop with an annual estimated global production of one million tonnes of which about 30 per cent is produced by Turkey. 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). Maharashtra is the largest producer of fig (7894 million tonnes) with largest area under cultivation (2242 hectares) out of total acreages in India (2899 hectares). But, the productivity of fig is highest in Karnataka with 9.39 tonnes per hectare which is 5.87 tonnes more than that of Maharashtra (3.52 tonnes per hectare). Fig is one of the highest plant sources of calcium and fiber (Joseph and Raj, 2011). They are rich in easily digestible natural sugars and contain rich amounts of anthocyanins and flavonoids that contribute to figs colouration (Solomon *et al*., 2006) [34]. The nutritive index of fig is as high as 11 as compared to 9 of apple, 8 of raisin and 6 of dates and pears. Fig is valued for its laxative properties and used in the treatment of skin infection.

The ripe fruit does not transport well, and once picked does not keep well. The soft and fleshy nature of the fig fruit makes it more susceptible to injuries increasing losses due to spoilage. Fig fruit is a so called "under-utilised crop", mainly because it is very perishable at the fresh state and also for the very poor product diversification (Addeo *et al*., 1990). Figs can be eaten fresh or dried, and used in jam-making. Dried fig has high demand in the market. 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. Hence, there is a great scope and need for drying of figs to produce dried fig with optimum quality.

Pre-treatments are important for successful drying and dehydration processes as they check the undesirable physico-chemical and other qualitative changes that may occur during the process. Sulphitation or sulphuring, blanching in hot water, steeping in sugar syrup, steeping in alkali or acid solutions, dip oil, *etc*., are some of the different pre-treatments being followed in dehydration of various fruits. Generally, these pre-treatments vary with nature of fruits. As the TSS of fig varieties grown in India ranges from 15 to 17^{0}B, the drying of such fruits yields unsatisfactory product. However, some pre-treatments like steeping in sugar solution have been reported to improve TSS of dried fruits (Pawar *et al*., 1992) [25].

In the present experiment, different pre-treatments followed by dehydration is attempted to study physico-chemical quality of dried figs.

Materials and Methods
Plant material
The experiment was conducted in the Dept. of Post Harvest Technology, College of Horticulture, Bagalkot. The fruits (*Ficus carica* L. cv. Bellary) were procured at firm ripe stage from farmer's field in Bellary. Fig fruits of uniform size, colour, and shape, and without any defects were selected and subjected to different pre-treatments as mentioned below:

Blanching: Fruits were tied in muslin cloth and placed in boiling water at a temperature ranging 90-95°C for 4 minutes.

Steam treatment: The fruits were steam treated in autoclave for 5 minutes by maintaining a pressure of 10 *psi.*

Sulphur dioxide (SO_2) fumigation: Fig fruits were subjected to sulphur fumigation in a closed box of dimension 60 cm x 50 cm x 75 cm at a rate of 1 g sulphur per kg of fruits for 30 minutes.

Drying
Pre-treated figs were dried in a tray dryer at a temperature of 55°C till reaching a safe moisture level of 17-20 per cent. The time required for drying in different pre-treatments to reach the safe and optimum moisture level was recorded in hours.

Pressing
Fig fruits were taken out from dryer when about half of the moisture was removed 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.

Observations recorded
The weight of dried fruits was divided by fresh fruits and expressed in percentage to calculate dried fig recovery. The total time taken by the whole fig fruits for reaching a safe moisture level of 17 to 20 per cent was recorded in hours and minutes. The moisture content of dried fig was estimated using Radwag moisture analyser (Model: MAC 50, Make Poland. The solid gain (SG) after steeping in the sugar solution was calculated using the equations given by El-Aouar *et al.* (2006) with slight modification.

$$SG (\%) = [(W_f (1-X_f /100) - W_i (1-X_i/100)) / W_i] \times 100$$

Where,
W_i and W_f are the initial and final (after steeping) weight of samples in Grams
X_i and X_f are the initial and final moisture content of samples (after dehydration) in percentage

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. Colour was expressed in *L** (lightness/darkness), *a** (redness/greeness) and *b** (yellowness/blueness). Texture of the dried samples was determined with TAXT Plus Texture Analyser (Make: Stable Micro System, Model: Texture Export Version 1.22). The force with which the sample gets cut was recorded in graph and the peak value in the graph was taken as the texture value in terms of Newton force (N).
The total sugar content of the dried figs was estimated by anthrone reagent method and the reducing sugar in the sample was estimated by di-nitrosalicylic acid method. The per-cent non-reducing sugar was obtained by subtracting the value of reducing sugar from that of total sugar as given by Miller (1972).

Sensory evaluation
Sensory evaluation of dehydrated figs was carried out by a semi trained panel consisting of Teachers and Post-Graduate students of College of Horticulture, Bagalkot with the help of nine point hedonic rating scale (1 = dislike extremely, 2 = like only slightly, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely) for colour and appearance, texture, taste, flavour and overall acceptability (Swaminathan, 1974).

Result and Discussion
Effect of different pre-treatments on the dried fig recovery is given in Table 1. The dried fig recovery was significantly higher in all the treatments involving steeping in sugar solution when compared to the control (T_1). Significantly maximum recovery was obtained in T_4 (21.12%) followed by T_3 (20.96%). The increase in the yield observed in pre-treatment of steeping in sugar solution may be attributed to the penetration of solution into the intercellular space, due to density differences between the syrup and the entrapped air in the intercellular spaces (Khan and Vincent, 1990 and Mavroudis *et al*., 1998) [14,19]. The pre-treatment T_4 (Steaming at 10 *psi* for 5 minutes + 0.2% KMS for 5 min + steeping in 40ºB sugar solution containing 0.5% citric acid for 12 hours) that involved the steam pre-treatment might have rendered the fruit skin to be loose and permeable than that of blanching treatment, thus allowing more transfer of sugars from the solution to the fruits. Similar result was obtained in a study by Naikwadi *et al*. (2010) [21] in figs. Steeping duration might also have influenced the transfer of solids to the fruits showing higher recovery in T_3 (Blanching for 4 minutes + 0.2% KMS for 5 min + steeping in 40ºB sugar solution containing 0.5% citric acid for 24 hours) in comparison to other pre-treatments. Similar result was obtained by Indudhara (2003) [11], Abhay (2004) [1] and Kaggodi (2007) in fig.
Pre-treatment and process conditions affecting the integrity of fresh fruit tissue have severe effects on the solid gain process responses. Blanching, sulfitation and freeze/thawing are all conducive to the uptake of solids (Mavroudis *et al*., 1998) [19]. This result can be correlated to the higher solid gain (%) observed in T_4 (29.21%) and T_3 (26.63%). The recovery was found to be minimum (16.09%) in control (T_1) with only blanching for 4 minutes.
Pre-treatments have a positive influence on the drying time of the product in this experiment (Table 1). Significantly lowest time taken for drying was recorded in T_1 (46.62 hrs) followed by T_5 (50.48 hrs) and T_4 (69.68 hrs), which was on par with T_2 (69.88 hrs). Significantly maximum drying time was found in T_3 (80.75 hrs). The results indicated that significantly more time for drying was taken by those fruits treated with sugar steeping in comparison to control. The increased concentration of sugar in the fruits due to longer duration of steeping (24 hrs) under T_3 might have increased the time taken for drying. Because, the sugar layer present on the

surface of the fruits hinders the free escape of the moisture, especially during the falling rate period of drying (Yadav and Singh, 2012). Similar results were reported by Indudhara (2003) [11], Abhay (2004) [1], Kaggodi (2005) [13] and Patil (2007) [24] in figs. With the same duration of sugar treatment (12 hrs), the pre-treatment T_5 has taken less time for drying than T_2 and T_4. This may be attributed to acceleration of drying caused by ethyl oleate in fig fruits under T_5. Water in the living tissues exists in bound form (colloidal water) or as free water. In this study, the proportion of bound water is expected to increase in fig fruits pre-treated by steeping in sugar solution. Water in the colloidal form cannot easily be removed than free water upon drying and therefore fig fruits under T_2, T_3, T_4 and T_5 took more time to bring down the moisture content to pre-determined level.

The results of solid gain percent as influenced by different pre-treatments are given in Table 1. Significantly higher solid gain (29.21%) was observed in steam treated sample (T_4) due to the influence of heat treatment on tissue microstructure in the epidermal cells (Fava *et al*., 2006 and Brambilla *et al*., 2011) [8,4] and steam-induced phenomena of cellular lysis and cell wall swelling. The application of high pressure was reported to have damaged the cell wall structure of pineapple tissue leaving the cells more permeable, which enhanced solute transfer (Rastogi and Niranjan, 1998) [30]. Blanching treatment increased skin permeability, probably by dissolving the hydrophobic waxy layer and by weakening cell walls and membrane of fig fruits leading to better solid intake as observed in T_2 (24.63%), T_3 (26.63%) and T_5 (23.85%). Among these, T_3 showed a maximum solid gain value of 26.63 per cent probably due to more steeping duration (24 hours) compared to other treatments with 12 hours duration (T_2 and T_5). Similar results were observed by Giovanelli *et al*. (2012) in blueberries. Osmotic dehydration is considered more as a pre-concentration than a dehydration step due to the fact that water loss rates are substantially decreased after the first 3 hours of steeping (Raoult-Wack, 1994) [29].

Table 1: Effect of different pre-treatments on dried fig recovery (%), drying time (hrs), solid gain (%), moisture (%) and texture (N) of dried figs

Treatments	Dried fig recovery (%)	Drying time (hrs)	Solid gain (%)	Moisture (%)	Texture (N)
T_1	16.09^{c}	46.62^{d}	$0.000 (0.70)^{c}$	19.26	451.56
T_2	19.38^{ab}	69.88^{b}	$24.63 (5.01)^{ab}$	19.03	458.80
T_3	20.96^{ab}	80.75^{a}	$26.63 (5.20)^{ab}$	18.50	447.86
T_4	21.12^{a}	69.68^{b}	$29.21 (5.44)^{a}$	17.94	456.01
T_5	18.9^{b}	50.48^{c}	$23.85 (4.92)^{b}$	19.03	444.43
Mean	19.25	63.48	20.87 (4.26)	18.75	451.73
S.Em±	0.71	0.75	1.57 (0.15)	0.38	19.92
C.D (5%)	2.12	2.26	4.74 (0.44)	NS	NS

Note: Values with the same superscripts with respect to pre-treatments are not significantly different by Duncan Multiple Range Test at P = 0.05 Values in paranthesis indicates the square root transformed values

In the present investigation, mean moisture content of dehydrated figs was ranging from 17.94 to 19.26 per cent. However, it did not differ significantly among the treatments (Table 1). Irrespective of the pre-treatments, figs were dried to pre-determined safe moisture level. Hence, pre-treatments had no significant effect on the moisture content of dried figs, although they played a role determining the drying time to bring moisture content in fig fruits to pre-determined safe moisture level. The results of instrumental texture analysis were found to be non-significant with respect to the pre-treatments (Table 1). The texture force in the dried fig samples in this study was ranging from 444.43 N to 458.80 N. In general, the toughness increases in dried fig fruit in comparison to its fresh form. This increased toughness of the product can be attributed to the effect of dehydration which reduced the moisture content of the product. Ramallo and Mascheroni (2012) [28] also reported that the drying process causes an increment in the fracture strain as well as in the values of failure stress, evidencing greater hardness in dehydrated pineapple fruit. As the water content of these samples decreases during drying, it is expected to observe greater values of shear force.

The effect of pre-treatments on L^*, a^*, b^* values of dried figs was found to be non-significant (Table 2). However, steeping in sugar syrup for 24 hrs showed maximum L^* value (36.57). The loss of intercellular air caused by sugar impregnation might have increased the light refraction (Lombard *et al*., 2008). In addition, pre-treatment with potassium metabisulphite reduced darkening and retained light colour in the dehydrated onion samples (Nihar *et al*., 2015) [22]. The pre-treatment T_5 (SO_2 fumigation at a rate of 1g Sulphur /kg for 30 min + 4% K_2CO_3 + 2% Ethyl Oleate for 5 min + steeping in 40°B sugar solution containing 0.5% citric acid for 12 hours) received the minimum value for L^* (30.72). As known, SO_2 has strong antioxidant activity and can protect the product from oxidation and browning. However, the effect of SO_2 in preserving light colour of the product was not observed in this experiment. It appears that the concentration of sulphur used for fumigation in this study (1000 ppm) might be less than the adequate level required to bring desirable change in colour. Salur-Can *et al*. (2017) opined that SO_2 concentration lower than 1594 mg/kg did not yield an acceptable colour in apricot. The concentrations of sulphur used for pre-treatment of figs in the present study were within the prescribed limit. Hence, the issue of residual sulphur may not arise. The maximum residual sulphur limit of sulphur dioxide in dehydrated fruits and vegetables is 2000 ppm (FSSAI, 2012). The maximum residual sulphur (500.18 ppm) was recorded in T_5 (SO_2 fumigation at a rate of 1g Sulphur /kg for 30 min + 4% K_2CO_3 + 2% Ethyl Oleate for 5 min + steeping in 40°B sugar solution containing 0.5% citric acid for 12 hours) and it was followed by T_4 (358.97 ppm) (Steaming at 10 *psi* for 5 minutes + 0.2% KMS for 5 min + steeping in 40°B sugar solution containing 0.5% citric acid for 12 hours) (Table 2). The maximum residual concentrations observed in this study were well below the maximum limit prescribed by the FSSAI.

Table 2: Effect of different pre-treatments on instrumental colour (L^*, a^* and b^* values) and residual sulphur (ppm) of dried figs

Treatments	L^*	a^*	b^*	Residual sulphur (ppm)
T_1	32.09	12.21	15.39	0.000^d(1.00^d)
T_2	31.05	13.80	19.54	341.01^c(2.55^{bc})
T_3	36.57	13.25	20.31	333.36^c(2.54^c)
T_4	33.11	14.04	16.42	358.97^b(2.57^b)
T_5	30.72	12.02	19.38	500.18^a(2.71^a)
Mean	32.71	13.06	18.21	306.70 (2.27)
S.Em±	2.04	0.97	2.16	5.89(0.020)
C.D (5%)	NS	NS	NS	17.77(0.023)

Note: Values with the same superscripts with respect to pre-treatments are not significantly different by Duncan Multiple Range Test at P = 0.05.Values in parenthesis represent the logarithmic transformation values.

Total sugar, reducing sugar and non-reducing sugar content in the dried fig samples were higher in sugar steeped samples than the control (Table 3). Regarding different pre-treatments, maximum total sugar and non-reducing sugar were observed in T_4 (55.03% and 1.72%, respectively) and reducing sugar in T_3 (53.57%). Minimum total sugar, reducing sugar and non-reducing sugar were noted in T_1 (44.25%, 43.47% and 0.79%, respectively). The increase in reducing sugar content of sample might be due to the conversion of non-reducing sugars into reducing sugars and also concentration of fruit sugars during drying process. Similar increase in reducing sugars and total sugars was observed in different fruits by various workers (Sankat and Castaigne, 2004 and Abrol *et al*., 2014) [32, 2]. The variation in sugar content due to treatment effect has also been reported by Phisut *et al*. (2012) in cantaloupe and Macro *et al*. (2005) [18] in apricot. The drying treatments caused a decrease in non-reducing sugar content. This may be due to the susceptibility of sucrose, being the most strongly affected non-reducing sugar, to hydrolysis by the effect of high drying temperatures. The result is in accordance with the work of Carranza-Concha *et al*. (2012) [5] in grapes.

Table 3: Effect of different pre-treatments on total sugars (%), reducing sugars (%) and non-reducing sugars (%) in dried figs

Treatments	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)
T_1	44.25^d	43.47^d	0.79
T_2	52.40^b	51.36^b	1.05
T_3	54.97^a	53.57^a	1.40
T_4	55.03^a	53.32^a	1.72
T_5	51.11^c	49.57^c	1.53
Mean	51.15	50.26	1.30
S.Em±	0.20	0.28	0.25
C.D (5%)	0.60	0.85	NS

Note: Values with the same superscripts with respect to pre-treatments are not significantly different by Duncan Multiple Range Test at P = 0.05

Sensory evaluation

The data pertaining to the orgnoleptic evaluation of dried figs as influenced by different pre-treatments are given in Table 4. Minimum score for colour and appearance was recorded in T_5 (SO_2 fumigation at a rate of 1g Sulphur/kg for 30 min + 4% K_2CO_3 + 2% Ethyl Oleate for 5 min + steeping in 40°B sugar solution containing 0.5% citric acid for 12 hours) (5.79) followed by T_1 (Blanching for 4 minutes) (5.90). SO_2 has strong antioxidant activity and can protect the product from oxidation and browning. However, the concentration of suphur used for fumigation in T_5 (1000 ppm) might not be adequate to bring desirable change in colour. According to Salur-Can *et al*. (2017) [31], SO_2 concentration lower than 1594 mg/kg led to an unacceptable colour in apricot. The maximum score (7.60) for colour and appearance was recorded in T_3 (Blanching for 4 minutes + 0.2% KMS for 5 min + steeping in 40°B sugar solution containing 0.5% citric acid for 24 hours) followed by T_4. However, both T_3 and T_4 were statistically on par with the market sample (7.32) for this parameter. This is corroborated by the maximum instrumental L^* value (T_3 - 36.57; T_4 - 33.11) observed for these treatments. Sensory score for texture was maximum for T_2 (6.79) and it was on par with T_3 (6.21) and T_4 (6.47). The variation observed in different treatments may be credited to the difference in damage done to the original anatomy of fruits during processing (O'Connor *et al*., 2001) which may have its bearing on texture.

Table 4: Effect of different pre-treatments on organoleptic parameters (colour and appearance, texture, taste, flavour and overall acceptability) of dried figs

Treatments	Colour and appearance	Texture	Taste	Flavour	Overall acceptability
T_1	5.90^c	4.71^d	5.02^b	5.35^b	4.99^c
T_2	6.50^{bc}	6.79^b	6.35^a	6.25^{ab}	6.56^b
T_3	7.60^a	6.21^{bc}	6.32^a	6.68^a	6.72^b
T_4	7.18^{ab}	6.47^b	6.98^a	7.25^a	6.84^b
T_5	5.79^c	5.32^{cd}	5.15^b	5.30^b	5.49^c
M	7.32^a	8.15^a	7.32^a	6.90^a	7.74^a
Mean	6.72	6.28	6.19	6.29	6.39
S.Em±	0.33	0.33	0.41	0.40	0.32
C.D (5%)	0.94	0.92	1.16	1.12	0.90

Note: Values with the same superscripts with respect to pre-treatments are not significantly different by Duncan Multiple Range Test at P = 0.05

T_1: Control (Blanching at 90-95oC for 4 minutes)
T_2: Blanching (4 minutes) + 0.2% KMS (5 min) + steeping in 40 oB sugar solution containing 0.5% citric acid for 12 hours
T_3: Blanching (4 minutes) + 0.2% KMS (5 min) + steeping in 40 oB sugar solution containing 0.5% citric acid for 24 hours

T_4: Steaming at 10 psi (5 minutes) + 0.2% KMS (5 min) + steeping in 40oB sugar solution containing 0.5% citric acid for 12 hours
T_5: SO2 fumigation (1g Sulfur /kg) for 30 min + (4% K2CO3 + 2% Ethyl Oleate) (5 min) + steeping in 40oB sugar solution containing 0.5% citric acid for 12 hours

On the other hand, market sample recorded maximum score for texture (8.15) than any of the treatments under the study. Market sample, which is imported, was found to have thin skin and more seeds in comparison to cv. Bellary considered in this investigation indicate differences in varieties with respect to anatomy and cellular structure.
Taste and flavour score was maximum for T_4 (6.98 and 7.25, respectively). This may be because of the absorption of more sugar in these samples due to steam treatment (Rastogi and Niranjan, 1998) [30]. In total, significantly maximum score for overall acceptability was recorded in T_4 (6.84) and T_3 (6.72). Similarly, higher oraganoleptic scores in fruits steeped in sugar syrup and citric acid were observed by Lakkond (2002) and Kotimani (2003) [16, 15] in sapota; Chandan (2004) [6] in Aonla and Kaggodi (2005) [13] and Patil (2007) [24] in fig.

Conclusion
Fig fruits (cv. Bellary) were subjected to five different pre-treatments and dried under electric tray dryer in order to standardize a dehydration protocol and to study its physico-chemical and organoleptic quality after dehydration. Among different pre-treatments tried, dried figs of moderately acceptable quality could be produced by either blanching the fruits for 4 minutes followed by dipping in 0.2% KMS solution for 5 min and steeping in 40ºB sugar solution containing 0.5% citric acid for 24 hours or by the application of steam (10 *psi*) for 5 minutes and then dipping in 0.2% KMS solution for 5 min followed by steeping in 40ºB sugar solution containing 0.5% citric acid for 12 hours.

References

1. Abhay KM. Standardization of protocol for preparation of dried fig (*Ficus carica* L.) fruits. M.Sc. (Hort) Thesis, Univ. Agric. Sci. Dharwad, 2004.
2. Abrol GS, Vaidya D, Sharma A, Sharma S. Effect of solar drying on physico-chemical and antioxidant properties of mango, banana and papaya. National Academy Science Letter. 2014; 37(1):51-57.
3. Anonymous. Agricultral Department of Maharashtra, 2008.
4. Brambilla A, Maffi D, Rizzolo A. Study of the influence of berry-blanching on syneresis in blueberry purees. Procedia Food Science. 2011; 1:1502-1508.
5. Carranza-Concha J, Benlloch M, Camacho MM, Martínez-Navarrete N. Effects of drying and pre-treatment on the nutritional and functional quality of raisins. Food Bio. Prod. Proc. 2012; 90:243-248.
6. Chandan K. Standardization of protocol for preparation of dehydrated slices and RTS beverage from aonla fruits. M.Sc. (Hort) Thesis, Univ. Agric. Sci. Dharward, 2004.
7. El-Aouar AA, Azoubel PM, Barbosa JL, Murr FE. Influence of the osmotic agent on the osmotic dehydration of papaya (*Carica papaya* L.). Journal of Food Engineering. 2006; 75:267-274.
8. Fava J, Alzamora SM, Castro MA. Structure and nanostructure of the outer tangential epidermal cell wall in *Vaccinium corymbosum* L. (blueberry) fruit by blanching, freezing–thawing and ultrasound. Food Sci. Technol. International 2006; 12:241–251.
9. FSSAI. Meeting on harmonization laboratory parametersfor analysis of imported food sample, parameters and limits, New Delhi, 2012.
10. Giovanelli G, Brambilla A, Rizzolo A, Sinelli N. Effects of blanching pre-treatment and sugar composition of the osmotic solution on physico-chemical, morphological and antioxidant characteristics of osmodehydrated blueberries (*Vaccinium corymbosum* L.). Food Research International. 2012; 49:263–271.
11. Indudhara SM. Standardization of drying techniques in fig (*Ficus carica* L.) fruits. *M.Sc. (Hort) Thesis*, Univ. Agric. Sci., Dharwad, 2003.
12. Joseph B, Raj SJ. Pharmacognostic and phytochemical properties of *Ficus carica* Linn —an overview. Int. J. PharmTech Res. 2011; 3(1):8–12.
13. Kaggodi R. Standardization of pre-treatments and methods of drying for fig fruits, *MSc. Thesis,* Uni. Hortic. Sci. Bagalkot (India), 2005.
14. Khan AA, Vincent JFV. Anisotropy of apple parenchyma. J. Sci. Food Agric. 1990; 52:455-466.
15. Kotimani S. Standardisation of processing technology for sapota (*Manikara achras* (Mill.) Fesberg.). M.Sc. (Hort.) Thesis, Univ. Agric. Sci., Dharwad, 2003.
16. Lakkond BR. Studies on processing of sapota (*Manilkara achras* (Mill.) Fosberg.) fruits. M.Sc. (Hort.) Thesis, Univ. Agric. Sci., Dharwad, 2002.
17. Lombard GE, Oliveira JC, Fito P, Andre´s B. Osmotic dehydration of pineapple as a pre-treatment for further drying. J. Food Eng. 2008; 85:277-284.
18. Macro R, Compolongo S, Leva AA, Maestrelli A, Torreggiani D. Structure property relationships in osmo-air dehydrated apricot cubes. Int. Food Res. J. 2005; 3(8):533-542.
19. Mavroudis NE, Gekas V, Sjoholm I. Osmotic dehydration of apples-effects of agitation and raw material characteristics. J. Food Eng. 1998; 35:191-209.
20. Miller GL. Use of di-nitro-salicylic acid reagent for determination of reducing sugar. J Annual Chem. 1972; 31:426-428.
21. Naikwadi PM, Chavan UD, Pawar VD, Amarowicz R. Studies on dehydration of figs using different sugar syrup treatments. J. Food Sci. Technol. 2010; 47(4):442–445.
22. Nihar RS, Lalit MB, Pal US, Dipika S. Impact of pre-treatment and drying methods on quality attributes of onion shreds. Food Technol. Biotechnol. 2015; 53(1):57–65.
23. O'Connor CJ, Fisk KJ, Smith BG, Melton LD. Fat uptake in French fries as affected by different potato varieties and processing. J. Food Sci. 2001; 66(6):903-908.
24. Patil RC. Studies on dehydration of fig fruits. *M.Sc. (Hort) Thesis*, Univ. Agric. Sci., Dharwad, 2007.
25. Pawar SG, Kulkarni DM, Kulkarni KD, Patil VK. Effect of pre-treatments on chemical composition and drying rates of solar dried figs. Ind. Food Packer. 1992; 46(1):39-44.
26. Phisut N. Factors affecting mass transfer during osmotic dehydration of fruits. International J Food Res. 2012; 19(1):7-18.
27. Piper CS. Soil and Plant Analysis. Han's Publication, Bombay, 1966.
28. Ramallo LA, Mascheroni RH. Quality evaluation of pineapple fruit during drying process. Food Bioprod. Process. 2012; 90:275-583.

29. Raoult-Wack AL. Recent advances in the osmotic dehydration foods. Trends Food Sci. Technol. 1994; 5:255-260.
30. Rastogi NK, Niranjan K. Enhanced mass transfer during osmotic dehydration of high pressure treated pineapple. J. Food Sci. 1998; 63(3):508–511.
31. Salur-Can A, Turkyılmaz M, Ozkan M. Effects of sulfur dioxide concentration on organic acids and b-carotene in dried apricots during storage. Food Chem. 2017; 221:412–421.
32. Sankat CK, Castaigne FF. Foaming and drying behaviour of ripe bananas. Lebenson Wiss Technol. 2004; 37:517-525.
33. Slavin JL. Figs: past, present and future. Nutr. Today. 2006; 41:180-184.
34. Solomon A, Golubowicz S, Yablowicz Z, Grossman S, Bergman M, Gottlieb HE, *et al.* Antioxidant activities and anthocyanin content of fresh fruits of common fig (*Ficus carica* L.). J. Agric. Food Chem. 2006; 54:7717-7723.
35. Swaminathan M. Essentials of Food and Nutrition. Ganesh and Co. Madras, 1974, 498.
36. Vinson JA. The functional food properties of fig. *Cereal* Food World. 1999; 44:82–87.
37. Yadav AK, Singh VR. Osmotic dehydration of fruits and vegetables: a review. J. Food Sci. Technol. 2012; 51(9):1654-1673.