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The effect of turmeric extract on the physiological responses of golden dragon fruit during postharvest storage

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ABSTRACT

Golden dragon fruit (*Hylocereus megalanthus* L.) is an economically important tropical fruit belonging to climbing cacti, which are well adapted to tropical and subtropical environments and exhibit high drought tolerance. Despite its commercial value and nutritional benefits, postharvest quality deterioration remains a major challenge, leading to significant losses in texture, flavor, aroma, and shelf life. Turmeric (*Curcuma longa* L.) extract has been reported to possess antimicrobial and bioactive compounds, particularly curcuminoids, which may contribute to the preservation of fruit quality during storage. This study aimed to determine the optimal concentration of turmeric extract and to evaluate its effects on the postharvest quality of golden dragon fruit. The experiment was conducted in March 2025 at PT Daya Semesta Agro Persada, Banyuasin Regency, South Sumatra, Indonesia. Fruits were harvested at 30 days after anthesis and stored under controlled conditions at 26.50 ± 1.02 °C and 75.77 ± 5.45% relative humidity, with individual weights ranging from 350 to 500 g. A Completely Randomized Design with four replications was employed, and treatments consisted of turmeric extract dissolved in distilled water at concentrations of 0, 5, 10, and 15 g L^{-1}. Observed parameters included fruit texture, flavor, aroma, physiological weight loss, fruit decay (rotting), and shelf life. Results indicated that golden dragon fruits treated with the highest concentration of turmeric extract (15 g L^{-1}) and stored for nine days exhibited superior retention of texture, flavor, and aroma. Furthermore, this treatment significantly reduced physiological weight loss and fruit decay while effectively extending shelf life compared with lower concentrations and the control. The findings suggest that turmeric extract at 15 g L^{-1} is an effective postharvest treatment to maintain quality and prolong the shelf life of golden dragon fruit, providing practical implications for commercial production and storage management.

Keyword: golden dragon fruit, organoleptic, postharvest quality, shelf life, turmeric extract

ABSTRAK

Buah naga golden (*Hylocereus megalanthus* L.) merupakan buah tropis yang memiliki nilai ekonomi tinggi, tergolong kaktus merambat yang adaptif terhadap lingkungan tropis dan subtropis serta memiliki toleransi yang tinggi terhadap kekeringan. Meskipun bernilai komersial dan kaya nutrisi, penurunan kualitas pascapanen masih menjadi tantangan utama yang dapat menyebabkan kerusakan tekstur, rasa, aroma, dan masa simpan buah. Ekstrak kunyit (*Curcuma longa* L.) dilaporkan mengandung senyawa bioaktif dan bersifat antimikroba, terutama kurkuminoid yang berpotensi mempertahankan kualitas buah selama penyimpanan. Penelitian ini bertujuan untuk menentukan konsentrasi optimal

ekstrak kunyit dan mengevaluasi pengaruhnya terhadap kualitas pascapanen buah naga golden. Penelitian dilakukan pada Mei 2025 di PT Daya Semesta Agro Persada, Kabupaten Banyuasin, Sumatera Selatan, Indonesia. Buah dipanen pada 30 hari setelah antesis dan disimpan dalam kondisi terkontrol pada suhu 26,50 ± 1,02 °C dan kelembaban relatif 75,77 ± 5,45%, dengan berat buah 350–500 g per buah. Penelitian menggunakan Rancangan Acak Lengkap dengan empat ulangan, dan perlakuan berupa ekstrak kunyit yang dilarutkan dalam aquades pada konsentrasi 0, 5, 10, dan 15 g L^{-1}. Parameter yang diamati meliputi tekstur, rasa, aroma, kehilangan bobot fisiologis, kerusakan buah, dan masa simpan. Hasil menunjukkan bahwa buah naga golden yang diberi perlakuan ekstrak kunyit dengan konsentrasi tertinggi (15 g L^{-1}) dan disimpan selama sembilan hari mempertahankan tekstur, rasa, dan aroma dengan baik. Selain itu, perlakuan ini secara signifikan menurunkan kehilangan bobot fisiologis dan kerusakan buah serta secara efektif memperpanjang masa simpan dibandingkan dengan perlakuan lain dan kontrol. Temuan ini menunjukkan bahwa ekstrak kunyit dengan konsentrasi 15 g L^{-1} merupakan perlakuan pascapanen yang efektif untuk mempertahankan kualitas dan memperpanjang masa simpan buah naga golden, dengan implikasi praktis bagi produksi komersial dan manajemen penyimpanan.
Keyword: melon, organoleptik, mutu pascapanen, masa simpan, ekstrak kunyit

1. Introduction

Pitaya (dragon fruit) is an economically important tropical fruit belonging to the genus Hylocereus within the family Cactaceae (order Caryophyllales). Three species—Hylocereus undatus (red peel with white flesh), *Hylocereus monacanthus* or *Hylocereus polyrhizus* (red peel with red flesh), and *Hylocereus megalanthus* or *Selenicereus megalanthus* (yellow peel with white flesh)—are widely cultivated and commercially produced as emerging fruit crops in various countries (Xie et al., 2020). Species of Hylocereus are herbaceous, perennial, climbing cacti that are well adapted to tropical and subtropical regions and exhibit high tolerance to drought stress. The genus is native to southern Mexico, Guatemala, and Costa Rica (Arivalagan et *al.*, 2021).

Initially valued for its distinctive appearance and exotic appeal, dragon fruit has attracted increasing scientific interest due to its high content of bioactive phytochemicals, including flavonoids, phenolic compounds, anthocyanins, and betalains. These compounds are associated with antioxidant, anti-inflammatory, antimicrobial, and anticancer activities, thereby enhancing the potential of dragon fruit as a functional food (Chen et al., 2024).

Despite its nutritional and economic importance, dragon fruit is highly susceptible to postharvest quality deterioration. Such deterioration is influenced by physiological processes (e.g., respiration and ripening), environmental conditions (including elevated temperature and humidity), and microbial infection by fungi and bacteria, which collectively result in a substantial reduction in fruit economic value.

In Indonesia, dragon fruit has gained increasing popularity and is extensively cultivated across multiple regions. Banyuwangi Regency, East Java Province, is recognized as the largest dragon fruit–producing area in the country and serves as a major production center characterized by year-round yields supported by favorable agroclimatic conditions. Red-, white-, and yellow-fleshed (golden) cultivars are produced to meet both domestic and export market demands. However, in Banyuasin Regency, South Sumatra Province, where golden dragon fruit (*Hylocereus megalanthus* L.) cultivation has been initiated, postharvest storage has emerged as a major constraint, with farmers experiencing a marked decline in fruit quality during the storage period.

One promising approach to maintaining fruit quality and extending shelf life is maceration with turmeric (*Curcuma longa* L.) extract. Turmeric extract exhibits antimicrobial activity by disrupting microbial cell wall components and interacting with cell membranes, leading to increased membrane permeability, leakage of intracellular constituents, and inactivation of essential enzymes (Asniati et *al.*, 2023). Turmeric is derived from the rhizome of Curcuma longa and is widely consumed in countries such as China, India, and Iran, where it has traditionally been used for its anti-inflammatory properties (Núñez et al., 2020). Curcumin, a principal bioactive compound of turmeric, has been reported to possess broad-spectrum antifungal activity (Yang et al., 2022). Therefore, this study was conducted to identify the optimal concentration of turmeric extract and to evaluate its effects on the postharvest quality of golden dragon fruit.

2. Materials and Methods

2.1. Study site and plant material

This study was conducted in March 2025 at PT Daya Semesta Agro Persada, Banyuasin Regency, South Sumatra, Indonesia. Golden dragon fruit plants used in the experiment were 1.6 years old, and fruits were harvested at 30 days after anthesis. Fruit storage was carried out under controlled environmental conditions at a temperature of 26.50 ± 1.02 °C and a relative humidity of 75.77 ± 5.45%. Fruits selected for analysis weighed between 350 and 500 g and were classified as medium size (M).1. Introduction. It begins with general discussion. The first sentence of opening paragraph should make readers appeal and curious. Then, background of research and related previous of study are explained after opening paragraph and before end paragraph. This section logically links the existed research problems with the approach that is operated to solve the problem. Introduction ends with the aim and purpose of research or the activity and main research finding.

2.2. Experimental design and treatments

The experiment was arranged in a Completely Randomized Design with four replications. Treatments consisted of turmeric extract dissolved in distilled water at concentrations of 0, 5, 10, and 15 g L^{-1}. Medium-sized golden dragon fruits were used as experimental units.

2.3. Postharvest treatment procedure

Postharvest treatment with turmeric extract was performed using a maceration technique. Finely ground turmeric was macerated in distilled water to extract bioactive compounds, particularly curcuminoids. The fruits were subsequently immersed in the extract solution for 15 min using a container.

2.4. Observation parameters

Observed parameters included changes in fruit appearance, organoleptic attributes (texture, aroma, and taste), physiological weight loss (PWL), fruit decay, and shelf life. Visual changes in fruit characteristics were documented through photographic recording at fixed intervals in a designated location under stable lighting conditions. No color enhancement or modification was applied during image processing (Figure 1).

2.5. Organoleptic evaluation and physiological measurements

Organoleptic evaluation was conducted by 20 untrained panellists using different fruit samples. Measurements of physiological weight loss and fruit decay were carried out following the procedures described by Khairi et al. (2023).

2.6. Statistical analysis

Data were statistically analyzed using Analysis of Variance (ANOVA). When significant differences were detected, Tukey’s Honestly Significant Difference (HSD) test was applied as a post hoc analysis at significance levels of $\alpha = 0.05$, 0.01, and 0.001. Pearson’s correlation analysis, ANOVA, and post hoc tests were performed using Minitab version 22.

3. Results and discussion

Dragon fruit is a crassulacean acid metabolism (CAM) plant which is classified as a long-day plant with a critical light length of 12 hours/day (Widodo et al., 2020). Its consumption is gaining popularity due to its nutritious value, health benefits and ready market for export (Bordoh et al., 2020). Dragon fruit entering the harvest season is always susceptible to quality degradation during storage. Postharvest handling therefore plays an important role in maintaining the physical and nutritional quality of dragon fruit, particularly in reducing water loss, peel deterioration, softening, and microbial decay during storage. Appropriate storage treatments are needed to extend shelf life and preserve fruit freshness, marketability, and consumer acceptance. We illustrate the different treatments for dragon fruit during storage in Figure 1 below.

As shown in Figure 1, visible differences in fruit quality were observed among the treatments throughout the 9-day storage period. The control treatment (K0) showed faster quality deterioration, indicated by peel browning, shrivelling, and severe decay at the end of storage. K1 and K2 also exhibited progressive changes in peel appearance, with K2 showing pronounced tissue damage and decay on day 9. In contrast, K3 appeared to maintain a relatively better visual appearance, with lower symptoms of severe deterioration during storage. These observations suggest that the applied treatments influenced the ability of dragon fruit to retain its postharvest quality.

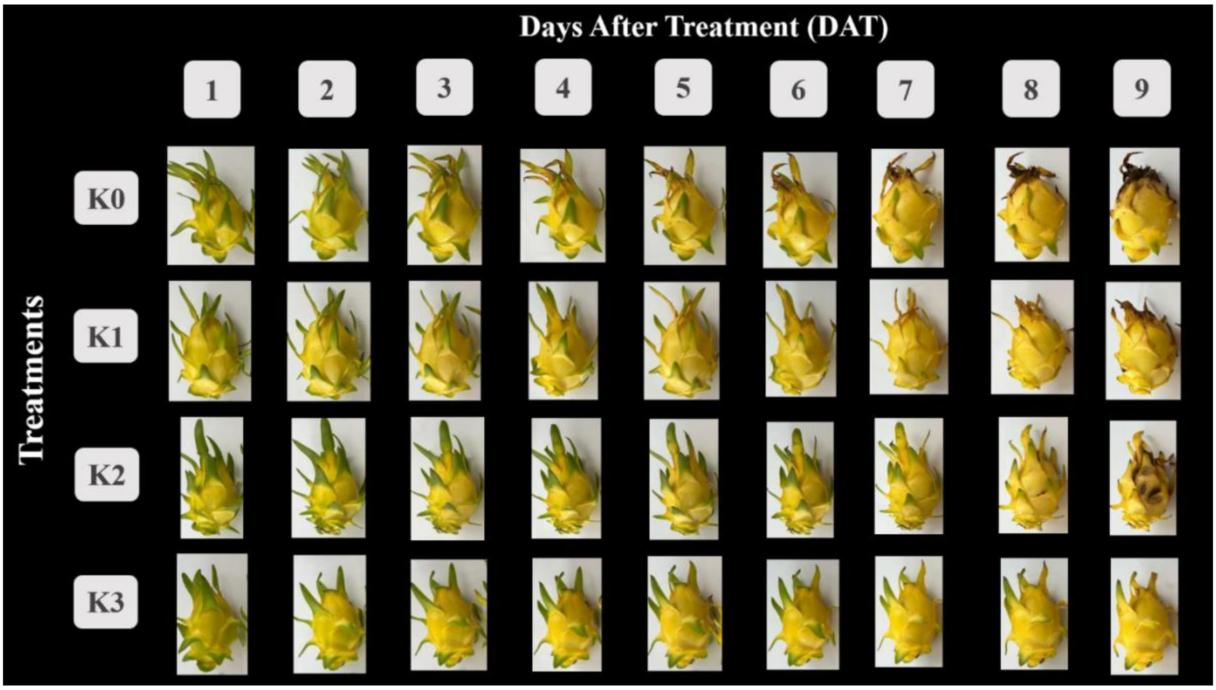

Figure 1. Developmental stages of golden dragon fruit from anthesis to harvest. Remarks: K0 = 0 g L^{-1}, K1 = 5 g L^{-1}, K2 = 10 g L^{-1}, K3 = 15 g L^{-1} of turmeric extract

The visual quality of golden dragon fruit treated with turmeric extract at a concentration of 15 g L^{-1} was effectively maintained throughout the storage period from day 1 to day 9, whereas control fruits exhibited a more rapid deterioration in appearance. This finding indicates that turmeric extract plays a role in delaying visual quality degradation during postharvest storage. Comparable results have been reported in previous studies on dragon fruit, particularly those involving preharvest treatments. Chang (2021) reported that preharvest application of forchlorfenuron (CPPU) significantly enhanced color retention, as indicated by the yellow index, in red-fleshed dragon fruit (*Hylocereus polyrhizus*) for up to 28 days after storage compared with untreated fruit. Similarly, Jiang et al. (2020) demonstrated that CPPU application effectively maintained fruit color by reducing the bract browning index for up to 20 days postharvest, an effect that was closely associated with reduced respiration rates and the subsequent preservation of fruit freshness.

The better visual appearance of fruit treated with 15 g L^{-1} turmeric extract was characterized by reduced browning and decay symptoms compared with the control treatment. In contrast, untreated fruits showed more apparent deterioration toward the end of storage, including browning of the bracts, shrinkage, and tissue damage. These changes commonly occur as a consequence of moisture loss, increased respiration, senescence, and microbial activity during postharvest storage. Therefore, maintaining the external appearance of dragon fruit is important because visual quality strongly influences marketability and consumer acceptance.

The effectiveness of turmeric extract may be associated with the bioactive compounds present in turmeric, especially curcumin and other phenolic constituents. These compounds are known to possess antioxidant and antimicrobial properties that may help suppress oxidative damage and inhibit the growth of spoilage microorganisms on the fruit surface. By reducing microbial development and slowing oxidation-related discoloration, turmeric extract may contribute to the preservation of peel and bract appearance during storage. This natural treatment could consequently provide an alternative to synthetic postharvest preservatives.

Overall, the results suggest that turmeric extract at 15 g L^{-1} has potential as a practical postharvest treatment for maintaining the visual quality of golden dragon fruit for up to nine days of storage. Although the present observation focused on external fruit appearance, further evaluation of weight loss, firmness, total soluble solids, titratable acidity, and microbial population would be useful to confirm the broader effect of turmeric extract on fruit quality and shelf life.

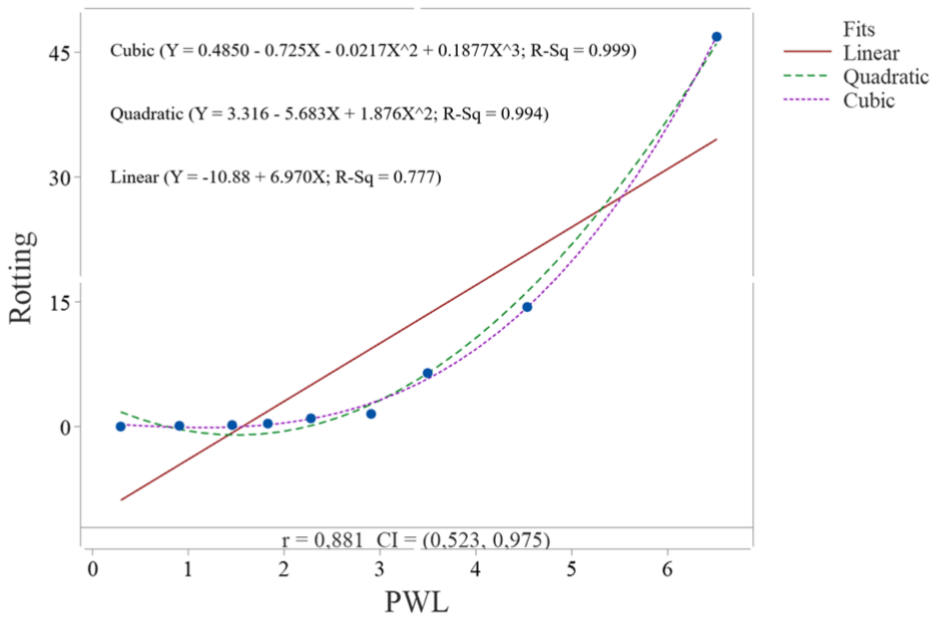

Figure 2. Relationship between physiological weight loss (PWL) and fruit rotting based on Pearson's correlation

A significant positive relationship was observed between PWL and fruit rotting, indicating that increases in PWL were consistently accompanied by greater rotting severity (Figure 2). This relationship was further supported by Pearson's correlation analysis, which revealed a strong positive correlation between the two variables ($r = 0.881$; CI = 0.523–0.975), demonstrating that higher levels of PWL are closely associated with accelerated fruit deterioration. Moreover, regression analysis showed that non-linear models described the relationship more effectively than the linear model. While the linear regression produced a moderate coefficient of determination ($R^2 = 0.777$), the quadratic ($R^2 = 0.994$) and cubic ($R^2 = 0.999$) models exhibited substantially higher goodness-of-fit values. Among these models, the cubic regression provided the best representation of the data, suggesting that fruit rotting increases disproportionately at higher levels of PWL.

Table 2. Effect of different concentrations of turmeric extract on the texture of golden dragon fruit

Days After Treatment (DAT)	Turmeric Extract			
	0 g/L	5 g/L	10 g/L	15 g/L
1 DAT	Solid	Solid	Solid	Solid
2 DAT	Solid	Solid	Solid	Solid
3 DAT	Solid	Solid	Solid	Solid
4 DAT	Solid	Solid	Solid	Solid
5 DAT	Solid	Solid	Solid	Solid
6 DAT	Solid	Solid	Solid	Solid
7 DAT	Slightly Soft	Solid	Solid	Solid
8 DAT	Slightly Soft	Slightly Soft	Slightly Soft	Solid
9 DAT	Slightly Soft	Slightly Soft	Slightly Soft	Slightly Soft

Remarks: Organoleptic evaluation for each treatment at each storage day involved 20 untrained panelists

Turmeric extract applied at a concentration of 15 g L^{-1} effectively preserved the texture of golden dragon fruit throughout the 9-day storage period (Table 1), indicating that higher concentrations of turmeric extract play a crucial role in maintaining postharvest fruit quality. In general, fruit softening commonly occurs during storage as a result of physiological and biochemical changes (Razali et al., 2021). One of the key factors influencing texture degradation is respiration rate, as higher respiratory activity accelerates metabolic processes and leads to faster softening (Kusumawati et al., 2018). Consistent with this mechanism, Kusumawati et al. (2018) reported a marked decline in firmness of untreated tomatoes during 7 days of storage, with texture values decreasing from 2.26 to 0.82 N. In contrast, tomatoes treated with edible film and turmeric extract maintained relatively stable firmness, ranging from 1.68 to 1.65 N, demonstrating the effectiveness of turmeric-based treatments in retarding textural deterioration during storage.

Table 3. Effect of different concentrations of turmeric extract on the taste of golden dragon fruit

Days After Treatment (DAT)	Turmeric Extract			
	0 g/L	5 g/L	10 g/L	15 g/L
1 DAT	Slightly Sweet	Slightly Sweet	Slightly Sweet	Slightly Sweet
2 DAT	Slightly Sweet	Slightly Sweet	Slightly Sweet	Slightly Sweet
3 DAT	Sweet	Sweet	Slightly Sweet	Slightly Sweet
4 DAT	Sweet	Sweet	Slightly Sweet	Slightly Sweet
5 DAT	Sweet	Sweet	Sweet	Slightly Sweet
6 DAT	Very Sweet	Sweet	Sweet	Sweet
7 DAT	Very Sweet	Very Sweet	Sweet	Sweet
8 DAT	Very Sweet	Very Sweet	Very Sweet	Sweet
9 DAT	Very Sweet	Very Sweet	Very Sweet	Very Sweet

Remarks: Organoleptic evaluation for each treatment at each storage day involved 20 untrained panelists

As shown in Table 2, turmeric extract applied at a concentration of 15 g L^{-1} effectively preserved the taste quality of golden dragon fruit during storage. Taste deterioration is a common manifestation of postharvest quality loss and is often associated with reduced consumer acceptability, particularly when fruits are subjected to prolonged transportation and distribution periods exceeding 7 days. The effectiveness of turmeric-based treatments in maintaining sensory attributes has also been reported in previous studies. Valizadeh et al. (2021) demonstrated that turmeric oil treatment significantly enhanced sensory taste scores of Agaricus bisporus compared with control throughout a 20-day storage period. Moreover, Nguyen et al. (2020) reported that hot water treatment induced significant changes in total soluble solids and titratable acidity during 6 days of storage of dragon fruit (Hylocereus undatus), reflecting alterations in fruit sweetness and acidity.

Table 4. Effect of different concentrations of turmeric extract on the aroma of golden dragon fruit

Days After Treatment (DAT)	Turmeric Extract			
	0 g/L	5 g/L	10 g/L	15 g/L
1 DAT	Weak	Weak	Weak	Weak
2 DAT	Weak	Weak	Weak	Weak
3 DAT	Moderate	Moderate	Weak	Weak
4 DAT	Moderate	Moderate	Weak	Weak
5 DAT	Moderate	Moderate	Moderate	Weak
6 DAT	Strong	Moderate	Moderate	Moderate
7 DAT	Strong	Strong	Moderate	Moderate
8 DAT	Strong	Strong	Strong	Moderate
9 DAT	Strong	Strong	Strong	Strong

Remarks: Organoleptic evaluation for each treatment at each storage day involved 20 untrained panellists

The application of turmeric extract at a concentration of 15 g L^{-1} was effective in maintaining the characteristic aroma of golden dragon fruit throughout the storage period (Table 3). In contrast, fruits subjected to the control treatment exhibited a more rapid decline in aroma quality during storage. This accelerated deterioration is likely attributable to endogenous ethylene production, which enhances ripening-related metabolic activity and leads to alterations in volatile compounds responsible for fruit aroma. Similar findings were reported by Valizadeh et al. (2021), who demonstrated that turmeric oil treatment significantly improved aroma sensory scores of Agaricus bisporus compared with the control over a 20-day storage period, highlighting the potential of turmeric-derived compounds in preserving postharvest aroma quality.

Table 5. Changes in physiological weight loss of golden dragon fruit as affected by turmeric extract concentration

Days After Treatment (DAT)	Turmeric Extract			
	0 g/L	5 g/L	10 g/L	15 g/L
1 DAT	0.30 ± 0.01 a	0.30 ± 0.00 a	0.30 ± 0.01 a	0.30 ± 0.01 a
2 DAT*	1.06 ± 0.15 a	0.75 ± 0.15 b	0.91 ± 0.02 ab	0.90 ± 0.02 ab
3 DAT**	1.53 ± 0.03 a	1.28 ± 0.12 b	1.52 ± 0.03 a	1.51 ± 0.03 a
4 DAT**	2.00 ± 0.16 a	1.59 ± 0.12 b	1.83 ± 0.04 ab	1.90 ± 0.11 ab
5 DAT***	2.46 ± 0.04 a	1.97 ± 0.13 b	2.46 ± 0.06 a	2.21 ± 0.11 ab
6 DAT***	3.18 ± 0.13 a	2.91 ± 0.15 ab	3.02 ± 0.13 ab	2.52 ± 0.11 b
7 DAT***	4.23 ± 0.10 a	3.55 ± 0.17 b	3.33 ± 0.13 bc	2.91 ± 0.10 c
8 DAT***	5.55 ± 0.09 a	4.84 ± 0.09 b	4.31 ± 0.13 c	3.47 ± 0.13 d
9 DAT***	7.95 ± 0.07 a	6.84 ± 0.07 b	6.47 ± 0.05 c	4.84 ± 0.08 d

Remarks: The number followed by the same letter on the same row has no significant difference based on Tukey's HSD test (* = α 0.05; ** = α 0.01; *** = α 0.001); mean ± standard deviation (n = 4)

During the initial phase of fruit storage (2 to 5 DAT), the application of turmeric extract at a concentration of 5 g L^{-1} proved to be significantly more effective in minimizing physiological weight loss (PWL). However, a shift in efficacy was observed during the later stages (6 to 9 DAT), where the 15 g L^{-1} concentration demonstrated superior results. These findings suggest that the physiological response of golden dragon fruit to turmeric extract concentrations is highly dependent on the duration of storage.

According to Kusumawati et al. (2018), the PWL in control tomato samples during a seven-day storage period ranged from 1.54% to 8.15%. In comparison, samples treated with an edible film enriched with turmeric extract exhibited a significantly lower PWL range of 0.56% to 5.56%. These findings indicate that the integration of turmeric extract into edible coatings effectively mitigates weight loss in stored produce. As established by Kusumawati et al. (2018), moisture loss is the leading cause of weight reduction during storage, which subsequently leads to diminished quality and increased susceptibility to damage in fresh produce.

A different case was also studied by Razali et al. (2021), who observed observed that PWL of red-fleshed dragon fruit (Hylocereus costaricensis) was significantly influenced by the application of a carnauba-based coating. After five days of storage, the treated fruit exhibited a PWL of 1.11%, a significant reduction compared to the 1.68% recorded in the control group. The reduction in fruit mass during the post-harvest period is predominantly attributed to water loss (Jiang et al., 2020). This physiological process leads to the contraction and thinning of the fruit peel, which significantly compromises the external quality of the produce.

Table 6. Changes in fruit rotting of golden dragon fruit as affected by turmeric extract concentration

Days After Treatment (DAT)	Turmeric Extract			
	0 g/L	5 g/L	10 g/L	15 g/L
1 DAT***	0.25 ± 0.04 a	0.00 ± 0.00 b	0.00 ± 0.00 b	0.00 ± 0.00 b
2 DAT***	0.26 ± 0.06 a	0.25 ± 0.05 a	0.00 ± 0.00 b	0.00 ± 0.00 b
3 DAT***	0.38 ± 0.10 a	0.50 ± 0.07 a	0.00 ± 0.00 b	0.00 ± 0.00 b
4 DAT***	0.75 ± 0.08 a	0.75 ± 0.04 a	0.00 ± 0.00 b	0.00 ± 0.00 b
5 DAT***	1.50 ± 0.06 b	2.75 ± 0.12 a	0.00 ± 0.00 c	0.00 ± 0.00 c
6 DAT***	3.25 ± 0.09 a	3.08 ± 0.86 a	0.00 ± 0.00 b	0.00 ± 0.00 b
7 DAT***	8.75 ± 0.07 a	9.03 ± 0.81 a	4.25 ± 0.09 b	3.75 ± 0.10 b
8 DAT***	20.5 ± 0.04 a	16.52 ± 0.82 b	17.05 ± 0.8 b	3.50 ± 0.12 c
9 DAT***	45.25 ± 0.08 b	63.51 ± 1.72 a	58.25 ± 4.61 a	20.25 ± 0.09 c

Remarks: The number followed by the same letter on the same row has no significant difference based on Tukey's HSD test (* = α 0.05; ** = α 0.01; *** = α 0.001); mean ± standard deviation (n = 4)

The incidence of decay in golden dragon fruit was significantly mitigated by the application of turmeric extract at a concentration of 15 g L^{-1} throughout the storage period (Table 5). In contrast, fruit rotting occurred predominantly in the control group and the 5 g L^{-1} treatment across all storage intervals. These findings indicate that the higher concentration of the extract provides a more consistent inhibitory effect against postharvest pathological breakdown.

Different research from Gbira et al. (2024) used aqueous turmeric extracts on mango (Mangifera indica L.). According to Gbira et al. (2024), aqueous turmeric extracts at concentrations of 10% and 25% (w/v) effectively suppressed the radial growth of pathogenic fungi, specifically Mucor sp., Colletotrichum sp., and Alternaria sp on mango. The study observed a dose-dependent relationship, where higher extract concentrations led to increased levels of inhibition. This antifungal activity is primarily attributed to the presence of diverse secondary metabolites—including alkaloids, saponins, tannins, steroids, phenols, flavonoids, hydrogen cyanide, and terpenoids—as confirmed by phytochemical screening (Gbira et al., 2024).

Fungal infections represent a primary constraint in the dragon fruit industry, often leading to significant postharvest losses (Nguyen et al., 2020). Research by Jitareerat et al. (2018) supports the efficacy of integrated management strategies, demonstrating that HWT (55°C for 5 min) coupled with 1% potassium sorbate significantly suppresses pathological symptoms on the fruit surface during refrigerated storage (13°C). As demonstrated by Chen et al. (2018), the extract of Curcuma longa contains essential phytochemicals such as phenols, flavonoids, and alkaloids, alongside saponins, tannins, and phytates. The presence of these metabolites underscores the extract's potential in providing antimicrobial and antioxidant protection.

Table 7. Changes in shelf life of golden dragon fruit as affected by turmeric extract concentration

Turmeric Extract	Shelf Life (days)***
0 g/L	6.50 ± 0.50 b
5 g/L	6.25 ± 0.43 a
10 g/L	7.25 ± 0.43 a
15 g/L	8.50 ± 0.50 c

Remarks: The number followed by the same letter on the same column has no significant difference based on Tukey's HSD test (* = α 0.05; ** = α 0.01; *** = α 0.001); mean ± standard deviation (n = 4)

The shelf life of golden dragon fruit was significantly extended by the application of turmeric extract at 15 g L^{-1} compared to all other treatments (Table 6). This concentration proved most effective in delaying senescence and maintaining the fruit's postharvest quality. The postharvest longevity of dragon fruit is frequently constrained by a combination of abiotic and biotic stressors. High ambient temperatures induce rapid respiration and ripening, while fungal infections—most notably anthracnose—serve as a primary cause of decay during the supply chain (Bordoh et al., 2020). Consequently, these factors significantly reduce the time available for effective transportation and marketing.

As highlighted by Asniati et al. (2023), the high-water content of dragon fruit (approximately 90%) renders it highly susceptible to rapid deterioration, with a storage life of fewer than 10 days even under refrigerated conditions (14°C). Such vulnerability underscores the necessity for advanced postharvest treatments. Implementing these techniques is crucial not only for prolonging shelf life but also for ensuring that the fruit's nutritional quality is preserved throughout the supply chain.

4. Conclusion

To sum up, golden dragon fruit treated with the highest concentration of turmeric extract (15 g L^{-1}) and stored for nine days showed superior preservation of texture, flavor, and aroma. Likewise, this treatment significantly reduced physiological weight loss and fruit decay and effectively extended shelf life compared with the other treatments.

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