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Effect of pre-treatment with coconut sugar and different drying methods on quality of dried fig (*Ficus carica* L.) Cv. Brown Turkey

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Abstract
The present research entitled "Effect of pre-treatment with coconut sugar and different drying methods on quality of dried fig (*Ficus carica* L.) Cv. Brown Turkey" was carried out during 2020-21 at Post Harvest Technology Laboratory, College of Horticulture, Rajendranagar, Hyderabad, Telangana. The main objective of the investigation was dehydration of figs and estimation of quality characteristics and storage stability of dried fruit. The experiment was carried out in factorial randomized block design with 3 replications and twelve treatment combinations. The different levels of drying methods (4 levels) are D_1- Sun drying, D_2-Solar drying, D_3-Hot air oven drying and D_4-Tray drying and Pre-treatment with coconut sugar (3 levels) C_1-Coconut sugar 30 °brix, C_2-Coconut sugar 40° brix, C_3-Coconut sugar 50° brix were tried, the results were recorded and summarized. Quality parameters like highest TSS (55.15OBrix, 55.16 ^{0}Brix, 51.58 ^{0}Brix, 51.83 ^{0}Brix and 51.84 ^{0}Brix), reducing sugars (38.21%, 37.93%, 37.94%, 38.10% and 38.12%) and total sugars (42.46%, 42.47%, 42.48%, 42.49% and 42.50%) were recorded in drying level D_4 (Tray drying) whereas maximum titratable acidity (0.080%, 0.081%, 0.082%, 0.083% and 0.084%) observed in D1 (Sun drying) at after drying, 15, 30, 45 and 60 DAS. Highest TSS (47.59 ^{O}Brix, 47.60 ^{0}Brix, 46.35 ^{0}Brix, 47.59 ^{0}Brix and 46.61 ^{0}Brix) and total sugars (36.64%, 36.66%, 36.67%, 36.68% and 36.68%) were recorded in coconut sugar level C_3 (Coconut sugar 50° brix), whereas maximum reducing sugars (32.45%, 31.03%, 31.05%, 31.24% and 31.26%) was noticed in C_2 (Coconut sugar 40° brix) and higher titratable acidity (0.064%, 0.066%, 0.067%, 0.068% and 0.069%) was reported in C_1 (Coconut sugar 30° brix) at after drying, 15, 30, 45 and 60 DAS. The treatment combination TSS (56.58 ^{0}Brix, 56.59 ^{0}Brix, 56.78 ^{0}Brix and 57.03 ^{0}Brix), reducing sugars (38.27%, 38.29%, 38.31% and 38.44%) and total sugars (43.56%, 43.57%, 43.52% and 43.53%) was found to be significant in treatment combination D_4C_3 (Tray drying, Coconut sugar 50° brix) at after drying, 15 DAS, 30 DAS and 45 DAS and titratable acidity (0.084% and 0.086%) was found to be significant in treatment combination D_1C_2 (Tray drying, Coconut sugar 50° brix) at 15 DAS and 45 DAS.

Keywords: Fig, coconut sugar, days of storage (DAS), sun drying, firmness, TSS, ascorbic acid, titrable acidity, total sugars, reducing sugars

Introduction
Fig (*Ficus carica* L.) is one of the ancient fruits known to mankind and regarded as “Poor man’s food.” It is reported to be under cultivation from 3000-2000 BC in the eastern Mediterranean region. In the Mediterranean region, the fig is widely used as both fresh and dried forms. Figs have a variety of potential health benefits in improving digestion, reducing constipation and maintaining blood fat and blood sugar levels. Figs are wholesome, nutritious and delicious fruits. Fresh fruits have 85% pulp and 15% skin. Fruits have high calorific value (74 kcal/100 g) and are rich in protein, calcium, iron and fibre. Edible portion of dried fig contains proteins (4 g), carbohydrate (69 g), fat (1 g), calcium (200 mg), iron (4 mg), vitamin A (100 g) and thiamine (0.1 mg). Total sugar content of fresh fruit is 16% while dried one is 52%. Fig is one of the highest plant sources of calcium and fibre (Joseph and Raj, 2011) [3]. 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) [7]. 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. As per 2020-21 APEDA statistics Turkey is the leading grower of fig occupying 27.06% share and with 306.50 MT of fig production in the world followed by Egypt, Morocco, and Algeria, Iran, Spain as the largest producers collectively accounting for 64% of the total production while

India ranks 13th position with percentage share of 1.30%.

Material and Methods

The present research entitled " Effect of different drying methods on fig drying using coconut sugar as pre-treatment (*Ficus carica* L.) Cv. Brown Turkey" was carried out during 2020-21 at Post Harvest Technology Laboratory, College of Horticulture, Rajendranagar, Hyderabad, Telangana. Rajendranagar falls under arid sub-tropical climatic zone with an average rainfall of 800 mm at an altitude of 542.3 m above mean sea level on 17.900 N latitude and 78.230 E longitude. It experiences hot dry summers and mild winters. The experiment was carried out in factorial randomized block design with 3 replications and twelve treatment combinations. The different levels of drying methods (4 levels) are D_1- Sun drying, D_2-Solar drying, D_3-Hot air oven drying and D_4-Tray drying and Pre-treatment with coconut sugar (3 levels) C_1-Coconut sugar 30 °brix, C_2-Coconut sugar 40° brix, C_3-Coconut sugar 50° brix were tried, the results were recorded and summarized.

Brown turkey variety of fig was bell shaped, medium size, light purple, with rosy flesh was procured from Sangareddy farmers field in order to compare the quality of different drying methods. Fully matured and uniformly ripen figs were procured. Before drying of figs, pre-treatment of the fruits was done with 30º brix, 40º brix and 50º brix coconut sugar. In the present study figs were dried by different drying methods *viz*., Sun drying, Solar drying, Hot air oven drying and Tray drying method. The time taken for drying of figs under different treatments was noted down and the end point of dried fig while drying was recommended with 20% moisture.

Results and Discussion

1. Total Soluble Solids (ºBrix)

The data pertaining to TSS of figs influenced by different sugar concentrations and different drying methods were presented in Table 1. The highest total soluble solids (55.15, 55.16, 51.58, 51.83, 51.84 ºBrix) were noticed in drying method D_4 (Tray drying) and lowest total soluble solids (34.37, 34.38, 38.77, 39.02, 39.03ºBrix) was recorded in drying method D_1 (Sun drying) at 0, 15, 30, 45, 60 DAS. Among different sugar concentrations he maximum total soluble solids (47.59, 47.60, 46.35, 46.60, 46.61ºBrix) were recorded in sugar concentration C_3 (50 °brix Coconut sugar solution) at 0, 15, 30, 45, 60 DAS. which was followed by C_2 (40 °brix Coconut sugar solution) (45.72 ºBrix). The interaction effect of different sugar concentrations and different drying methods was found significant for total soluble solids. The maximum total soluble solids (56.58, 56.59, 56.78, 57.03 ºBrix) were recorded in treatment combination D_4C_3 (Tray drying, 50° brix Coconut sugar solution) at 0, 15, 30, 45 DAS and the minimum total soluble solids (32.54, 32.55, 32.89, 33.14 ºBrix) was recorded in D_1C_1 (Sun drying, 30° brix Coconut sugar solution) at 0, 15, 30, 45 DAS. The interaction effect different drying methods and different sugar concentrations was found to be non-significant for total soluble solids at 60 DAS. Similar results were also reported by Abrol *et al*. (2019) [1], Naikwadi *et al*. (2010) [5] and Abul-Fadl *et al*. (2015) [2] in dried fig.

2. Reducing sugars (%)

The data pertaining to reducing sugars of figs influenced by different sugar concentrations and different drying methods were presented in Table 2. The highest reducing sugars (38.21, 37.93, 37.94, 38.10, 38.12%) was noticed in drying method D_4 (Tray drying) AT 0, 15, 30, 45, 60 DAS and the lowest reducing sugars (22.26, 21.80, 21.82,21.98, 22.00%) was recorded in drying method D_1 (Sun drying). At 0, 15, 30, 45, 60 DAS. Among different sugar concentrations the maximum reducing sugars (32.45%) was recorded in sugar concentration C_3 (50 °brix Coconut sugar solution) at 0 DAS while it was maximum in C_2 (40 °brix Coconut sugar solution) (31.01, 31.05, 31.24, 31.26%) at 15, 30, 45, 60 DAS. The minimum reducing sugars (28.44, 28.46, 28.47, 28.65, 28.67%) was recorded in sugar concentration C_1 (30 °brix Coconut sugar solution) AT 0, 15, 30, 45, 60 DAS. The interaction effect of different sugar concentrations and different drying methods was found significant for reducing sugars. The maximum reducing sugars (38.27, 38.29, 38.31, 38.42%) was recorded in treatment combination D_4C_3 (Tray drying, 50 °brix Coconut sugar solution) at 0, 15, 30, 45 DAS. The minimum reducing sugars (20.86, 20.88, 20.89, 21.07%) was recorded in D_1C_1 (Sun drying, 30 °brix Coconut sugar solution) at 0, 15, 30, 45 DAS while it was found to be non-significant for reducing sugars at 60 DAS. Similar results were also reported by Abrol *et al*. (2019) [1], Vaghani and Chundawat (1986) [9], and Mali (1997) [4] in dried fig.

3. Non-reducing sugars (%)

The data pertaining to non-reducing sugars of figs influenced by different sugar concentrations and different drying methods were presented in Table 3. The highest non-reducing sugars (6.39, 6.40, 6.41, 6.45, 6.46%) was noticed in drying method D_3 (Hot air oven drying) and the lowest non-reducing sugars (3.91, 3.92, 3.93, 3.97, 3.98%) was recorded in drying method D_1 (Sun drying) at 15, 30, 45, 60 DAS. Among different sugar concentrations the maximum non-reducing sugars (5.61, 5.63, 5.64, 5.73, 5.74%) was recorded in sugar concentration C_2 (40 °brix Coconut sugar solution) and the minimum non-reducing sugars (4.81, 4.82, 4.83, 4.84, 4.85%) was recorded in sugar concentration C_1 (30 °brix Coconut sugar solution) at 15, 30, 45, 60 DAS. The interaction effect of different sugar concentrations and different drying methods was found significant for non-reducing sugars. The maximum non-reducing sugars (7.00, 7.01, 7.02, 7.03%) was recorded in treatment combination D_4C_3 (Tray drying, 50 °brix Coconut sugar solution) The minimum non-reducing sugars (2.49,2.50, 2.52, 2.53%) was recorded in D_1C_1 (Sun drying, 30° brix Coconut sugar solution) after drying at 15, 30, 45, DAS while it was found to be non-significant for non-reducing sugars at 60 DAS. Similar results were also reported by Abrol *et al*. (2019) [1], Vaghani and Chundawat (1986) [9], and Mali (1997) [4] in dried fig.

4. Total sugars (%)

The data pertaining to total sugars of figs influenced by different sugar concentrations and different drying methods were presented in Table 4. The highest total sugars (42.46, 42.47, 42.48, 42.49, 42.50%) were noticed in drying method D_4 (Tray drying) and the lowest total sugars (26.46, 26.47, 26.50, 26.52, 26.52%) was recorded in drying method D_1 (Sun drying) at 0, 15, 30, 45, 60 DAS. Among different sugar concentrations the maximum total sugars (36.64, 36.66, 36.67, 36.68, 36.68%) were recorded in sugar concentration C_3 (50 °brix Coconut sugar solution) and the minimum total

sugars (32.63, 32.64, 32.67, 32.68, 32.69%) was recorded in sugar concentration C_1 (30 °brix Coconut sugar solution) at 0, 15, 30, 45, 60 DAS. The interaction effect of different sugar concentrations and different drying methods was found significant for total sugars. The maximum total sugars (43.56, 43.57, 43.52, 43.53%) were recorded in treatment combination D_4C_3 (Tray drying, 50° brix Coconut sugar solution) and the minimum total sugars (25.05, 25.06, 25.09, 25.10%) was recorded in D_1C_1 (Sun drying, 30° brix Coconut sugar solution) at 0, 15, 30, 45, DAS while it was found to be non-significant for total sugars at 60 DAS. Similar results were also reported by Abrol *et al*. (2019) [1], Naikwadi *et al*. (2010) [5] and Abul-Fadl *et al*. (2015) [2] in dried fig.

5. Titratable acidity (%)

The data pertaining to titratable acidity of figs influenced by different sugar concentrations and different drying methods were presented in Table 5. There was a significant difference observed among the treatments for titratable acidity after drying. The highest titratable acidity (0.080, 0.082, 0.083, 0.084, 0.085%) was noticed in drying method D_1 (Sun drying) which was followed by D_2 (Tray drying) (0.067%). The lowest titratable acidity (0.036, 0.038, 0.039, 0.040, 0.041%) was recorded in drying method D_4 (Tray drying). The effect of different sugar concentrations shows significant difference among the treatments. The maximum titratable acidity (0.064, 0.066, 0.067, 0.068, 0.069%) was recorded in sugar concentration C_1 (30 °brix Coconut sugar solution) which was followed by C_2 (40 °brix Coconut sugar solution) (0.060%). The minimum titratable acidity (0.052, 0.054, 0.055, 0.056, 0.057%) was recorded in sugar concentration C_3 (50 °brix Coconut sugar solution). The interaction effect of different sugar concentrations and different drying methods was found significant for titratable acidity. The maximum titratable acidity (0.084, 0.086%) was recorded in treatment combination D_1C_2 (Sun drying, 40 °brix Coconut sugar solution) which was on par with D_1C_1 (Sun drying, 30 °brix Coconut sugar solution). The minimum titratable acidity (0.082, 0.037%] was recorded in D_4C_3 (Tray drying, 50° brix Coconut sugar solution) 15 and 45 DAS. The interaction effect different drying methods and different sugar concentrations was found to be non-significant for titratable acidity at 0, 30, 60 DAS. Similar results were reported by Shobha *et al*. (2001) [6] and Unde *et al*. (2001) [8].

Table 1: Influence of dehydration methods and coconut sugar concentration on total soluble solids (°Brix) of dehydrated fig during storage

Treatment	After Drying				15 DAS				30 DAS				45 DAS				60 DAS			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
D_1	32.54	34.31	36.28	34.37	32.55	34.32	36.29	34.38	32.89	35.74	47.66	38.77	33.14	35.99	47.91	39.02	33.15	36.01	47.92	39.03
D_2	35.73	44.37	45.24	41.78	35.74	44.38	45.25	41.79	53.95	34.51	44.52	44.33	54.20	34.76	44.77	44.58	54.21	34.78	44.78	44.59
D_3	47.46	49.16	52.29	49.63	47.47	49.17	52.30	49.64	49.33	55.27	36.43	47.01	49.58	55.52	36.68	47.26	49.59	55.54	36.69	47.27
D_4	53.81	55.07	56.58	55.15	53.82	55.08	56.59	55.16	45.48	52.46	56.78	51.58	45.73	52.71	57.03	51.83	45.74	52.73	57.04	51.84
Mean	42.38	45.72	47.59		42.39	45.73	47.60		45.42	44.50	46.35		45.67	44.75	46.60		45.67	44.77	46.61	
	C	D	C x D		C	D	C x D		C	D	C x D		C	D	C x D		C	D	C x D	
S.E(m)	0.18	0.20	0.35		0.18	0.21	0.37		0.004	0.005	0.008		0.03	0.04	0.07		0.01	0.02	0.03	
C.D.	0.52	0.60	1.03		0.54	0.62	1.07		0.011	0.013	0.023		0.10	0.11	0.19		0.03	0.06	NS	

Table 2: Influence of dehydration methods and coconut sugar concentration on reducing sugars (%) of dehydrated fig during storage

Treatment	After Drying				15 DAS				30 DAS				45 DAS				60 DAS			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
D_1	20.86	22.22	22.27	22.26	20.88	22.24	22.29	21.80	20.89	22.26	22.31	21.82	21.07	22.45	22.42	21.98	21.09	22.47	22.44	22.00
D_2	23.31	29.97	27.97	27.97	23.33	29.99	27.99	27.11	23.35	30.01	28.01	27.12	23.53	30.20	28.12	27.28	23.55	30.22	28.14	27.30
D_3	32.35	33.66	34.02	34.02	32.37	33.68	34.04	33.36	32.38	33.70	34.06	33.38	32.56	33.89	34.17	33.54	32.58	33.91	34.19	33.56
D_4	37.24	38.21	38.27	38.21	37.26	38.23	38.29	37.93	37.27	38.25	38.31	37.94	37.45	38.44	38.42	38.10	37.47	38.46	38.44	38.12
Mean	28.44	31.01	32.45		28.46	31.03	30.66		28.47	31.05	30.67		28.65	31.24	30.78		28.67	31.26	30.80	
	C	D	C x D		C	D	C x D		C	D	C x D		C	D	C x D		C	D	C x D	
S.E(m)	0.47	0.54	0.93		0.01	0.01	0.02		0.01	0.01	0.02		0.01	0.01	0.03		0.01	0.01	0.02	
C.D.	1.37	1.58	2.73		0.03	0.03	0.06		0.03	0.04	0.07		0.03	0.03	0.09		0.04	0.03	NS	

Table 3: Influence of dehydration methods and coconut sugar concentration on non-reducing Sugars (%) of dehydrated fig during storage

Treatment	After Drying				15 DAS				30 DAS				45 DAS				60 DAS			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
D_1	2.49	3.85	5.37	3.91	2.50	3.87	5.38	3.92	2.52	3.88	5.39	3.93	2.53	3.97	5.40	3.97	2.54	3.98	5.41	3.98
D_2	4.95	4.53	5.20	4.89	4.96	4.55	5.21	4.91	4.97	4.56	5.22	4.92	4.98	4.65	5.23	4.95	4.99	4.66	5.24	4.96
D_3	6.91	8.22	4.03	6.39	6.92	8.24	4.04	6.40	6.93	8.25	4.05	6.41	6.94	8.34	4.06	6.45	6.95	8.35	4.07	6.46
D_4	4.87	5.84	7.00	5.90	4.88	5.86	7.01	5.92	4.89	5.87	7.02	5.93	4.90	5.96	7.03	5.97	4.91	5.97	7.04	5.98
Mean	4.81	5.61	5.40		4.82	5.63	5.41		4.83	5.64	5.42		4.84	5.73	5.43		4.85	5.74	5.44	
	C	D	C x D		C	D	C x D		C	D	C x D		C	D	C x D		C	D	C x D	
S.E (m)	0.23	0.27	0.46		0.01	0.01	0.03		0.01	0.01	0.02		0.01	0.01	0.03		0.01	0.01	0.02	
C.D.	0.62	0.78	1.35		0.04	0.05	0.09		0.03	0.04	0.08		0.03	0.03	0.09		0.04	0.03	NS	

Table 4: Influence of dehydration methods and coconut sugar concentration on total sugars (%) of dehydrated fig during storage

Treatment	After Drying				15 DAS				30 DAS				45 DAS				60 DAS			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
D_1	25.05	26.41	27.93	26.46	25.06	26.42	27.94	26.47	25.09	26.45	27.97	26.50	25.10	26.47	27.98	26.52	25.11	26.48	27.98	26.52
D_2	27.50	34.16	34.83	32.16	27.51	34.17	34.84	32.17	27.53	34.18	34.88	32.20	27.54	34.20	34.89	32.21	27.55	34.21	34.90	32.22
D_3	36.54	37.85	40.26	38.21	36.55	37.86	40.27	38.23	36.58	37.91	40.29	38.26	36.59	37.93	40.30	38.27	36.60	37.94	40.31	38.28
D_4	41.43	42.40	43.56	42.46	41.44	42.41	43.57	42.47	41.46	42.45	43.52	42.48	41.47	42.47	43.53	42.49	41.48	42.48	43.54	42.50
Mean	32.63	35.20	36.64		32.64	35.22	36.66		32.67	35.25	36.67		32.68	35.26	36.68		32.69	35.27	36.68	
	C	D	C x D		C	D	C x D		C	D	C x D		C	D	C x D		C	D	C x D	
S.E (m)	0.31	0.36	0.63		0.01	0.01	0.03		0.01	0.02	0.04		0.01	0.01	0.03		0.01	0.01	0.02	
C.D.	0.92	1.06	1.84		0.03	0.04	0.08		0.04	0.06	0.12		0.03	0.03	0.09		0.04	0.03	NS	

Table 5: Influence of dehydration methods and coconut sugar concentration on titratable acidity (%) of dehydrated fig during storage

Treatment	After Drying				15 DAS				30 DAS				45 DAS				60 DAS			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
D_1	0.081	0.082	0.076	0.080	0.082	0.084	0.078	0.081	0.083	0.085	0.079	0.082	0.084	0.086	0.080	0.083	0.085	0.087	0.081	0.084
D_2	0.080	0.062	0.060	0.067	0.081	0.064	0.062	0.069	0.082	0.065	0.063	0.070	0.083	0.066	0.064	0.071	0.084	0.067	0.065	0.072
D_3	0.058	0.059	0.040	0.052	0.059	0.061	0.042	0.054	0.060	0.062	0.043	0.055	0.061	0.063	0.044	0.056	0.062	0.064	0.045	0.057
D_4	0.039	0.037	0.033	0.036	0.040	0.039	0.035	0.038	0.041	0.040	0.036	0.039	0.042	0.041	0.037	0.040	0.043	0.042	0.038	0.041
Mean	0.064	0.060	0.052		0.066	0.062	0.054		0.067	0.063	0.055		0.068	0.064	0.056		0.069	0.065	0.057	
	C	D	C x D		C	D	C x D		C	D	C x D		C	D	C x D		C	D	C x D	
S.E(m)	0.001	0.001	0.002		0.001	0.001	0.003		0.001	0.001	0.002		0.010	0.010	0.030		0.001	0.001	0.002	
C.D.	0.003	0.003	NS		0.003	0.003	0.008		0.003	0.003	NS		0.030	0.030	0.090		0.003	0.003	NS	

DAS: Days after Storage

D_1 - Sun drying
D_2 - Solar Drying
D_3 - Hot air oven drying
D_4 - Tray drying

C_1 - 30° brix Coconut sugar solution
C_2 - 40° brix Coconut sugar solution
C_3 - 50° brix Coconut sugar solution

Conclusion

On the basis of results observed from this experiment it was concluded that the treatment combination TSS (56.58 ^{0}Brix, 56.59 ^{0}Brix, 56.78 ^{0}Brix and 57.03 ^{0}Brix), reducing sugars (38.27%, 38.29%, 38.31% and 38.44%) and total sugars (43.56%, 43.57%, 43.52% and 43.53%) was found to be significant in treatment combination D4C3 (Tray drying, Coconut sugar 50° brix) at after drying, 15 DAS, 30 DAS and 45 DAS and titratable acidity (0.084% and 0.086%) was found to be significant in treatment combination D1C2 (Tray drying, Coconut sugar 50° brix) at 15 DAS and 45 DAS.

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