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Study of physico-chemical parameters and shelf life of fresh fruits of fig (*Ficus carica* L.) cv. Deanna harvested at different maturity stages

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Abstract
The effect of different fruit maturity stages on quality attributes and shelf life of fresh fruit of fig cv. Deanna was studied at College of Horticulture, Anantharajupeta. Fig fruits harvested at full ripe stage had higher fruit weight, fruit length, fruit diameter, fruit volume, moisture content, TSS, total sugars, reducing sugars and non-reducing sugars whereas, lower firmness, specific gravity, titrable acidity, ascorbic acid and crude fibre content were recorded in figs harvested at commercial ripe stage. Fruits harvested at commercial ripe stage also had maximum shelf life than full ripe stage. Therefore, it is important to optimize harvesting stages of fruit which ultimately affects the shelf life and quality of fresh fruits as well as processed products prepared from them.

Keywords: Fig, commercial ripe stage, shelf life, firmness, specific gravity

Introduction
The common fig (*Ficus carica* L.) is indigenous to South West Asia and the Eastern Mediterranean region. It is believed to be one of the oldest fruit trees cultivated in the world and is a member of the family Moraceae (Solomon *et al*., 2006) [21]. In India, total area under fig farming is around 5600 hectares of land with a production of about 13,802 thousand tonnes (Anon., 2019) [2]. Fig is one of the highest plant sources of calcium and fiber (Joseph and Raj, 2011) [12]. Figs have a nutritional value of 11 as compared to 9 of apple, 8 of raisin and 6 of dates and pears. Fig is delicious, nutritive fruit and has medicinal properties such as lowering risk of cancer and heart disease (Vinson, 1999) [23].
Harvest maturity is the most critical element in determining storage life and final fruit quality. Every fruit retain its full characteristics flavour, taste and colour during storage if it is picked at optimum time (Kader, 1997) [13]. Fruits that are picked at optimum maturity stage reduced the postharvest losses and extended the shelf life of fruits. The pre-harvest loss of fruits starts at the point when it just passed the optimum maturity stage. Decreasing trend of shelf-life and firmness of fruits were observed with the advancement of maturity. On the other hand, dry matter content and yield of fruits increased with the advancement of harvesting days (Crisosto *et al*., 2010) [4].
Maturity stages of fruit affects physico-chemical parameters of fruit which ultimately affects the quality of processed products prepared from them. Hence, an experiment was undertaken to study the effect of different stages of maturity on physico-chemical parameters of fresh fruits of fig cv. Deanna.

Material and Methods
The experiment was laid out in a Completely Randomized Design with three treatments *i.e.* Commercial ripe stage (M_1), Tree ripe stage (M_2) and Full ripe stage (M_3) each having six replications. For each treatments ten fruits of uniform size, colour, and shape, and without any blemishes and damage were selected and used for the experimental purpose.This investigation was carried out in the Department of Fruit Science Laboratory and Postharvest Technology Laboratory, College of Horticulture, Anantharajupeta, Annamayya district, Andhra Pradesh during the year 2021-22. Fruits harvested at commercial ripe stage are firm and mature, light yellow in colour. Fruits were harvested seven days before the tree ripening stage when the fruit flesh gave slightly softer when touched. Treatment M_2 (tree ripe stage) fruits are golden yellow in colour and are more ripen and softer than commercial ripe stage.

The fruits were harvested three days before full ripe stage. Treatment M_3 (full ripe stage) fruits are fully ripe, deep yellow in colour and sometimes drop of nectar will be noticed too but not an overripe.

Skin and pulp colour of fruits were recorded through visual observations. Fruit length and diameter was measured with the help of vernier calipers and expressed in centimeter. The volume of fruit was measured as the volume of water displaced in a measuring cylinder by immersing randomly selected fruits and the average was expressed as milliliter (ml). Specific gravity of fruits was computed by dividing the fresh weight of the fruit by volume of fruit and expressed in (g/ml). The firmness of the fruit was tested by a pocket penetrometer (FR-5120 Digital Fruit Firmness Tester). Shelf life of the fruit was determined by observing and judging the quality parameters as well as rotting, shriveling, incidence of diseases, etc. with respect to storage days (Rahman *et. al.*, 2016) [17].

The moisture content of fruit was estimated using Radwag moisture analyzer (Model: MAC 50, Make Poland). TSS of fig was determined by using digital hand refractometer and expressed in °Brix. The total sugar content of the fig fruit was estimated by anthrone reagent method. Reducing sugar in the sample was estimated by di-nitrosalicylic acid method (Miller, 1959) [15]. Method described by Ranganna (1977) [19] was adopted for estimation of titratable acidity. Ascorbic acid content of the fig fruit was determined by 2-6-dichlorophenol indophenol titration method (Ranganna, 1977) [19]. Crude fibre content of fig fruits was estimated as method described in AOAC, (2000) [3]. Statistical analysis was performed using Web Agri Stat Package (WASP) Version 2 (Jangam and Thali, 2010) [11].

Results and Discussion

The data presented in Table. 1 indicated that all the maturity stages of fig fruit had significant influence on physical parameters of fig fruit.

The colour of fig fruit skin changed from light yellow (commercial ripe stage) to golden yellow and pulp colour changed from white (commercial ripe stage) to creamy yellow (full ripe stage) during ripening. Similar results were reported by Crisosto *et al.* (2010) [4]. They reported that green–yellow skin color cultivars (Calimyrna and Kodata fig) became more yellow at higher maturity stage (tree ripe). External skin and pulp colour varies with cultivars and ripening stages.

Significant gradual increase in fruit weight was observed with advancement of maturity stages. Maximum fruit weight (58.65 g), fruit length (7.18 cm), fruit diameter (6.08 cm) and fruit volume (57.67 ml) was observed in full ripe stage (M_3) and minimum fruit weight (40.68 g), fruit length (5.68 cm), fruit diameter (4.95 cm) and fruit volume (37.75 ml) was recorded in commercial ripe stage (M_1). Dogan *et al.* (2018) [6] and Crisosto *et al.* (2010) [4] reported that weight of fruit increases with the advancement of maturity. The size increase may be due to enhanced cell division and/or cell expansion.

Specific gravity, firmness and shelf life of fresh fig fruits decreased with advancement of maturity stages. Commercial ripe stage (M_1) recorded significantly maximum specific gravity (1.07 g/ml), firmness (0.44 kg/cm^2) and shelf life (5.5 days), whereas, minimum specific gravity (1.00 g/ml), firmness (0.16 kg/cm^2) and shelf life (2.5 days) was observed in full ripe stage (M_3). Kaushik *et al.* (2000) [14] reported declining trend of specific gravity throughout the development of the fruit. Ali *et al.* (2011) [1] opined that decreasing fruit firmness might be associated with fruit softening. Moreover, the breakdown of the cell wall caused by the transformation of insoluble pectin into soluble forms contributes to the loss of firmness (Verlent *et al*., 2005) [22]. The decrease in shelf life may have reflected degradation and solubilization of cell wall polyuronides and hemicelluloses associated with fruit softening (Huber, 1984) [9]. Rahman *et al*. (2016) [17] reported similar results in strawberry fruit.

It is observed from Table. 2 that, all the chemical parameters studied showed significant differences with respect to ripening stages of fruit. The moisture content of fresh fig varied from 73.89% (M_1) to 86.56% (M_3). Garande and Joshi (1995) [7] stated that the increase in moisture content might be due to rapid physiological activities taking place in the fruit during cell division and cell enlargement which ultimately lead to an increase in fruit size and absorption of water in jamun (*Syzygium cumini* Skeels) fruits. Significantly highest TSS (21.40 ^{0}Brix) total sugars (20.82 %) reducing sugars (19.04 %) and non-reducing sugars (1.78 %) were recorded in full ripe stage (M_3). The lowest total, reducing and non-reducing sugars were recorded in commercial ripe stage (M_1) (15.59 %, 14.51 % and 1.08 % respectively). Rajput *et al.* (1999) reported that the increase in total soluble solids might be due to quick metabolic transformations in soluble compounds, mainly sugars. Identical results were reported by Crisosto *et al.* (2010) [4] and Dogan *et al.* (2018) [6] in fresh figs. The sugars (total, reducing and non-reducing) content of fig fruit was directly proportional to total soluble solids. Thus, there is an increase in sugars content observed as the fruits ripened. Garande and Joshi (1995) [7] reported that an increase in sugar content might be due to conversion of starch into sugars.

Titrable acidity, ascorbic acid and crude fibre of fresh fig fruit decreased with advancement of maturity stages. The maximum per cent of titrable acidity (0.240 %), ascorbic acid (5.78 %) and crude fibre (2.36 %) was recorded in M_1 (commercial ripe stage) and minimum titratable acidity, ascorbic acid and crude fibre recorded in M_3 (commercial ripe stage) (0.138 %, 3.17 % and 1.93 % respectively). According to Moing *et al.* (2001) [16], titrable acidity reduced in ripe fruits. Acidity and pH of fruits were inversely connected. The high pH and low acid content of the ripe fruit matched each other. Dogan *et al.* (2018) [6] also reported similar result in 'Bursa Siyahi' figs. According to Hulme (1970) [10], ascorbic acid levels decreased as a result of the enzyme ascorbic acid oxidase's oxidative degradation of ascorbic acid during fruit ripening. Desai and Kotecha, (1995) [5] reported that crude fibre content decreased as the fig fruits matured.

Table 1: Effect of different stages of maturity on physical parameters and shelf life of fresh fruits of fig cv. Deanna

Sl. No	Treatments	Fruit skin colour	Fruit pulp colour	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (ml)	Specific gravity (g/ml)	Firmness (kg/cm^2)	Shelf life (days)
1.	Commercial ripe stage (M_1)	Light yellow	White	40.68	5.68	4.95	37.75	1.07	0.44	5.5
2.	Tree ripe stage (M_2)	Golden yellow	Creamy white	49.33	6.28	5.52	47.60	1.03	0.31	4.0
3.	Full ripe stage (M_3)	Dark yellow	Creamy yellow	58.65	7.18	6.08	57.67	1.00	0.16	2.5
	S.E.m±	-	-	0.61	0.11	0.11	0.59	0.01	0.02	0.13
	C.D (5%)	-	-	1.85	0.32	0.33	1.77	0.03	0.05	0.39

Table 2: Effect of different stages of maturity on chemical parameters of fresh fruits of fig cv. Deanna

Sl. No	Treatments	Moisture content (%)	Total soluble solids (^{0}Brix)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Titratable acidity (%)	Ascorbic acid (mg/100 g)	Crude fibre (%)
1.	Commercial ripe stage (M_1)	73.89	15.96	15.59	14.51	1.08	0.240	5.78	2.36
2.	Tree ripe stage (M_2)	78.96	19.08	18.09	16.72	1.37	0.171	4.22	2.18
3.	Full ripe stage (M_3)	86.56	21.40	20.82	19.04	1.78	0.138	3.17	1.93
	S.E.m±	0.62	0.17	0.36	0.37	0.05	0.010	0.15	0.02
	C.D (5%)	1.89	0.50	1.07	1.12	0.16	0.030	0.45	0.06

Conclusion

From the present study, it is concluded that, physical parameters *viz*. weight of fruit, length and diameter of fruit, volume of fruit and chemical parameters *viz*. moisture content, T.S.S, total sugars, reducing sugars and non-reducing sugars increase with advancement of maturity stages. Specific gravity, firmness, titrable acidity, ascorbic acid and crude fibre content of fig fruits decreased as the maturity stages advanced. Shelf life of fig fruit decreased from commercial ripe stage to full ripe stage. These could be considered as maturity indices to judge the ripening stages of fig fruit for fresh consumption as well as preparation of various value added products.

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