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Effects of Guar Gum-glycerol Edible Coatings on Physicochemical Properties and Shelf-life Extension of Red Dragon Fruit Stored at Ambient Temperature

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Abstract

Background: Dragon fruit production in India has increased, but challenges like weight loss, shriveling and post-harvest diseases affect shelf life. This study examined guar gum-glycerol edible coatings' effects on dragon fruit's physicochemical properties and shelf life at ambient temperature.

Methods: Dragon fruits were coated with guar gum (1%, 2%, 3%) and 1% glycerol, then stored at room temperature. Physiological loss in weight, firmness, total soluble solids, titrable acidity, pH and shelf life were evaluated periodically.

Result: The 3% guar gum + 1% glycerol coating (T_3) significantly reduced weight loss, maintained firmness and preserved soluble solids and acidity compared to uncoated fruits (T_4) and lower guar gum concentrations (T_1, T_2). T_3 extended shelf life to 12 days, while uncoated fruits lasted 8 days. Findings show guar gum-glycerol coatings' potential for improving dragon fruit quality and shelf life at ambient storage.

Key words: Guar gum, Physicochemical properties, Red dragon fruit, Shelf life.

Introduction

Dragon fruit also known as pitaya is the fruit produced by various different tropical climbing plants belonging the genus *Hylocereus*, family Cactaceae (Nishikito *et al*., 2022; Trong *et al*., 2022; Pavithra and Mini, 2023). It is a native fruit from Mexico, Central America and South America (Carrillo-Fasio *et al*., 2022). It is now grown globally because of its commercial value and minimal cultivation needs, such as high drought resistance, easy adaptation to varying light levels and high temperature, a broad tolerance for different soil salinities and its health benefits for humans (Vishakha *et al*., 2021; Crane *et al*., 2017; Mercado, 2018).

Dragon fruit is highly perishable fruit with a limited post- harvest shelf life of 8 days (Chen *et al*., 2024). Various factors affect its quality and storage duration (Huang and Zhao, 2023). Research on extending shelf life using sustainable approaches is lacking. Preservation technologies like modified atmospheric packaging, controlled atmosphere storage, controlled atmospheric storage and cold storage have shown promise in maintaining freshness and reducing losses (Habib *et al*., 2015; Jadhav, 2018; Hazarika *et al*., 2023). This technique helps to maintain firmness, color, flavor and nutritional content while reducing weight loss and pathogen susceptibility (Bassolino *et al*., 2013; Thole *et al*., 2020).

Guar gum is a natural polysaccharide obtained the seeds of guar beans, served as an edible coating and has high molecular weight, extended polymeric chains, presence of natural antioxidants and bioactive compounds, widespread availability and its capacity to improve water solubility (Thombare *et al*., 2016). Guar gum has reported positive results as a coating material for extending shelf life of various fruits. Studies have demonstrated its effectiveness in preserving quality parameters and prolonging storage periods of mangoes, tomatoes and blueberries (Naeem *et al*., 2018; Prasad *et al*., 2022; Totad *et al*., 2019). Utilization of guar gum-based coatings on tomatoes improved the shelf stability up to 60 days at 10°C (Naeem *et al*., 2018). No studies have been done before on extension of shelf life of dragon fruits by utilising guar gum as a coating material. In the context of this study was planned to extend the shelf life of red dragon fruit by using the edible coatings of guar gum at ambient temperature.

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MATERIALS AND METHODS

Preparation of composite guar gum and glycerol solution

Guar gum coating solution was prepared according to methods advised by Ghosh *et al*. (2014) by dissolving 10 gm, 20 gm and 30 gm of guar gum powder in 1000 ml of distilled water with 1% of glacial acetic acid. 1% glycerol solution was added to each.

Application of coatings solution to dragon fruits

DF were washed, air dried and divided into 4 lots of 15 fruits each. These lots were coated with guar gum + glycerol solution solutions for 60 seconds, while one lot served as an untreated control (T_4). After air drying, fruits were stored at ambient temperature. Quality attributes were analyzed at 2- day and 5- day intervals to assess the shelf life.

Determination of qualitative attributes

Physiological weight loss (PLW) was determined by taking the difference between initial and final weights at designed sampling intervals and was represented as a percentage (%). A penetrometer was employed to measure the firmness of the fruit, with direct readings expressed in kg/cm^2. The TSS of red dragon fruit was measured using digital ATAGO portable refracto - polarimeter. The titratable acidity of dragon fruit was assessed as anhydrous citric acid by titrating with 0.1N NaOH, using phenolphthalein as an indicator following the method recommended by A.O.A.C. (2005). 10 gm of dragon fruit flesh (homoginized), was taken in a beaker and pH was determined using a microprocessor controlled digital pH analyzer (Lab India, Model PHAN, New Delhi, version I) with combined glass electrode. The shelf life of dragon fruit was determined by counting the number of days it took for them to reach the final stage of ripening, up to the point where they were still suitable for sale (Gol *et al*., 2015).

Statistical analysis

The experiments were conducted in triplicate. Results were expressed as mean±standard deviation. Statistical differences were determined using IBM SPSS (Version 26, IBM analytics, New York NY USA.), One-way ANOVA was performed ($p<0.05$) and Duncans multiple range tests compared means and assessed variable homogeneity.

RESULTS AND DISCUSSION

Effects of Guar gum- Glycerol based edible coating on physicochemical and biochemical attributes of red dragon fruits stored at ambient temperature

Physiological loss in weight (%)

The reduction in fruit weight throughout storage is a significant factor contributing to postharvest losses, which cause shriveling and wilting of fruits which ultimately retards the marketability of fruits (Lufu *et al*., 2024). In this context PLW of dragon fruits was calculated and obtained results are in Table 1.

The study revealed significant rise in % PLW over time for both control and coated dragon fruit (DF) samples ($p<0.05$). Control samples (T_4) exhibited the highest weight reduction, with shrinkage occurring more rapidly than in coated fruits. Weight loss was attributed to moisture loss, transpiration, respiration, storage conditions, fruit charact-eristics and physiological changes (Umeohia *et al*., 2024). Control samples showed progressive weight reduction that is on 2 day 0.85%, on 4 day 3.20% and at 8 day1 0.77%. Initial weight loss was less pronounced compare to subsequent storage period.

Coated dragon fruit with 3% guar gum + 1% glycerol (T_3) showed a minimum % PLW compared to T_2 and T_1. Guar gum coatings form a semipermeable layer reducing transpiration, respiration, reduced the movement of O2, CO_2, moisture and solutes thereby reducing water loss (Ruelas-Chacon *et al*., 2017). T_3 treatment showed minimal reduction, reaching 8.21% PLW on day 12. T_2 reached 8.45% PLW on day10, while T_1 reached 10.81%. T_1 and T_2 treated DF remained stable for 10 days before decay, evident through physiological weight loss. Saha *et al*. (2016) reported guar gum based edible coatings reduced weight loss in cucumber effectively over the uncoated cucumbers. Guar gum and glycerol-based coatings were applied to tomato by Ruelas-Chacon *et al*. (2017) and observed that application of 1.5% of guar gum could effectively reduce the weight loss.

Table 1: Effects of guar gum-based edible coating on physiological loss of weight of red dragon fruit stored at ambient temperature.

Treatments	Physiological loss in weight (%)					
	2	4	6	8	10	12
T_1	0.57±0.03^a	2.21±0.14^b	5.34±0.03^c	8.34±0.32^d	10.81±0.51^e	NA
T_2	0.52±0.02^a	1.77±0.18^b	3.45±0.12^c	5.77±0.07^d	8.45±0.35^e	NA
T_3	0.42±0.01^a	0.94±0.06^b	1.84±0.02^c	3.31±0.43^d	5.2±0.36^e	8.21±0.36^f
T_4	0.85±0.02^a	3.20±0.03^b	6.36±0.42^c	10.77±0.10^d	NA	NA

The values are presented as mean±sd (n= 3). Different superscript letters in rows indicate significant differences ($p<0.05$), while same superscript indicate no significant difference ($p>0.05$) according to Duncan's multiple comparison test.

T_1: 1% guar gum + 1% glycerol.

T_2: 2% guar gum + 1% glycerol.

T_2: 3% guar gum + 1% glycerol.

T_4: Uncoated (Control).

Firmness

Firmness is an important parameter of freshly harvested red dragon fruit as it influenced the quality perceived by consumer and storage potential. Firmness of ambiently stored red dragon fruit were assessed at every 2 days of interval until they decayed and obtained results of the investigation are presented in Table 2.

The data in the Table 2 indicates a decrease in firmness for all treated fruit samples. This loss of firmness can lead to changes in the fruits visual appeal, potentially making it appear softer or more fragile (Su *et al*., 2022). Control samples without coating (T4) showed the highest firmness reduction and were statistically significant ($p<0.05$) at each evaluation stage. Firmness (T_4) decreased from 5.5 Kg/ cm2 (0th day) to 2.6 kg/cm2 (8th day), likely due to respiration and transpiration and was highest compared to coated DF. Coated DF maintained superior firmness compared to untreated DF and this was due to reduced breakdown of insoluble protopectin into soluble pectin and pectic acid (Yaman and Bayoéndérlé, 2002). During ripening, pectin chains undergo polymerization or shortening due to increased pectin-esterase and polygalacturonase enzyme activity (Desai and Park, 2006).

T_1 showed the highest firmness reduction compared to other coated samples. From day 0 to 2, minimal reduction was observed in coated fruits with non-significant differences. Significant differences reported from day2 onwards. On 2nd day of evaluation T_1 had the firmness 5.4 kg/ cm2 whereas T_2 and T_3 had 5.4 and 5.6 kg/cm2. On 4th day of evaluation T_1 had the firmness 4.7 kg/ cm2 whereas T_2 and T_3 had 4.9 and 5.1 kg/cm^2. T_1 red dragon fruit had statistically significant ($p<0.05$) differences like that of control sample at each harvesting stage and reached the 2.5 Kg/ cm^2 firmness on 10th day of evaluation. T_2 dragon fruit had statistically significant subsequent differences after 2nd day to up to 10th day of evaluation achieving firmness of 2.4 kg/ cm^2. T_3 coated dragon fruit samples showed the least reductions in firmness and maintained highest values of it, as it can be evident by its statistical differences. T_3 DF maintained the highest firmness of 2.9 kg/cm^2 on day 12, with non-significant differences between 0-2 day and 4-6 day but statistically significant differences observed from day 2-4 and 6-12. Higher firmness suggests preserved structural integrity, associated with reduced enzymatic activity and minimal cell wall breakdown (Wismer, 2014).

Coated dragon fruit especially T_3, showed minimal firmness reduction due to coating's barrier effect, which reduces moisture loss and enzymatic activities responsible for softening (Huang and Zhao, 2023). Decreased firmness is linked to turgor pressure loss, cell wall disintegration and polysaccharide degradation (Gidado *et al*., 2023). Studies on guar gum- based coatings for red DF have

Table 2: Effects of guar gum-based edible coating on firmness of red dragon fruit stored at ambient temperature.

Treatments	Firmness Kg/ cm^2						
	0	2	4	6	8	10	12
T_1	5.7±0.1^a	5.4±0.2^b	4.7±0.2^c	3.9±0.26^d	3.2±0.1^e	2.5±0.1^f	NA
T_2	5.6±0.0^a	5.4±0.1^a	4.9±0.2^b	3.8±0.3^c	3.4±0.00^d	2.4±0.0^e	NA
T_3	5.7±0.1^a	5.6±0.0^a	5.1±0.1^b	4.9±0.26^b	4.2±0.17^c	3.5±0.1^d	2.9±0.26^e
T_4	5.5±0.2^a	5.1±0.4^b	4.4±0.3^c	3.5±0.1^d	2.6±0.1^e	NA	NA

The values are presented as mean±SD (n= 3). Different superscript letters in rows indicate significant differences ($p<0.05$), while same superscript indicate no significant difference ($p>0.05$) according to Duncan's multiple comparison test.

T_1: 1% guar gum + 1% glycerol.

T_2: 2% guar gum + 1% glycerol.

T_2: 3% guar gum + 1% glycerol.

T_4: Uncoated (Control).

Table 3: Effects of guar gum-based edible coating on TSS of red dragon fruit stored at ambient temperature.

Treatments	TSS (°Brix)						
	0	2	4	6	8	10	12
T_1	10.4±00^a	10.5±0.17^a	11.1±0.10^b	11.7±0.26^c	12.2±0.10^d	11.9±0.26^{cd}	NA
T_2	10.6±0.10^a	10.6±0.26^a	10.9±0.10^a	11.5±0.1^b	12.4±0.20^c	11.8±0.15^b	NA
T_3	10.6±0.30^a	10.6±0.30^a	10.8±0.17^a	11±0.17^a	11.6±0.20^b	12.3±0^b	11.9±0.1^b
T_4	10.5±0.26^a	10.8±0.1^a	11.6±0.00^b	12.3±0.34^c	11.5±0^b	NA	NA

The values are presented as mean±sd (n= 3). Different superscript letters in rows indicate significant differences ($p<0.05$), while same superscript indicate no significant difference ($p>0.05$) according to Duncan's multiple comparison test.

T_1: 1% guar gum + 1% glycerol.

T_2: 2% guar gum + 1% glycerol.

T_2: 3% guar gum + 1% glycerol.

T_4: Uncoated (Control).

demonstrated the effectiveness of coatings in maintaining fruit firmness compared to uncoated samples (Ruelas-Chacon, 2017; Nguyen *et al*., 2021).

Total soluble solids (TSS)

TSS indicates fruit sugar content, a key quality parameter. Monitoring TSS during storage assesses ripeness and palatability, affecting consumer acceptance and marketability (Islam *et al*., 2013). Table 3 shows TSS changes in stored dragon fruit.

Table 3 shows TSS in dragon fruits increased then decreased on the final evaluation day across all treatments. T_4 had the highest TSS increase, while T_3 had the least. Coated fruits showed significantly less TSS increase than control fruits. No significant differences (p>0.05) were noted observed between days 0-2 but, significant differences were noted thereafter for T_4. T_4 treated fruit TSS ranged from 10.5 to 11.5, peaking at 12.3 on day 6 before decreasing to 11.5, reaching at 12.3 on day 6 before decreasing to 11.5 on the final day. This pattern of increasing TSS followed by decrease on the last day was observed across treatments.

T_4 treatment showed the least changes in TSS, followed by T_1. TSS content ranged from 10.4 -11.9 for T_1 and 10.6 - 11.8 for T2 during the 10-day evaluation. Both T_1 and T_2 showed TSS reduction on day 10 compared to day 8. T3 exhibited the minimum TSS increase among all treatment, with non- significant changes up to day 6, indicating better shelf stability. Significant differences were observed on day 8 compared to day 6 for T_3. The TSS concentration increase in stored fresh fruits is due to moisture loss and polysaccharide hydrolysis (Anjum *et al*., 2020). Coating dragon fruits modifies atmospheric conditions, slowing metabolism increasing TSS content compared to uncoated fruits (Nguyen *et al*., 2021). A slight decrease in TSS content on the final evaluation day was observed in mangoes, bananas and guavas (Singh *et al*., 2021; Islam and Rab, 2016; Rahman *et al*., 2012).

% Acidity

Acidity of uncoated and coated red dragon fruits stored at ambient temperature decreased progressively throughout storage and are reported in Table 4. T_4 (Uncoated control) showed the highest reduction in acidity, followed T_1 and T_2, while T_3 exhibited the highest retention. There were similar results in mangoes treated with guar gum and CMC and ber fruits coated with chitosan (Hmmam *et al*., 2021; Hesami *et al*., 2021) The reduction in acidity may be due to the conversion of organic acid into sugars or their use in respiration (Singh *et al*., 2010).

Uncoated dragon fruits showed the lowest acidity retention (0.27%) by day 8. Guar gum coated fruits maintained higher acidity (0.26 to 0.31 %). T_1, T_2 and T_4

Table 4: Effects of guar gum-based edible coating on % Acidity of red dragon fruit stored at ambient temperature.

Treatments	% Acidity						
	0	2	4	6	8	10	12
T_1	0.42±0.026^d	0.39±0.04^d	0.36±0.02^c	0.33±0.02^b	0.29±0.04^{ab}	0.26±0.04^a	NA
T_2	0.41±0.01^d	0.39±0.03^d	0.37±0.01^c	0.34±0.01^b	0.31±0.03^a	0.29±0.03^a	NA
T_3	0.42 ±0.02^d	0.40±0.02^c	0.39±0^c	0.36±0.01^b	0.34±0^a	0.33±0.01^a	0.31±0.04^a
T_4	0.43±00^c	0.40±0.02^c	0.35±0.04^b	0.30±0.06^b	0.27±0.01^a	NA	NA

The values are presented as mean±sd (n= 3). Different superscript letters in rows indicate significant differences (p<0.05), while same superscript indicate no significant difference (p>0.05) according to Duncan's multiple comparison test.

T_1: 1% guar gum + 1% glycerol.

T_2: 2% guar gum + 1% glycerol.

T_2: 3% guar gum + 1% glycerol.

T_4: Uncoated (Control).

Table 5: Effects of guar gum-based edible coating on pH of red dragon fruit stored at ambient temperature.

Treatments	pH						
	0th day	2nd day	4th day	6th day	8th day	10th day	12th day
T_1	4.36±0.02^a	4.38±0.01	4.52±0.01^b	4.68±0.08^c	4.84±0.02^d	4.94±0.02^e	NA
T_2	4.39±0.00^a	4.41±0.07	4.48±0.07^b	4.64±0.02^c	4.78±0.02^d	4.89±0.02^e	NA
T_3	4.28±0.04^a	s4.30±0.03	4.33±0.03^b	4.41±0.0 0^c	4.53±0.03^d	4.67±0.01^e	4.81±0.03^f
T_4	4.41±0.01^a	4.44±0.02	4.64±0.02^b	4.91±0.0 3^c	5.06±0.01^d	NA	NA

The values are presented as mean±sd (n= 3). Different superscript letters in rows indicate significant differences (p<0.05), while same superscript indicate no significant difference (p>0.05) according to Duncan's multiple comparison test.

T_1: 1% guar gum + 1% glycerol.

T_2: 2% guar gum + 1% glycerol.

T_2: 3% guar gum + 1% glycerol.

T_4: Uncoated (Control).

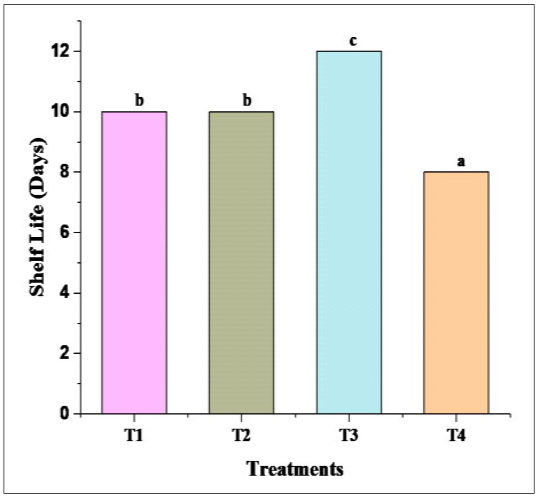

Fig 1: Effects of guar gum- glycerol based edible coatings on shelf life of dragon fruits stored at ambient temprature.

showed non-significant differences in days 0-2. T_3 treatment reported to be non-significant differences from days 0- 4 and 8- 12, indicating minimal acidity reduction. Bhan *et al*. (2022) reported guar gum coating reduces kinnow fruit respiration. For Roma tomatoes, guar gum with glycerol coating slowed acidity loss over 20 days at 22°C (Ruelas – Chacon *et al*., 2017). This may apply to dragon fruit. The effect likely results from reduced, decreasing respiratory activities. Guar gum- based coatings effect on dragon fruit acidity at ambient storage aligns with Goswami *et al*. (2023), who found significant acidity retention (0.29%) in guar gum and chitosan coated mandarin.

pH

Red fleshed dragon fruit coated with edible coatings of guar gum and glycerol was assessed for its pH content on regular interval of 2 days. Obtained results from analysis are demonstrated in following Table 5.

pH increased across all treatments over storage time due to decreased acidity. Control (T_4) showed the highest pH change, from 4.41 to 5.06. Coated fruits (T_1 and T_2) reported lesser pH increase due to guar gum and glycerol coatings. pH of T_1 treatment ranged from 4.36 to 4.94, while T_2 ranged from 4.39 to 4.89. T_3 with higher guar gum content, showed least pH change among all treatments.

Previous studies by Bal, 2013 and shah *et al*. (2021) on pear and plum fruit coated with chitosan and edible coatings reported similar rise in pH of coated fruits respectively. Reported findings of present investigation are similar with the findings of Nguyen *et al*. (2021), they reported on k-carrageenan coatings of DF.

Shelf life (Days)

The shelf life of coated red DF significantly increased compared to uncoated fruit and results are depicted in Fig 1. Australian-grown white DF had slightly longer shelf life (9 days) than imported fruits (8 days) under ambient conditions, while red varieties showed similar shelf life (8 days) (Chen *et al*., 2024). Lata *et al*. (2024) reported a 7- day shelf life for untreated, ambiently stored red and white pulped DF, aligning with the present findings for uncoated fruits. Control DF samples began decaying after 7 days of storage at 25°C and 75% relative humidity (Chaemsanit *et al*., 2018).

The values are presented as mean±sd (n= 3). Different superscript letters indicate significant differences ($p<0.05$), while same superscript indicate no significant difference ($p>0.05$) according to Duncan's multiple comparison test. Two coating treatments T_1 and T_2 showed the shelf stability up to 10 days. T_3 dragon fruit treated with 3% Guar gum and 1% glycerol showed the highest shelf life of 12 days and was found to be statistically significant ($p<0.05$) compared to all the treatments.

CONCLUSION

In conclusion, guar gum-glycerol edible coatings, particularly the 3% guar gum + 1% glycerol formulation (T_3), effectively improve postharvest quality and extend shelf life of red dragon fruits at room temperature. T_3 significantly reduced weight loss, preserved firmness and maintained favorable soluble solids and acidity levels, extending shelf life to 12 days versus 8 days for uncoated fruits. This highlights the potential of guar gum-glycerol coatings as a sustainable postharvest solution. Future studies should focus on sensory evaluation and commercial scalability to refine this preservation strategy.

Conflict of interest

The authors do not have any conflict of interest.

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