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INFLUENCE OF GUAR GUM – GLYCEROL COMPOSITE COATINGS ON POSTHARVEST QUALITY AND SHELF-LIFE EXTENSION OF DRAGON FRUIT STORED AT REFRIGERATED TEMPERATURE (8°C)

SHAILESH JANARDAN VEER*[1] AND RAJESH BALIRAM KSHIRSAGAR[2]

College of Food Technology, VNMKV, Parbhani, M.S., India

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Abstract–This study reported the effects of guar gum-glycerol based edible coatings on the physico-chemical properties and shelf life of red dragon fruit (*Hylocereus spp*.) stored at refrigerated temperature (8 °C). Dragon fruits were coated with different concentration of guar gum and glycerol (1%, 2%, 3%) based coatings compared to uncoated control fruits. Physiological loss in weight (PLW), firmness, total soluble solids (TSS), Titrable acidity, pH and shelf life were evaluated at regular intervals during storage. Coated fruits exhibited lower PLW and better retention of firmness compared to uncoated control. The T3 treatment showed least changes in PLW (0.29% to 5.78%), firmness (5.9 to 4.1 kg/cm^2), TSS (10.3 to 11.4 Brix°), acidity (0.42% to 0.27%), and pH (4.36 to 4.74) during the 30-day storage period. T_3 coated fruits also had the longest shelf life of 32 days, followed by T2 (29 days), T1 (28 days), and uncoated control (26 days). The results demonstrate that guar gum- glycerol composite coatings at 3% concentration can effectively improve the quality and enhances the shelf life of red dragon fruit at refrigerated temperature.

INTRODUCTION

Dragon fruit, known as pitaya or pitahaya is an exotic tropical fruit of the cactaceae family (Taharuddin *et al*., 2023). Native to Latin America and South America, particularly Mexico, Central America, and South America, this climbing vine cactus has gained popularity worldwide and is now cultivated in various tropical and subtropical regions, including Vietnam, China, and Australia (Chen *et al*., 2024; Rathi *et al*., 2023). The fruit is renowned for its unique appearance, featuring an attractive shape and magnificent color, as well as its refreshing and mouthwatering taste (Jalgaonkar *et al*., 2020). Dragon fruit comes in different varieties, with red fleshed Hylocereus being the most popular species (Huang *et al*., 2021; Riska *et al*., 2023). The fruits flesh constitutes about two thirds of its total weight, while the peel makes up approximately one third (Taharuddin *et al*., 2023).

Fruit's shelf life is a crucial factor influenced by post-harvest ripening and susceptibility to pathogen infection (Bassolino *et al*., 2013). Storage of dragon fruit at 5 °C or 7 °C maintained better visual appearance, reduced decay incidence and preserved greener bracts compared to storage at 10 °C (Freitas and Mitcham, 2013).

Guar gum has shown promising results as a potential coating agent for fruits, demonstrating its ability to increase the shelf life and improve fruit quality during storage. When used as a coating for guava fruits, gaur gum at 1.5% concentration significantly reduced moisture loss and decay, while preserving bioactive compounds like phenolics, flavonoids, and antioxidants (Prasad *et al*., 2022). For mangoes, guar gum based silver nanoparticle coatings effectively delayed ripening and maintained fruit quality during cold storage by reducing weight loss, respiration rate and preserving firmness (Hmmam *et al*., 2021). No research has been documented on the impact of guar gum based edible coating on the shelf life of dragon fruit. In this context of this study was planned to develop the guar gum- glycerol composite coatings and evaluate its effect on physicochemical properties and shelf life of dragon fruit stored at refrigerated temperature (8 °C).

([1]Ph.D. Scholar, [2]Associate Dean and Principal)

MATERIALS AND METHODS

Guar gum and glycerol-based edible coating of red dragon fruits stored at ambient temperature

Preparation of composite guar gum and glycerol solution

Guar gum was available from the Department of Food Chemistry and Nutrition, CFT VNMKV Parbhani. 1%, 2 % and 3% of guar gum solution was prepared by dissolving 10 g, 20 g and 30 g of guar gum powder in 1000 ml of distilled water containing 1 per cent of glacial acetic acid. To this prepared guar gum solution, 1% of glycerol solution was added.

Application of coatings solution to dragon fruits

Fresh, fully mature, uniform-sized, and disease-free dragon fruits were cleansed with tap water to remove extraneous matter and thereafter air dried at ambient temperature. The fruits were segregated into 4 lots, each comprising 15 specimens, with one lot designated as a control without any treatment. Each fruit was immersed in guar gum + glycerol solutions according to the prescribed treatments for approximately 60 seconds. Subsequently, the treated dragon fruits were air-dried and placed in plastic trays. The coated and control dragon fruit samples were stored at refrigerated storage (8 ˚C) and subsequently analysed for quality attributes at 2-day and 5 days intervals respectively to assess shelf life.

Table 1. Treatments of coatings

Treatment Coding	Treatment details
T_1	1 % guar gum + 1 % glycerol
T_2	2 % guar gum + 1 % glycerol
T_3	3 % guar gum + 1 % glycerol
T_4	Control

Determination of qualitative attributes

Physiological loss in weight (PLW)

Weight loss (PLW) of dragon fruits was evaluated by using electronic digital weighing balance machine. PLW was assessed by taking the difference between the initial and final weight at designated sampling times, and it was represented as percentage (%) based on the edible coatings impact on the shelf life of dragon fruit.

Firmness

Penetrometer was used to record the firmness of fruit and direct readings were obtained in terms of kg/cm^2. The sample fruits were subjected to penetrometer by pressing near the centre of the fruit and flesh of fruit and direct reading on the scale was recorded.

TSS

The TSS content was measured with the help of digital ATAGO portable refracto– polarimeter. Before measurement instrument was calibrated with distillation a small portion of flesh of dragon fruit flesh was placed on the digital refractometer's vial and then the measurement button pressed and noted the readings as degree brix.

Titratable acidity (%)

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).

$$\% \textbf{ Acidity} = \frac{\text{Titre value} \times \text{Volume made up} \times \text{eq. wt. of acid}}{\text{Wt. of sample} \times \text{Vol. of aliquot} \times 1000} \times 100$$

pH

10 Ml of dragon fruit flesh (homoginized), was taken in a beaker and pH was determined using a microprocessor controlled digital pH analyser (Lab India, Model PHAN, New Delhi, version I) with combined glass electrode.

Shelf Life (days)

The shelf life of dragon fruit was determined by measuring the number of days required for the fruit to reach the final stage of ripening, while still being considered suitable for marketing (Gol *et al*., 2015).

RESULTS AND DISCUSSION

Effects of Guar gum- Glycerol based edible coating on physicochemical and Biochemical attributes of red dragon fruit stored in refrigerator (8 ˚C)

Physiological loss in weight (PLW)

The weight of each of the treated fruits was reported to be reduced. The weight reduction of uncoated dragon fruits was much faster compared to coated ones. Uncoated dragon fruits T_4 reduced weight from 0.83% to 7.49%, whereas T_3 coated dragon fruits showed the least reduction in weight, in the range of 0.29 to 5.78%. T_1 and T_2 coated dragon fruit showed least % weight loss compared to uncoated dragon fruit and high % weight loss compared to T_3 coated dragon fruit. T_1 coated fruit showed the PLW

in the range of 0.42% to 6.69% whereas, T_2 had 0.36 to 6.46.

Compared to uncoated dragon fruits, the least reduction in weight was observed in coated dragon fruits, which ultimately helped to increase the shelf life of dragon fruits. This effect was due to a decrease in the transpiration and respiration rate of fruits. Physiological weight loss of dragon fruit was meagre compared to reported results for other fruits in various literature. This reduced weight loss may be attributed to the thicker peel and waxy substances present on dragon fruit, which likely impeded moisture loss. Coated fruits generally showed a less decrease in loss of weight than to the uncoated control fruits while storage. Carnaúba-based wax coating on 'Valencia Delta' oranges resulted in significantly less weight loss compared to uncoated fruits, which decreased about 3.0% moisture after 35 days of refrigerated storage at 7 ± 2 °C (Pereira *et al*., 2013). Similarly, Kassem *et al*. (2022) reported that coating mangoes by using chitosan and nano-silicon dioxide films significantly decreased weight loss compared to uncoated controls when stored at 13 ± 1 °C for 30 days (Kassem *et al*., 2022).

Firmness

The firmness of dragon fruits coated with guar gum - glycerol, stored at refrigerated conditions (8 ˚C) was analysed, and the obtained results are reported in table 3. Fruit firmness tends to decrease, but this change is at the slowest rate compared to fruits stored at room temperature. The firmness of the fruit decreased irrespective of treatments. Control fruit (T_4) demonstrated the highest decrease in fruit firmness, evidenced by statistically significant ($p<0.05$) differences at each analysis stage and was in the range of 6 to 3.6 kg/ cm^2. T_1 and T_2 treated dragon fruit showed less changes in firmness than control samples and was in the range of 5.9 to 4.0 and 5.8 to 4.2 kg/cm^2.

Compared to all the treatments, T3-treated dragon fruits were reported to be firmer fruits and were denoted to be in the range of 5.9 to 4.1 kg/cm^2. Statistically, non-significant ($p>0.05$) differences were reported between 0 to 15 days, signifying the highest firmness retention in T_3-treated dragon fruits. The highest firmness retention in T3-treated dragon fruit could be due to a higher percentage of coating treatments.

Several studies reported least decreased in firmness of coated fruits compared to uncoated one. For, mangoes, carboxymethyl cellulose and guar gum-based silver nanoparticle coatings reduced the decrease in firmness during cold storage compared

Table 2. Physiological loss in weight of red dragon fruit stored at refrigerated temperature

Treatment	% PLW (Days)					
	5	10	15	20	25	30
T_1	0.42^a	0.97^b	3.14^c	4.97^d	6.69^e	NA
T_2	0.36^a	0.81^b	2.94^c	4.15^d	6.46^e	NA
T_3	0.29^a	0.72^b	1.66^c	2.78^d	4.19^e	5.78^f
T_4	0.83^a	1.91^b	3.88^c	5.56^d	7.49^e	NA

The data are presented as mean ± sd (n= 3). According to Duncans multiple comparison test, values in rows with different superscript letters show significance differences ($p<0.05$). Conversely, values in rows sharing the same superscript do not exhibit significant differences ($p>0.05$).NA= Not Analysed.

Table 3. Effects of guar gum - glycerol based edible coating on firmness of dragon fruit stored at refrigerated temperature (8 ˚C)

Treatment	Days						
	0	5	10	15	20	25	30
T_1	5.9 ± 0.43^e	5.6 ± 0.1^{de}	5.2 ± 0.36^{cd}	4.8 ± 0.26^{bc}	4.4 ± 0.43^{ab}	4.0 ± 0.23^a	NA
T_2	5.8 ± 0.24^d	5.5 ± 0.43^{cd}	5.3 ± 0.36^{bc}	4.9 ± 0.55^{ab}	4.6 ± 0.50^{ab}	4.2 ± 0.26^a	NA
T_3	5.9 ± 0.34^d	5.7 ±0.55^{cd}	5.5 ± 0.3^{cd}	5.3 ± 0.75^{cd}	5.0 ± 0.45^{bc}	4.6 ± 0.40^{ab}	4.1 ± 0.26^a
T_4	6.0 ± 0.26^e	5.6 ± 0.36^d	5.0 ± 0.1^c	4.5 ± 0.34^b	4.0 ± 0.12^{ab}	3.6 ± 0.36^a	NA

The data are presented as mean ± sd (n= 3). According to Duncans multiple comparison test, values in rows with different superscript letters show significance differences ($p<0.05$). Conversely, values in rows sharing the same superscript do not exhibit significant differences ($p>0.05$). NA= Not Analysed.

to uncoated fruit (Hmmam *et al*., 2021). Similarly, a chitosan-gelatin composite coating significantly enhanced pepper fruit texture and extended cold storage life (Poverenov *et al*., 2014). Refrigeration slows down the ripening process and metabolic activities in fruits, leading to better retention of firmness (N *et al*., 2020). Refrigeration also slows down moisture loss, which is crucial for maintaining fruit turgor and firmness (Singh and Narula, 2017).

TSS

The results presented in Table 4 demonstrate the effects of guar gum-glycerol based edible coating on the Total Soluble Solids (TSS) content of dragon fruit stored at 8°C over 30 days.

Refrigerated storage of dragon fruits at around 8 °C effectively reduces the changes in TSS content compared with storage at ambient temperature. Many studies supported this fact. Dong *et al*., (2011) reported little effect on TSS of pear fruit at cold storage compared to storage at ambient conditions. This effect was due to the decreased softening and respiratory activity at low temperature. In loquat fruits coated with chitosan and stored at 5 °C, the increase in TSS was inhibited compared to control fruits (Song *et al*., 2016). Punitha *et al*., 2009 reported similar rise in TSS content of dragon fruits stored at 6 °C and 16 °C.

The justification for using guar gum-glycerol based edible coatings is supported by previous research, which has demonstrated that such coatings can efficiently decelerating the ripening process and prolonging the shelf life of fruits by serving as barriers to exchange of gas and loss of moisture (Baldwin *et al*., 1995; Park, 1999). Effects of coated dragon fruits stored at 8° C on TSS content are corroborated with the reported results of Prasanth *et al*., 2023.

Percent Acidity

Percent Acidity is a crucial factor in fruit flavor and can also play a role in microbial resistance. The results presented in Table 5 demonstrate the impact of guar gum-glycerol based edible coating on the acidity of dragon fruit stored at 8 °C over a 30th day period.

Percent acidity of dragon fruits was noted to be decreased. This decline in acidity is consistent with the fruit storage period, where organic acids are typically broken down or converted to sugars. Treatment T_3 exhibited the highest initial acidity

Table 4. Effects of guar gum- glycerol based edible coating on TSS of dragon fruit stored at refrigerated temperature (8 °C)

Treatment	Days						
	0	5	10	15	20	25	30
T_1	10.2 ±0.2^{a}	10.3 ± 0.10^{a}	10.6 ±0.50^{ab}	10.9 ±0.78^{ab}	11.2 ± 0.26^{bc}	11.5± 0.36^{c}	NA
T_2	10.3 ± 0.36^{a}	10.4 ±0.45^{a}	10.6 ± 0.70^{ab}	10.8 ± 0.36^{ab}	11 ± 0.27^{ab}	11.3 ± 0.43^{b}	NA
T_3	10.3 ±0.32^{a}	10.3 ± 0.26^{a}	10.4 ± 0.10^{a}	10.6 ± 0.36^{ab}	10.8 ± 0.26^{ab}	11.1 ±0.40^{bc}	11.4 ± 0.43^{c}
T_4	10 ±0.34^{a}	10.2 ±0.35^{ab}	10.7 ± 0.27^{abc}	11 ± 0.51^{bc}	11.4 ±11.7^{bc}	11.6 ± 0.88^{c}	NA

The data are presented as mean ± sd (n= 3). According to Duncans multiple comparison test, values in rows with different superscript letters show significance differences ($p<0.05$). Conversely, values in rows sharing the same superscript do not exhibit significant differences ($p>0.05$). NA= Not Analysed.

Table 5. Effects of guar gum-glycerol based edible coating on acidity of dragon fruit stored at refrigerated temperature (8 °C)

Treatment	Days						
	0	5	10	15	20	25	30
T_1	0.38 ± 0.02^{c}	0.36 ± 0.045^{c}	0.33 ± 0.043^{cb}	0.30 ± 0.060^{ba}	0.27± 0.036^{ba}	0.24 ±0.034^{a}	NA
T_2	0.39 ± 0.026^{b}	0.37 ± 0.07^{b}	0.34 ± 0.055^{ba}	0.31 ±0.07^{ba}	0.29 ± 0.041^{ba}	0.26 ± 0.04^{a}	NA
T_3	0.42 ± 0.043^{b}	0.41 ± 0.026^{b}	0.38 ± 0.040^{ba}	0.37 ± 0.037^{ba}	0.34 ± 0.055^{ba}	0.30 ± 0.062^{ba}	0.27 ± 0.036^{a}
T_4	0.40 ± 0.026^{c}	0.37 ± 0.036^{c}	0.31 ±0.062^{cb}	0.27± 0.060^{ba}	0.25 ± 0.062^{ba}	0.21 ±0.041^{a}	NA

The data are presented as mean ± sd (n= 3). According to Duncans multiple comparison test, values in rows with different superscript letters show significance differences ($p<0.05$). Conversely, values in rows sharing the same superscript do not exhibit significant differences ($p>0.05$). NA= Not Analysed.

(0.42%) and maintained relatively higher acidity levels throughout the storage period compared to other treatments. Suggesting that this specific coating formulation may be more effective in preserving the fruit's acid content. T_3 treatment on 30th day had the percent acidity of 0.27 %.

Treatment T_4 demonstrated the most pronounced decrease in acidity, starting from 0.40% on day 0 and dropping to 0.21% by day 25. This suggested thatT_4 coating may be less effective in preserving the fruit's acidic compounds or may allow for faster metabolic processes that consume acids. Compared to uncoated dragon fruit T_1 and T_2 dragon fruits showed minimal changes in percent acidity and was in the range of 0.38 to 0.24% and 0.39 to 0.26% respectively throughout studied period. The coating used in T_3 reported to be the most effective in maintaining acidity levels, potentially due to its ability to reduce respiration rate or create a more effective barrier against gas exchange.

pH

Effects of guar gum coated dragon fruit stored at refrigerated temperature on pH of fruits as it indirectly determines its quality was assessed and obtained results reported in the following Table 6.

The highest decrease in pH content of dragon fruits was reported for uncoated control dragon fruits, which ranged from 4.42 to 4.82. The least change was contributed by T_3 treatment. T_1 and T_2 demonstrated the least changes compared to uncoated dragon fruits and reported results for T1 were in the range of 4.38 to 4.75 and 4.37 to 4.73 for T_2. Statistically non-significant differences were demonstrated for T_3 treatment during the 0 to 10 days, demonstrating its shelf stability compared to other treatments.

pH of all the treated and untreated dragon fruit samples was reported to be increased. An increase in pH signifies the depletion of organic acid that are consumed during ripening process (Adetunji *et al*., 2014). The rise in pH could be because of the water loss in fruits while storage and this water loss also affects weight loss. Similar decrease in pH of strawberry stored at refrigerated storage at 6° C was studied by Nasrin *et al*., 2017.

Shelf Life

Dragon fruit's shelf life was evaluated and obtained results of study are demonstrated in following Table 7.

Table 7. Effects of guar gum- glycerol based edible coating on firmness of dragon fruit stored at refrigerated temperature (8 °C)

Treatment	Shelf life (Days)
T_1 (Guar gum 1% + 1 % glycerol)	28^{b}
T_2 (Guar gum 2% + 1 % glycerol)	29^{c}
T_3 (Guar gum 3% + 1 % glycerol)	32^{d}
T_4 (Uncoated)	26^{a}

The data are presented as mean ± sd (n= 3). According to Duncans multiple comparison test, values in rows with different superscript letters show significance differences ($p<0.05$). Conversely, values in rows sharing the same superscript do not exhibit significant differences ($p>0.05$). NA= Not Analysed.

Shelf life was observed to be highest for T3-treated dragon fruit at 32 days, as these treated dragon fruits exhibited greater retention of firmness and less variation in TSS, PLW, and pH acidity than that of the rest treatments. The shelf life of T3-treated dragon fruit was demonstrated to be statistically significant rather the rest of other treatments. The shortest shelf life of 26 days was observed for uncoated dragon fruits (T4). The shelf life of T1 and T2 dragon fruits was reported to be 28 days and 29 days, respectively.

According to previous studies when dragon fruit

Table 6. Effects of guar gum-glycerol based edible coating on pH of dragon fruit stored at refrigerated temperature (8 °C)

Treatment	Days						
	0	5	10	15	20	25	30
T_1	4.38 ± 0.011^{a}	4.41 ± 0.052^{ab}	4.51 ± 0.01^{bc}	4.59 ± 0.065^{cd}	4.65 ± 0.095^{de}	4.75 ± 0.045^{e}	NA
T_2	4.37 ± 0^{a}	4.39 ± 0.034^{a}	$4.47\ 0.06^{b}$	4.56 ± 0.02^{c}	4.63 ± 0.02^{d}	4.73 ± 0.03^{e}	NA
T_3	4.36 ± 0.02^{a}	4.37 ± 0.036^{a}	4.41 ± 0.05^{ab}	4.47 ± 0.055^{b}	4.57 ± 0.01^{c}	4.67 ± 0.034^{d}	4.74 ± 0.043^{e}
T_4	4.42 ± 0.034^{a}	4.45 ± 0.01^{a}	4.56 ± 0.03^{b}	4.64 ± 0.052^{c}	4.70 ± 0.034^{d}	4.82 ± 0.02^{e}	NA

The data are presented as mean ± sd (n= 3). According to Duncans multiple comparison test, values in rows with different superscript letters show significance differences ($p<0.05$). Conversely, values in rows sharing the same superscript do not exhibit significant differences ($p>0.05$). NA= Not Analysed.

stored at 5 °C in sealed polypropylene bags, untreated control dragon fruit maintained acceptable internal appearance and taste for up to 4 weeks, though external appearance deteriorated over time (Hoa *et al*., 2006)

CONCLUSION

The 3% guar gum + 1% glycerol coating (T3) showed best results, significantly reducing physiological weight loss, preserving firmness, and slowing changes in TSS, acidity and pH compared to uncoated control fruits. This treatment extended the shelf life of dragon fruits to 32 days, compared to 26 days for uncoated fruits. It can be concluded that composite coating at 3% can be effective post-harvest treatment for maintaining dragon fruit quality and extending marketability during refrigerated storage.

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