The Pharma Innovation Journal 2022; 11(12): 5063-5066

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 5063-5066

www.thepharmajournal.com
Received: 28-11-2022
Accepted: 30-12-2022

T Branham
Research Scholar, Department of Fruit Science, College of Horticulture, Mojerla, Sri Konda Laxman Telangana State Horticultural University, Mulugu (M&V), Siddipet, Telangana, India

Rajasekhar M
Professor and Dean of PG studies, (Fruit Science), College of Horticulture, Mojerla, Telangana, India

J Shankaraswamy
Assistant Professor, (Crop Physiology), College of Horticulture, Mojerla, Telangana, India

P Gouthami
Assistant Professor, (Crop Physiology), College of Horticulture, Mojerla, Telangana, India

G Sathish
Assistant Professor, (Agricultural Statistics), College of Horticulture, Mojerla, SKLTSHU, Mulugu (M&V), Siddipet, Telangana, India

Corresponding Author:
T Branham
Research Scholar, Department of Fruit Science, College of Horticulture, Mojerla, Sri Konda Laxman Telangana State Horticultural University, Mulugu (M&V), Siddipet, Telangana, India

Effect of edible coatings on physical properties of fresh fig (*Ficus carica* L.) cv. Deanna

T Branham, Rajasekhar M, J Shankaraswamy, P Gouthami and G Sathish

Abstract
The present study conducted on fig fruits cv. Deanna coated with Chitosan, *Aloe vera* gel, and Gaur gum with different concentrations. The experiment was laid in completely randomized design (CRD) with 7 treatments 3 replications and stored at ambient condition for 4 days. The results revealed that the chitosan 1% significantly reduced the decrease of physiological loss in weight, decay, shriveling also delayed firmness and color. This indicated that edible coatings affected physical properties of figs during ambient storage and extended the shelf life.

Keywords: post-harvest life, chitosan, coating, ambient storage, shelf life

Introduction

The fig (*Ficus carica* L.) is native to western Asia and has been an important crop worldwide for dry and fresh consumption (Kamiloglu and Capanoglu, 2015) [9]. The production of this fruit is mainly located in Turkey, Egypt, Algeria, and Morocco, which accounts for 65% of the world production, but it is also well spread through the Mediterranean basin, USA (California), Brazil, India and Japan (Reyes-Avalos *et al.*, 2016) [18]. It is one of the most abundant fruits in the Mediterranean diet, containing considerable amounts of amino acids, polyphenols, several carotenoids, vitamins, dietary fibers, polyunsaturated fats and minerals (e.g., such as potassium, calcium and iron). Figs are free of sodium, and like other fruits, cholesterol-free (Kamiloglu and Capanoglu, 2015) [9]. Fig is very sensitive to microbial growth of bacteria, molds and yeasts even when stored at low temperature (Villalobos *et al.*, 2016) [19] and is considered a climacteric fruit (Reyes-Avalos *et al.*, 2016) [18] and hence depending on the maturity stage at which the fruit is harvested, it exhibits autocatalytic synthesis of ethylene and a respiratory upsurge which affects its commercial quality, promoting senescence, increase in microbial growth, induction of physiological disorders, and development of undesirable flavors (Wills and Rigney 1980) [20]. In this sense, edible coatings such as chitosan (main constituent of crustaceans' exoskeleton) guar gum (from Indian cluster bean) *Aloe vera* gel can provide an alternative method to design the passive modified atmosphere created in the package over time, due to their barrier properties, reducing the quality changes and quantity losses during storage, which may contribute to extending the product shelf life. Edible coatings are also thin layers of edible materials applied on the product's surface in addition to or as a replacement for natural protective waxy coatings to provide a barrier to moisture, solutes or gases, water/lipid solubility, and other functional characteristics, for example, color, enhanced appearance and peel mechanical properties (Reyes-Avalos *et al.*, 2016) [18]. They also have a high potential to carry active ingredients such as anti-browning agents, colorants, flavors, nutrients and antimicrobial compounds that can extend product shelf life and reduce the risk of pathogen growth on the food surface. Moreover, edible coatings or edible/biodegradable films are important solutions for the reduction in synthetic packaging waste, because of their biodegradable raw materials (Galus and Kadzinska 2015) [6].

Keeping the above points in view, the present study was undertaken on the effect of edible coatings on physical properties of fresh fig (*Ficus carica* L.) cv. Deanna stored at ambient conditions.

Material and Methods
Experimental details
The experiment was conducted during 2021-2022 at fruit science laboratory, Sri Konda Laxman Telangana State Horticultural University, College of Horticulture, Mojerla, Wanaparthy (dist.), Telangana. Fresh mature fig fruits of cv. Deanna were procured from a commercial farmers fig orchard located at, Gadwal (dist.), The design adopted was Completely Randomized Design (CRD) and the data was statistically analysed by the method given by Panse and Sukhatme (1985) [15]. Significance was tested by 'F' value at 5 per cent level of significance. Total 7 treatments with 3 replications for each treatment, T1-(Chitosan 0.5%), T2-(Chitosan 1%), T3-(*Aloe vera* gel 10%), T4-(*Aloe vera* gel 20%), T5-(Gaur gum 0.5%), T6-(Gaur gum 1%), T7-(Control). The analysis of the fruits was done every day for 4 days without intervals.

Methodology
Physical Parameters
1. Physiological loss in weight (%)
2. Decay (%)
3. Shrivelling (%)
4. Surface color (L, a, b values)
5. Firmness (kg/cm2)
6. Shelf life (days)

Results and Discussion
1. Physiological loss in weight (%)
Treatment with T2-chitosan @ 1% recorded the lowest physiological loss in weight during the 1st day (7.93), 2nd day (12.44), 3rd day (16.33) and 4th day (19.70) followed by treatment with T1-chitosan @ 0.5% during the 1st day (8.68), 2nd day (13.71), 3rd day (18.33) and 4th day (20.83). Highest physiological loss in weight was observed in T7-control (untreated) fig fruits during the 1st day (15.07) and 2nd day (26.99), on the 3rd day end of shelf life was recorded. Highest physiological loss in weight was observed in treatment with T3-*Aloe vera* gel @ 10%. on 3rd day (22.26) and 4th day (25.16). Although, Chitosan coating serves as a semi-permeable layer which reduces gas exchange and moisture to reduce respiration and water loss during the postharvest storage of fruits (Dutta *et al.*, 2016) [4]. This observations are supported by (Prashanth *et al.*, 2022) [16]

2. Decay (%)
No decay was observed in all the treatments on the 1st day. Lowest decay (%) was observed in treatment with T2-chitosan @ 1% during 3rd day (2.79) and 4th day (5.29), followed by T1-chitosan @ 0.5% during the 3rd day (4.45) and 4th day (7.16). Highest decay (%) was recorded in T3-*Aloe vera* gel @ 10% during the 3rd day (7.10) and 4th day (13.34). On the 3rd day, T7-control (untreated) fruits recorded end of shelf life. Chitin is a common component of fungal cell walls, chitosan induces chitinase as a defense enzyme which catalyzes the hydrolysis of chitin, thus preventing the growth of fungi on the fruit (El-Ghaouth *et al.*, 1992) [5]. Chitosan coating can form a protective barrier on the surface of fresh fruit, and bring about to decrease microbial growth that causes fruit rotting (Qiuping and Wenshui, 2007) [17]. These observations are similar to (Prashanth *et al.*, 2022) [16].

3. Shrivelling (%)
No shriveling was observed in all the treatments on the 1st day. Lowest shriveling was observed in treatment with T2-chitosan @ 1% on 2nd day (0.45), 3rd day (2.00), 4th day (5.00) followed by T1-chitosan @ 0.5% during the 2nd day (1.00), 3rd day (3.00) and 4th day (7.00). On the 2nd day the highest shriveling was recorded in T7-control (untreated), on 3rd day end of shelf life was recorded. Highest shriveling was recorded in T3-*Aloe vera* gel @ 10% during the 3rd day (18.00) and 4th day (23.00). The moisture content of the ripen fig fruit is about 86% due to its high moisture content the fig fruit is readily prone to the attack of yeast and mould. Niranjan *et al.* (2018) [13] High temperatures led to increased water loss from fruits resulting in fruit shriveling and loss of fresh appearance (Wills and Rigney 1980) [20]. Maximum moisture lost in untreated control might be due to high rate of respiration and transpiration (Abbasi *et al.*, 2009) [1]. In spite of that, chitosan coatings act as barrier, thereby restricting water transfer and protecting fruit skin from mechanical injuries, as well as sealing small wounds and thus delaying dehydration (Hernandez-Munoz *et al.*, 2006) [7]. Low temperatures reduce the sensitivity of fruits to ethylene, thus delaying fruit senescence and shriveling (Wills and Rigney 1980) [20]. These findings are in conformity with (Mani *et al.*, 2018) [12].

4. Surface color (L, a, b)
On the 1st day, T2-chitosan @ 1% recorded the highest colorimetric values (39.88) which was on par with T1-chitosan @ 0.5% (38.99), T6-guar gum @ 1% (38.62) and T5-guar gum @ 0.5% (38.89). On the 2nd day, T2-chitosan @ 1% recorded the highest colorimetric values (38.53) which was on par with T1-chitosan @ 0.5% (37.98) and T6-guar gum @ 0.5% (37.63). Lowest colorimetric values was recorded in T7-control (untreated), on 1st (35.07) and 2nd (34.93), on 3rd day end of shelf life was recorded. On the 3rd and 4th day there was no significant difference was observed among the treatments. Higher loss in green colour at ambient temperatures may be caused by increased breakdown of chlorophyll and synthesis of β-carotene and lycopene pigments, which occur during ripening. In addition, chitosan coating resulted in slow rate of respiration and reduced ethylene production, leading to a modified internal atmosphere of the fruit (Ali *et al.*, 2011) [3]. However, chitosan coated figs with higher lightness and chroma values in treated fruits throughout the storage period. Furthermore, ascorbic acid controlled the color changes due to enzymatic browning, in coated figs, as previously reported by (Liu *et al.*, 2014). These findings are similar to (Prashanth *et al.*, 2022) [16].

5. Firmness (kg cm-2)
Treatment with T2-chitosan @1% recorded the highest firmness during the 1st day (2.79), 2nd day (2.77), 3rd day (2.73) and 4th day (2.70) followed by treatment with T1-chitosan @ 0.5% during the 1st day (1.80), 2nd day (1.76), 3rd day (1.72) and 4th day (1.68). Lowest firmness was observed in T7-control (untreated) fig fruits during the 1st day (0.52) and 2nd day (0.43), on the 3rd day end of shelf life was recorded. During the, Lowest firmness was observed in treatment with T3-*Aloe vera* gel @10% *Aloe vera* gel on 3rd day (1.10) and 4th day (1.03). The better firmness of coated fruits as compared to untreated ones can probably be

explained by degradation of insoluble protopectins to soluble pectin and pectic acid (Ozden and Bayindirli, 2002) [14]. Nevertheless, the rate of decrease in firmness in treated fruits was slow when compared to control fruits which indicated the hindrance of the ripening process. The highest firmness may be due to a low rate of respiration due to the application of surface coatings which slowdowns the metabolic activity of fruits leading to retention of firmness in fruits. These findings are in accordance with (Prashanth *et al.*, 2022) [16]

6. Shelf life (days)

Highest shelf life was recorded in fruits treated with T2-chitosan @1% (4.00) which was on par with T1-chitosan @ 0.5% (3.90), T6-guar gum @1% (3.80), T5-guar gum @ 0.5% (3.70), T4 – *Aloe vera* gel @ 20% (3.60), T3-*Aloe vera* gel @ 10% (3.55). Lowest shelf life was recorded in untreated fruits of T7-control (2.00). Chitosan coatings reduce shrinkage by reducing loss of moisture, transpiration and respiration losses thereby retaining the freshness of the fruits. Chitosan increases the shelf-life of fruit by preventing fruit shriveling, water loss and controlling decay. (Hesami *et al.*, 2021) [8]. The chitosan coated samples delayed ripening process so that they had lower weight loss (Lustriane *et al.*, 2018) [11], In addition, chitosan delayed the loss of green colour and onset of yellowing compared to the control one. Similar results have been reported in papaya (Ali *et al.*, 2011) [3]. These observations are in conformity with (Prashanth *et al.*, 2022) [16].

Table 1: Effect of edible coatings on physiological loss in weight (%) of fresh fig (*Ficus carica* L.) cv. Deanna

Treatments	Mean of physiological loss in weight (%)			
	1st Day	2nd Day	3rd Day	4th Day
T1	8.68e	13.71d	18.33c	20.83de
T2	7.93f	12.44e	16.33d	19.70e
T3	12.62b	16.65b	22.26a	25.16a
T4	11.31c	17.24b	21.30ab	22.99b
T5	10.89c	15.80c	20.80b	22.06bc
T6	9.59d	14.01d	19.05c	21.31cd
T7	15.07a	26.99a	*	*
Mean	10.87	16.69	16.87	18.87
S.E.M.	0.15	0.25	0.37	0.39
C.D. 5%	0.46	0.76	1.11	1.19

*End of shelf life

Table 2: Effect of edible coatings on decay (%) of fresh fig (*Ficus carica* L.) cv. Deanna

Treatments	Mean of decay (%)			
	1st Day	2nd Day	3rd Day	4th Day
T1	0.00	0.00	4.45e	7.16e
T2	0.00	0.00	2.79f	5.29f
T3	0.00	0.00	7.10a	13.34a
T4	0.00	0.00	6.57b	11.80b
T5	0.00	0.00	5.08c	9.44c
T6	0.00	0.00	4.08d	7.78d
T7	0.00	25.00a	*	*
Mean	NA	25.00	4.30	7.83
S.E.M.	NA	0.23	0.09	0.20
C.D. 5%	NA	0.99	0.27	0.61

*End of shelf life

Table 3: Effect of edible coatings on shriveling (%) of fresh fig (*Ficus carica* L.) cv. Deanna

Treatments		Mean of shriveling (%)		
	1st Day	2nd Day	3rd Day	4th Day
T1	0.00	1.00f	3.00e	7.00e
T2	0.00	0.45g	2.00f	5.00f
T3	0.00	15.00b	18.00a	23.00a
T4	0.00	11.00c	14.00b	16.00b
T5	0.00	4.00d	7.00c	10.00c
T6	0.00	3.00e	5.40d	9.00d
T7	0.00	27.00a	*	*
Mean	NA	8.78	7.06	10.00
S.E.M.	NA	0.13	0.18	0.14
C.D. 5%	NA	0.40	0.55	0.44

*End of shelf life

Table 4: Effect of edible coatings on colour (L, a, b) of fresh fig (*Ficus carica* L.) cv. Deanna

Treatments		Mean of color (L, a, b)		
	1st Day	2nd Day	3rd Day	4th Day
T1	38.99a	37.98ab	36.49	35.56
T2	39.38a	38.53a	37.17	36.33
T3	35.64b	35.35c	34.99	34.31
T4	36.47b	36.34bc	35.77	35.12
T5	37.89ab	36.85b	36.01	35.48
T6	38.62a	37.63ab	36.75	35.23
T7	35.07b	34.93c	*	*
Mean	37.44	36.80	31.02	30.29
S.E.M.	0.56	0.49	0.64	0.51
C.D. 5%	1.70	1.49	NS	NS

*End of shelf life

Table 5: Effect of edible coatings on firmness (kg/cm2) of fresh fig (*Ficus carica* L.) cv. Deanna

Treatments	Mean of firmness (kg/cm2)			
	1st Day	2nd Day	3rd Day	4th Day
T1	1.80b	1.76b	1.72b	1.68b
T2	2.79a	2.77a	2.73a	2.70a
T3	1.24f	1.17f	1.10f	1.03d
T4	1.32e	1.26e	1.19d	1.12d
T5	1.43d	1.37d	1.31d	1.25c
T6	1.51c	1.46c	1.41cd	1.36c
T7	0.52g	0.43g	*	*
Mean	1.51	1.46	1.35	1.30
S.E.M.	0.02	0.01	0.13	0.03
C.D. 5%	0.09	0.07	0.12	0.13

*End of shelf life

Table 6: Effect of edible coating on shelf life (days) of fresh fig (*Ficus carica* L.) cv. Deanna

Treatments	Mean of shelf life (days)
T1	3.90a
T2	4.00a
T3	3.55a
T4	3.60a
T5	3.70a
T6	3.80a
T7	2.00b
Mean	3.50
S.E.M	0.03
C.D. 5%	1.76

Conclusion

The chitosan-based coating is a valid postharvest treatment that contributes to extending the shelf-life of fresh figs. This treatment preserved physical properties slowed down browning reactions and counteracted the oxidative stress of coated figs during ambient storage. Chitosan-based coating contributed to reducing the physiological loss in weight, decay, shriveling also delayed firmness, color, and maintained the shelf life for 4 days. These findings suggest that chitosan-based treatment can be used for extending marketable shelf-life of fresh figs.

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