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Molecular Characterization of Strawberry Mold and Antifungal Potential of *Psidium guajava* and *Laurus nobilis* Extracts for Post-Harvest Quality Preservation

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ABSTRACT

Postharvest decay, especially gray mold caused by *Botrytis cinerea*, severely restricts the shelf life of strawberries (*Fragaria* × *ananassa* Duch) and causes significant economic losses. This study investigated the potential of *Psidium guajava* (Pg) and *Laurus nobilis* (Ln) leaf extracts as natural antifungal agents, both individually and in an Arabic gum (GA) edible coating, to preserve strawberry quality. Phytochemical analysis showed that Pg extract was rich in phenolics (63.14 mg GAE/g), while Ln extract was higher in flavonoids (29.15 mg QE/g), both exhibiting significant antioxidant and antifungal characters against *B. cinerea*. In an in vivo trial, strawberries were treated and stored at 4°C for twelve days. The GA-Pg composite was the most effective. It reduced decay incidence (DI) to 42.22% and decay severity (DS) to 15.56%, representing a substantial improvement over the control fruit, which had a DI of 97.78% and DS of 58.33%. Furthermore, these composite treatments excelled at preserving critical quality attributes, including total soluble solids (TSS), titratable acidity (TA), ascorbic acid, and phytochemical content (total phenolics, flavonoids, and anthocyanins), thereby maintaining higher antioxidant capacity. At a molecular level, the GA-Pg and GA-Ln treatments significantly reduce the relative expression of pectin-degrading genes, pectin lyase (PL) and pectin esterase (PE), which are responsible for fruit softening. These findings demonstrate that a composite edible coating of Arabic gum with *P. guajava* or *L. nobilis* extract is a promising, eco-friendly postharvest strategy to control fungal decay, maintain the quality of fruit, and extend the life span of strawberries.

INTRODUCTION

Strawberries (*Fragaria* × *ananassa*) are highly valued for their nutritional quality, distinctive flavor, and abundance of bioactive compounds—such as anthocyanins, phenolic acids, and ascorbic acid—which confer strong antioxidant properties(Afrin *et al.*, 2016); Giampieri *et al.* (2012). Nevertheless, they are one of the most perishable fruits, short-lived due to their water content, fragile structure, and continuing metabolic process after harvest (Paniagua et al., 2014). The post-harvest quality degradation is mostly due to physiological water loss, softening, microbial decay, and fungal pathogens, which account for most quality loss during storage and transport (Feliziani and Romanazzi, 2016).

Botrytis cinerea is a fungus that has a broad range of hosts, invades a variety of growing crops as well as postharvest commodities, and thus, the pathogen could be easily encountered. The *B. cinerea* fungus stands in second place in the ranking of the world's top 10 pathogens considered for their scientific and economic significance (Dean *et al.*, 2012). It is estimated that the *B. cinerea* fungus may utilize as hosts more than 200 dicotyledonous crop species spread across the globe (Plesken *et al.*, 2021). Among the pathogens affecting strawberries postharvest, *B. cinerea* is viewed as one of the most frequent and significant (Romanazzi and Feliziani, 2014). It is one of those necrotrophic fungi that is very adaptable and infects fruits in the field or after harvest and handling, thereby resulting in fruit decay in a swift manner, which is characterized by soft rot, mycelial growth, and grayish conidiophores (Dean *et al.*, 2012). The molecular characterization of *B. cinerea* isolates has become the basis to understand the diversity of the pathogen, virulence mechanism, and to develop selective control strategies (Leroch *et al.*, 2013).

The use of chemical fungicides for the prevention of postharvest decay raises serious

concerns regarding the environment and human health due to their indiscriminate use; this has led to the quest for safer control options. In addition, consumers want to purchase fruits with very low pesticide residues or even those without any, which has encouraged the governments to tighten the import regulations concerning the maximum limits of chemical residues in the edible portion of fruits (Mari *et al.,* 2016; Riquelme *et al.,* 2021). Thus, the need for developing sustainable and eco-friendly alternatives for postharvest applications is growing, with emphasis on maintaining quality and food safety (Romanazzi *et al.,* 2017). Amongst the alternatives, natural plant extracts enriched with phenolic compounds have gained considerable interest as promising agents due to their inherent antimicrobial activities, antioxidant activity, and general recognition as safe (GRAS) status (Oms-Oliu *et al.,* 2010).

Leaves of *Psidium guajava* L. have been examined extensively for their rich phenolic composition, including flavonoids, tannins, and phenolic acids, exhibiting potent antimicrobial and antioxidant potential (Biswas *et al.,* 2013; Kumar *et al.,* 2021; Mazumder *et al.,* 2023). In addition, the leaves of *Laurus nobilis* L., bay laurel, have been found to contain a varied assortment of bioactive metabolites, especially flavonoids and phenolic acids which have present significant antifungal potency against several plant pathogens (Dobroslavić *et al.,* 2022). Extraction using hydro-ethanol of these bioactive compounds is quite effective in optimizing the recovery of phenolic compounds while preserving their biological activity (Mazumder *et al.,* 2023; Seo *et al.,* 2014). One of the innovative techniques to enhance the effectiveness and use of edible coatings like arabic gum in postharvest treatments is the incorporation of plant extracts into edible coatings (Ali *et al.,* 2010; Razak and Lazim, 2015). Edible coatings have achieved considerable attention as innovative packaging technologies that can enhance the shelf life of fresh produce while maintaining nutritional quality. Arabic gum (GA), a natural hydrocolloid obtained from *Acacia senegal* and *A. seyal*, has shown exceptional potential as an edible coating material as a result of its excellent film-forming attributes, biocompatibility, and ability to integrate bioactive substances (El-Anany *et al.,* 2009). Arabic gum, being a natural biopolymer, can form an excellent carrier matrix for bioactive compounds and provide some extra barriers against moisture loss and pathogen invasion (Anjum *et al.,* 2020; Tiamiyu *et al.,* 2023). Edible coatings combined with plant extracts have had synergistic effects towards extending the storage period while still maintaining physicochemical quality parameters of fruits (Shiekh *et al.,* 2013).

Multiple previous studies have highlighted the potency of different plant extracts individually in the management of post-harvest diseases (Kebriti *et al.,* 2025; Wang *et al.,* 2024; Yang *et al.,* 2022). Nevertheless, not much research has included the comparative evaluation of *P. guajava* and *L. nobilis* extracts for strawberry preservation. This study set out to develop and validate a natural, consumer-safe postharvest treatment that can control gray mold and extend the durability of strawberries stored at 4 °C. Specifically, we aimed (i) to isolate and molecularly characterize local *Botrytis cinerea* strains from diseased strawberries, (ii) to determine the in-vitro antifungal potency of polyphenol-rich ethanolic extracts obtained from *Psidium guajava* and *Laurus nobilis* leaves against these isolates, (iii) to evaluate, the in-vivo efficacy of these polyphenol extracts and arabic gum-incorporated extract formulations on decay, physicochemical quality, antioxidant status, and expression of pectin-degrading genes of stored fruits of strawberry. thereby contributing to reduced food waste and promoting food security.

MATERIALS AND METHODS

1. Leaf extract preparations.

Samples of 200 g of leaves were ground and macerated in 2 L of 70% ethanol for 48 h. at room temperature to prepare extracts of *P. guajava* and *L. nobilis* leaves. After 48 h, the extract was filtered using Whatman filter paper No. 4, and the filtrates were concentrated with a rotary evaporator at 50°C. The obtained filtrates were freeze-dried (Labconco, MO, USA) and stored at -18 °C for analysis and assay(Aamer *et al.,* 2025).

2. Phytochemical analysis and antioxidant activity

2.1. Total phenolic content (TPC)

The Folin-Ciocalteu procedure of Singleton and Rossi (1965) was maintained to evaluate the phenolic compound contents in the samples with some modifications. The 1 mL portion of each extract was diluted with 2 mL of distilled water and 0.5 mL of Folin-Ciocalteu reagent (Sigma Co.), and after standing for 3 minutes, 0.5 mL of 10% Na_2CO_3 solution was added and stood in the dark for 1 h. The absorbance was recorded at 760 nm (Jasco V-530). Standard gallic acid was used, and results were presented as mg gallic acid equivalent (GAE)/g.

2.2. Total flavonoid content (TFC)

The flavonoid content was estimated following Aryal *et al.* (2019). A 1-mL portion of the extract was mixed with 1 mL of 10% aluminum chloride, 0.1 mL of potassium acetate solution, and 4.3 mL of 80% ethanol. After 40 minutes of standing in the dark, absorbance was read at 415 nm (Jasco V-530). TFC was calculated using quercetin as a standard, and results were presented as mg quercetin equivalent (QE)/g.

2. 3. DPPH scavenging assay

The scavenging activity of extracts on 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) was measured following the method developed by Chu *et al.* (2000). Leaf extract (1 mL) was added to a DPPH-methanol solution (0.05 mg/mL, 2 mL). The decline in absorbance at 517 nm was recorded. The scavenging activity is calculated using the following equation:

$$\text{DPPH Scavenging activity (\%)} = [1 - A_s/A_c] \times 100$$

where A_s is the abs. of the sample solution and A_c is the abs. of the DPPH. solution before adding the extract.

2.3 Gray mold isolation and molecular characterization

Three isolates named BC010, BC011, and BC012 of *B. cinerea* were successfully obtained from the naturally infected strawberries displaying symptoms such as soft rot, brown lesions, and the existing of gray sporulation characteristic of gray mold. Infected tissue pieces were surface sterilized with 70% ethanol and 1% NaOCl, followed by plating them into potato dextrose agar (PDA) media supplemented with streptomycin and chloramphenicol. After 5-7 days of incubation at 22°C, emerging fungal colonies displayed typical morphological characters of B. cinerea—a gray-brown mycelium—and were purified through a single-spore purification technique.

For molecular identification, genomic DNA was extracted from the purified isolates, and the internal transcribed spacer (ITS) region of ribosomal DNA was amplified using the universal primer pair ITS1/ITS4 (White et al. 1990). The PCR reaction was performed in a 25 µL mixture containing 12.5 µL of PCR Master Mix, 8.5 µL of sterile distilled water, 1 µL of each primer (10 pM), and 2 µL of genomic DNA (50 ng). PCR conditions were applied as previously described by Gaber et al., (2020). The amplified products were visualized using 2% agarose gel electrophoresis and then sent for sequencing at Macrogen Inc. (Seoul, South Korea). The obtained sequences were analyzed using the BLAST tool from NCBI to confirm identity. Phylogenetic analysis was conducted using MEGA11 software, applying the neighbor-joining method with bootstrap values calculated from 1,000 replicates to ensure reliability.

2.4 In-vitro antifungal activity

Antifungal evaluation was done through the poisoned food technique (Grover and Moore, 1962). The leaf extract was incorporated into PDA medium in doses of 1, 2, 4, 6, and 8% (w/v). A 5-mm mycelial disc was cut from a 7-day-old *B. cinerea* isolate colony and was placed centrally on each plate. For each isolate, control plates were prepared without extract. The plates were cultured in dark conditions at 22°C, and then radial growth was determined when the control plates had been completely covered. Percent inhibition of mycelial growth was estimated using the following equation:

$$\text{Radial growth inhibition (\%)} = \frac{\text{Control colony diameter (mm)} - \text{treatment colony diameter (mm)}}{\text{control colony diameter (mm)}} \times 100$$

2.5 Postharvest trial

2.5.1 Preparation of coating solutions

Arabic gum (Loba Chemie Co., food grade) was dissolved in sterilized distilled water (SDW) to make a 5% w/v concentration. The solution was stirred with mild heat (50°C) for 1 h on a magnetic hot plate (HT-1003) and then filtered through a vacuum flask to separate undissolved impurities. Once cooled down to 30 °C, 1.0% glycerol was integrated as a plasticizer. The pH of the solutions was adjusted to 5.6 using 1 N sodium hydroxide; this solution was named gum Arabic solution (GA). Leaf extract at 8% w/v of Arabic gum solution was added to the prepared GA solution and fully blended using a homogenizer for 10 min. The prepared GA solution incorporated with *P. guajava* leaf extract, named GA-Pg, and the GA solution incorporated with *L. nobilis* leaf extract, named GA-Ln, the solution of *P. guajava* leaf extract in distilled water and 1% glycerol, named Pg, and the *L. nobilis* leaf extract in distilled water containing 1% glycerol, named Ln. Distilled water containing 1% glycerol was considered for the control CK treatment.

2.5.2 Strawberry preparation and coating treatments

Strawberry fruits (*Fragaria ananassa* Duch) were brought to commercial maturity from an orchard located on the Alexandria-Cairo Desert Road, Egypt. The intact fruits were selected for standard consistency in maturity and size. The strawberries were dipped in a 1% NaOCl solution for 1 min. and cleaned with SDW after that, dried for 30 mins. at room temperature in a biosafety hood. Strawberry fruit was allocated randomly to six treatments with five replicates of 15 strawberries per group; two groups were used for sampling from each treatment, and three replicates for estimating decay and weight loss. Each treatment group then underwent a 3-minute dip in the solution of The treatments were GA, GA-Pg, GA-Ln, Pg, Ln, and Ck; the samples were allowed to drip off excess solution and air-dried before inoculation with 1 x 10^6 spores/mL of the *B. cinerea* BC-012 isolate, which were applied by hand spraying (3 mL for each of the treatments and Ck). The strawberry samples were then dried in the biosafety cabinet for 1 h, packed in plastic boxes covered with polythene films, and maintained under refrigeration at 4°C and relative humidity (> 90%) for twelve days in darkness. Samples were captured on days 0 and 3 day interval up to 12 days, then the parameters for the strawberry fruit were evaluated.

2.5.3. Decay evaluation

During the storage, and at 3-day intervals, disease incidence (DI) was monitored as the percentage of strawberries that had decay symptoms (Eq. 1). Disease severity (DS) was furthermore monitored according to a scale composed of five degrees. 0, healthy fruit; 1, 1–25% fruit surface infected; 2, 25–50% fruit surface infected; 3, 50–75% fruit surface infected; 4, more than 75% of the strawberry surface infected (Eq. 2) (Feliziani *et al.*, 2015; Rongai *et al.*, 2018).

$$Disease\ Incidance\ (\%) = \frac{deacayed\ fruit}{total\ No.of\ fruit} \times 100$$

Eq. 1

$$Disease\ severity\ (\%) = \frac{\sum(S \times N)}{(T \times df)} \times 100$$

Eq.2

Where; S severity scale, P number of fruit in the scale, M total observed fruit, N degree of freedom of severity scale (5-1=4)

2.5.4 Fruit quality parameters

2.5.4.1 Weight loss

Strawberry fruit weight loss under storage conditions and different treatments was estimated by the following formula: Weight loss% % is calculated using the formula (a-b/a) x100, where a represents the initial weight and b represents the weight of the same group after various storage intervals (AOAC, 2000).

2.5.4.2 Total soluble solids (TSS), Titratable acidity (TA), pH, and Ascorbic acid content

Strawberry purees were picked on a refractometer (PR-1, Atago Co., Japan) at 20°C, and readings were recorded in °Brix. Titratable acidity (TA) was estimated by titrating strawberry juice with (0.1 N) NaOH in existence of Phenolphthalein, and the results were presented as citric acid percent equivalent (Wani *et al.*, 2021). The pH was estimated with a pH meter (Toledo, ON, USA). The ascorbic acid content was estimated as per the procedure of AOAC (2000) using the dye 2,6-dichlorophenol-indophenol (DCPIP).

2.5.4.3 Total phenol, total flavonoid, total anthocyanin content, and radical antioxidant capacity

Strawberry fruit samples at each interval time were extracted in acidified methanol (0.1% HCl), subsequently stood in the refrigerator for 60 min before filtration and centrifugation at 12,000 × g for 15 min at 4°C to acquire supernatant as fruit extract. Total phenolic content (TPC) was estimated utilizing the Folin–Ciocalteu procedure (Singleton and Rossi, 1965). TPC is calculated as mg GAE per 100 g fresh weight. Total flavonoid content (TFC) was estimated utilizing the aluminum chloride procedure outlined by Aryal *et al.* (2019) and calculated as mg QE per 100 g fresh weight. Total anthocyanin content (TAC) was estimated utilizing the pH difference procedure described by Kara and Erçelebi (2013). The absorbance was recorded at 510 nm and 700 nm in buffers at pH 1.0 and 4.5. The outcomes were manipulated as mg pelargonidin 3-glucoside (P3-G) equivalents per 100 g fresh weight. Radical scavenging activity (RSA) was estimated to reflect the total antioxidant capacity of fruit samples at various storage times and treatments using fruit extract and the 2,2-diphenyl-1-picryl-hidrazil (DPPH) radical-scavenging procedure as outlined by Chu *et al.* (2000); those findings were depicted as the radical scavenging activity percentage (RSA%).

2.5.4.4 Pectin lyase (PL) and Pectin esterase (PE) *gene expression analysis*

Strawberry tissues were frozen in nitrogen for 1 h and milled in a mortar to a powder state using a pestle. Total RNA extraction was carried out according to the hot borate method. Pure RNA was quantified by measuring absorbance at 260 nm. Pure RNA was treated with RNase-free DNase (Promega Biotech Ib´erica. Madrid, Spain) before reverse transcription into cDNA by AMV Reverse Transcriptase (Takara, Dalian, China). The dilutions of corresponding cDNA were used as templates for qRT-PCR.

qRT-PCR amplification was conducted with gene-specific primers (Table 1) He *et al.*, 2019). The internal control used for all strawberry genes was 26S–18 S. Each PCR reaction was performed in triplicate for each sample and amplification reactions were set up in a total volume of 20 *L containing 5* L cDNA, 25 p mol of specific primers, and 10 µL of Power SYBR Green PCR Master Mix (Applied Biosystems) following the manufacturer's instruction. Each PCR run was carried out using the ABIVeriti (Applied Biosystems, USA) for 2 min at 95◦C and then for 40 cycles as follows: 5 s at 95◦C, 10 s at 58◦C, and 10 s at 72◦C.

Table 1: Primers utilized for qRT-PCR of pectin lyase (PL) and pectine esterase (PE) genes.

Name of gene	Sequence of the 5–3 primers, forward/reverse
Pectin lyase (PL)	CTCGTTTGCGTATCGG TGCGTGCTCATTCCA
Pectin esterase (PE)	TTGGACCACATTTCGC GGTCGGCTCATCTTTGT
26S-18S (housekeeping gene)	ACCGTTGATTCGCACAATTGGTCATCG TACTGCGGGTCGGCAATCGGACG

Specificity of the PCR amplification was verified using melt curve analysis. Relative expression levels were then calculated using the 2-ΔΔCt method.

2.6 Statistical analysis

All experimental outcomes underwent one-way analysis of variance (ANOVA) utilizing Minitab software (v. 21.1). Mean separations were achieved via Tukey's Honestly Significant Difference (HSD) test at a significance level of $p < 0.05$. Each experiment was conducted in triplicate (n = 3), and results are presented as mean ± standard deviation (SD). Visual representations were created utilizing GraphPad Prism (version 10.5).

RESULTS AND DISCUSSION

1. Phytochemicals content and antioxidant activity of leaf extracts

Phytochemical analyses carried out on *P. guajava* (Pg) and *l. nobilis* (Ln) leaf extracts revealed a difference in their bioactive compounds (Table 2). The extract of *P. guajava* had much greater total phenolic content, 63.14 mg GAE g $^{-1,}$ than that of *L. nobilis*, 44.90 mg GAE g $^{-1}$. In contrast, *L. nobilis* had a larger total flavonoid content of 29.15 mg QE g^{-1} compared with that of *P. guajava*, 21.62 mg QE g^{-1}. RSA% % value was also observed to be significantly high ($P < 0.05$) in *P. guajava*, 68.51% as compared to *L. nobilis*, 56.35 %. The findings corroborate earlier studies that pointed out guava leaves are rich in diverse phenolic compounds such as quercetin, catechin, and epicatechin (Venkatachalam *et al.*, 2012); whereas, Alejo-Armijo *et al.* (2017) pointed out that the primary phenolic constituents of alcohol extracts of laurel leaf are flavonoids mainly apigenin, kaempferol, quercetin, and their glycosides are also frequently encountered.

3.2 In-vitro antifungal potency and molecular characterisation of B. cinerea.

Three isolates of *B. cinerea*, designated BC010, BC011, and BC012, were successfully obtained from naturally infected strawberries that showed symptoms of gray mold, such as soft rot and brown lesions. To confirm the identity of the fungal isolates, genomic DNA was extracted, and the internal transcribed spacer (rDNA-ITS) region was amplified via PCR. This region was commonly used for fungal identification.

The resulting DNA sequences were analyzed using the BLAST tool at the National Center for Biotechnology Information (NCBI) to confirm their identity as *B. cinerea* with a similarity percentage of 100% and an e-value of zero. A phylogenetic tree was then constructed to visualize the genetic relationships among the isolates (Figure 1).

Table 2: Total phenolic content (TPC), total flavonoid content (TFC), and DPPH b radical scavenging activity of *P. guajava* and *L. nobilis* leaf extracts.

Extracts	TPC (mg GAE g^{-1})	TFC (mg QE g^{-1})	DPPH˙ RSA (%)
Psidium guajava	63.14 ± 1.92 [a]	21.62 ± 2.32	68.51 ± 2.87
Laurus nobilis	44.90 ± 2.06 [b]	29.15 ± 1.79	56.35 ± 2.40

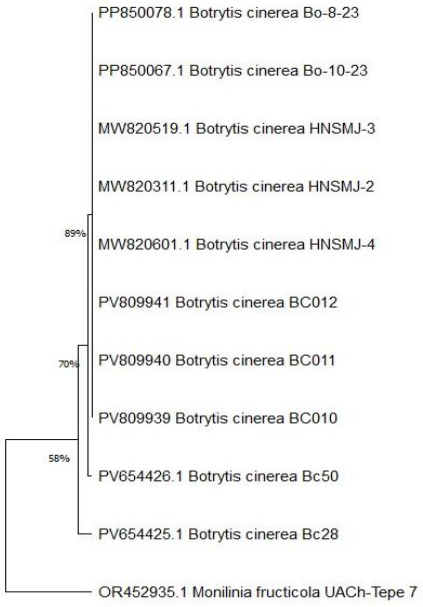

Figure 1: Phylogenetic tree of *B. cinerea* via internal transcribed spacer (ITS) region that was generated using neighbor joining in MEGA11.

Table 3: Inhibitory effect of *P. guajava* and *L. nobilis* leaf extracts on the radial growth of three *B. cinerea* isolates.

Leaf extract	Conc. [% w/v]	*B. cinerea* inhibition (%± SD)		
		(BC010)	(BC011)	(BC012)
P. guajava	1	7.78 ± 1.11^{c}	10.37 ± 1.70^{e}	9.63 ± 1.28^{e}
	2	14.82 ± 1.70^{d}	19.63 ± 1.28^{d}	20.37 ± 1.28^{d}
	4	24.07 ± 1.28^{c}	29.63 ± 1.28^{c}	26.30 ± 1.28^{c}
	6	32.22 ± 1.11^{b}	42.22 ± 1.11^{b}	37.78 ± 1.11^{b}
	8	40.74 ± 1.28^{a}	54.82 ± 1.28^{a}	51.48 ± 1.70^{a}
L. nobilis	1	2.59 ± 1.28^{e}	3.33 ± 1.92^{e}	2.59 ± 2.31^{e}
	2	16.67 ± 1.92^{d}	21.11 ± 1.92^{d}	9.63 ± 1.28^{d}
	4	21.85 ± 2.31^{c}	27.04 ± 1.70^{c}	16.30 ± 2.31^{c}
	6	31.85 ± 1.70^{b}	34.07 ± 1.70^{b}	29.26 ± 1.70^{b}
	8	40.00 ± 1.92^{a}	43.33 ± 2.94^{a}	35.93 ± 1.70^{a}

For each extract, mean inhibition values within the same column followed by the same letter are not significantly different. All comparisons were made using Tukey's HSD test ($p > 0.05$).

This was done using MEGA11.0 software, employing the neighbor-joining method, a common algorithm for building phylogenetic trees. The reliability of the tree's branching patterns was tested using a bootstrap analysis, with values greater than 70% considered significant.

In the in vitro antifungal activity analysis using the poisoned food technique, both Pg and Ln extracts display significant, dose-dependent antifungal activity toward the isolated *B. cinerea* strains (Table 3). There are significant variations ($p < 0.05$) among the fungal isolates, which reflect the impact of *B. cinerea* strains' molecular variations on the antifungal potency of leaf extracts. This molecular variation between isolates impacts the reported in *Fusarium oxysporium f. sp. lycopersici* (Gaber *et al.*, 2025). This efficacy is attributable to the phytochemicals identified; phenolic and flavonoid compounds are known to disrupt fungal cell membrane integrity, inhibit crucial enzymes, and interfere with cell wall synthesis, thereby hindering pathogen growth (Konuk and Ergüden, 2020). These results align with reports from Biswas *et al.* (2013) and Güler *et al.* (2018), who confirmed the antimicrobial properties of Pg and Ln extracts, respectively.

Postharvest trial

Decay incidence (DI) and decay severity (DS)

The impact of the treatments on the percentage of infected fruits (decay incidence DI) and the extent of fungal growth on the fruit surface (decay severity DS) was evaluated. Strawberry postharvest physiological functions and highly perishable characteristics constrain its durability period (García *et al.*, 1998). The results, presented in Figures 2a & 2b, demonstrate DS and DI, respectively, of control and treated strawberries. Both CK and coated strawberry fruit demonstrate an elevation in DI over the storage period. But the control fruit revealed significantly ($P \leq 0.05$) high DI, reaching 97.78%, and DS, reaching 58.33%, by the end of 12 days of the storage duration. All treatments significantly suppressed fungal infection on strawberry fruits ($p < 0.05$). The composite coatings containing GA and extract showed the strongest protective impact. The GA-Pg treatment limited DI to 42.22% and DS to 15.56% after 12 days. The GA-Ln treatment also performed well, showing 51.11% DI and 19.44% DS. Specifically, at day 9, the GA-Pg treatment kept DS at a low 7.78%, significantly outperforming all other treatments. The statistical analysis underscores the significant impact of the treatments, after 12 days of storage, on controlling decay severity ($p < 0.05$). This potent decay prevention effect can be attributed to a synergistic mechanism combining the physical barrier of the arabic gum with the antifungal characteristics of the botanical extracts (Bordoh *et al.*, 2022; Wani *et al.*, 2021). Biochemical properties of the plant extracts. *P. guajava* and *L. nobilis* leaves are rich sources of phenolic and flavonoid compounds, which have antifungal properties and thoroughly documented antimicrobial capabilities (Biswas *et al.*, 2013; Güler *et al.*, 2018; Kareem and Kadhim, 2024). These compounds can disrupt fungal cell membranes and inhibit crucial enzymatic activities, thereby hindering pathogen growth (Konuk and Ergüden, 2020; Nazzaro *et al.*, 2019). GA also acts as a carrier for sustained release of these antimicrobial compounds (Khaliq *et al.*, 2015). These outcomes correspond with Wani *et al.* (2021), who stated that GA reduces decay percentage up to 15.19% after eight days of strawberry storage compared to 55.42% in the control treatment. In addition to several studies in other fruits which established that the GA coating, whether used alone or conjunction with other preservative ingredients diminishes postharvest deterioration and preserves the generally postharvest quality of harvested fruits including banana, papaya, mango, tomato, ponkan fruits, and guava fruits (Huang *et al.*, 2021; Tahir *et al.*, 2020). Comparably, Zhang *et al.* (2010)

documented that pomegranate peel extract possesses the capability to manage strawberry gray mould and get in-vivo DS and DI at 29.33 and 66,6%, respectively, for both of which are significantly lower than 74.66 and 93.33% acquired in the control. which aligns with our findings showing substantial reductions in Pg and Ln extract treatments.

Weight loss

Weight loss occurs when fruits lose moisture at the outer layer to the environment. Among those fruits, strawberries exhibit higher losses due to having very thin skins as a protective layer. In storage, the results indicated an increment in weight loss over storage time (Figure 2c); control fruit also showed the highest weight loss, i.e., 13.25% on day 12 of storage, while the coating treatments were fewer weight loss, viz 8.75 to 9.61% for the Pg and Ln extracts, whereas the composite treatments contain GA and GA-infused extract GA-Pg and GA-Ln showed lower weight loss ranging from 4.36 to 5.33% at the 12th day of the storage duration. Out of the treatments, GA-Pg showed the least loss in weight, 4.36%, followed by GA-Ln and GA at the 12th day of storage. According to Maqbool *et al.* (2011) and Tiamiyu *et al.* (2023), reduced fruit weight loss is because the applied films on fruit skin form semipermeable barriers that restrict moisture transfer; thus, it slows down water loss. GA-Pg and GA-Ln showed synergistic effects when combined because the polyphenols in P. guajava and L. nobilis improved the integrity of the films and their antioxidant capacity, thus reducing the metabolic rates (Vu *et al.*, 2011). These observations correspond with Tahir *et al.* (2018), who documented that gum arabic coatings significantly retarded weight loss in cold-stored strawberries. The 10 and 15% GA coatings significantly decreased fruit deterioration and weight loss.

Total soluble solids (TSS)

TSS content, a key quality factor in fruits, quantify sugar concentrations that directly influence taste and consumer acceptance (Fan *et al.*, 2022). In this investigations, the TSS levels decreased through consumption of sugars as substrates for respiration by all treatments in the 12-day postharvest period (Figure 3a). The loss of TSS was most prominent in control (CK) fruits, which recorded the minimal TSS of 6.12 °Brix on day 12. On the contrary, all postharvest treatments significantly reduced TSS losses ($p < 0.05$). Composite coatings were the postharvest treatments most capable in retaining sugars; GA-Pg and GA-Ln treatments maintained the highest TSS of 7.31 °Brix and 7.10 °Brix, respectively, at the end of storage. The preservation of sugars is directly linked to the function of edible coatings acting as semi-permeable barriers on the fruit surface. The coating modifies the internal atmosphere and reduces the rate of gas exchange, thereby reducing the overall metabolic and respiratory activity of the fruit. Since sugars are the main fuel for respiration, a reduced rate of respiration results in slower depletion of sugars, contributing to high TSS content. These findings coincide with the outcomes of Ali *et al.* (2010) and (Qamar *et al.*, 2018) showed that gum Arabic- and alginate-based edible coatings can effectively preserve TSS of strawberries by stunting their metabolic process.

These outcomes corroborate the results of prior investigations that demonstrated the ability of edible coatings to reduce sugar metabolism and maintain fruit quality. The work done by Gol *et al.* (2013) on gum arabic coatings on strawberries showed a significant maintenance of TSS during storage, while Hernandez Monoz *et al.* (2008) exhibited that chitosan-based coatings incorporated with natural extracts promote the maintenance of the soluble solids of strawberries. Polyphenolic compounds from the extracts of *P. guajava* and *L. nobilis* may have acted to preserve the soluble solids through the mitigation of oxidative processes and the preservation of the integrity of cellular structures (Morais-Braga *et al.*, 2016).

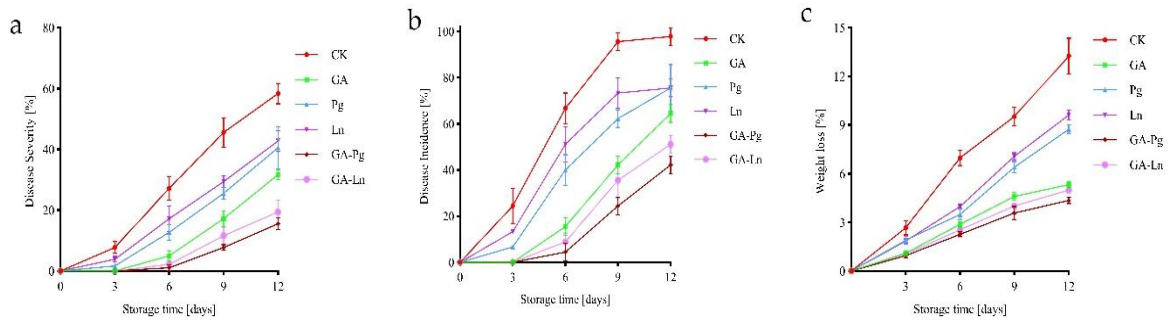

Figure 2:The effect of postharvest treatments on (a) disease severity, (b) disease incidence, and (c) weight loss of strawberry fruit during 12 days of storage. Treatments were: CK (control), GA (gum Arabic), Pg (*Psidium guajava* leaf extract), Ln (*Laurus nobilis* leaf extract), GA-Pg (gum Arabic with Pg extract), and GA-Ln (gum Arabic with Ln extract). Data points depict the mean, and error bars represent the standard deviation (SD).

Titratable acidity (TA)

The titratable acidity gradually diminished across all treatments during storage (Figure 3b). The treatment GA-Ln exhibited the highest acidity-stabilizing effect in retaining 0.32% of acids at day 12, followed closely by GA-Pg with 0.31%. The control was the treatment to witness the steepest decline in acidity, having decreased to 0.20% by day 12, thus showing a 59.2% reduction from initial values. Individual extract treatments (Ln and Pg) were shown to perform better than the control, but not as well as the combined GA treatments. The retention of acidity is critical in aroma perception and the inhibition of microbial growth in strawberries. Velickova *et al.* (2013) reported similar findings, stating that chitosan coatings augmented with plant extracts better preserve strawberries' titratable acidity than uncoated ones. Organic acids present in strawberries, mainly citric and malic acids, are tendency to degradation through enzymatic destruction and respiratory metabolism (Aday *et al.*, 2013). The activity of the leaf extracts used in this study may act through their antioxidant properties to hinder the metabolic degradation of these organic acids by inhibiting the enzymes involved.

Ascorbic acid content

Vitamin C varies significantly in content preservation among treatments (Figure 3c). After day 3, highly significant differences were instituted between treatments ($p < 0.05$). The GA-Ln treatment exhibited the best retention of vitamin C level at 43.18 mg/100g by day 12 (20.3% loss), followed closely by GA-Pg at 42.04 mg/100g (22.9% loss). The control exhibited the worst vitamin C retention, which was down to 21.70 mg/100g by day 12, showing a decline of 60.0% of the initial total amount. Vitamin C degradation in fruits is mainly due to enzymatic oxidation, particularly ascorbate oxidase, while others prevail by non-enzymatic reactions that consume oxygen and light (Lee & Kader, 2000). The protection seen from the combined treatments corroborated results found by Nasrin *et al.* (2017) and Nasrin et al. (2020) that gum Arabic coatings enriched with natural antioxidants could significantly reduce ascorbic acid losses in strawberries. The stabilization of vitamin C by extracts of guava and bay laurel appears to occur by scavenging free radicals and alleviating oxidative stress, owing to their high antioxidant capacity due to rich polyphenolic contents (Flores *et al.*, 2015; Mrabet *et al.*, 2024).

pH

Strawberry pH increased significantly during storage (Figure 3d), with the control (Ck) exhibiting the most emphasized increase in pH (4.05 by day 12). All treatments significantly mitigated pH elevation ($p < 0.05$), particularly GA-Pg (3.78) and GA-Ln (3.82), which maintained the lowest pH at termination. This stabilization is biologically significant, as pH increase correlates with tissue degradation and microbial proliferation (Hernandez Monoz *et al.*, 2008). The superior pH stability in GA-plant extract composites is attributable to that GA, as a gas barrier, reduces respiration and causes CO_2 accumulation (Ali *et al.*, 2010), and polyphenolic acids in *P. guajava* and *L. nobilis* buffer pH shift through carboxyl group dissociation (Lamar *et al.*, 2024). This aligns with findings where chitosan-aloe vera coatings maintained strawberry pH below 3.8 after 15 days (Sogvar *et al.*, 2016), whereas our GA-Pg achieved pH 3.78 at day 12.

The total phenolic content (TPC)

The TPC of strawberry showed significant variations among treatments across the 12-day storage duration at 4°C (Figure 4a). During storage, the control treatment (Ck) proved the most accelerated reduction in phenolic content, diminishing from 222.36 mg GAE/100g FW at day 0 to 93.12 mg GAE/100g FW at day 12, representing a 58.1% reduction. The GA-Pg treatment displayed the highest preservation of phenolic compounds, with an upkeep of 150.76 mg GAE/100g FW at day 12, followed by GA-Ln (136.80 mg GAE/100g FW). The combination treatments (GA-Pg and GA-Ln) consistently surpassed individual treatments and control across the storage period. The Ln treatment alone showed better phenolic preservation than the control, reaching 114.85 mg GAE/100 g FW at day 12. These outcomes align with previous research demonstrating that phenolic compounds in strawberries are prone to degradation during postharvest storage as a result of enzymatic oxidation and environmental stresses (Holcroft and Kader, 1999). The antioxidant capacity of strawberry fruit mostly arises from secondary metabolites, such as phenolic compounds, flavonoids, anthocyanins, etc., which progressively diminish with storage (Fan *et al.*, 2022). The enhanced preservation observed with plant extract treatments can be attributed to the high content of important antioxidants in guava leaves. Numerous scientific studies have demonstrated that leaf extract possesses antioxidant properties, principally due to its high phenolic content (Flores *et al.*, 2015; Naseer *et al.*, 2018).

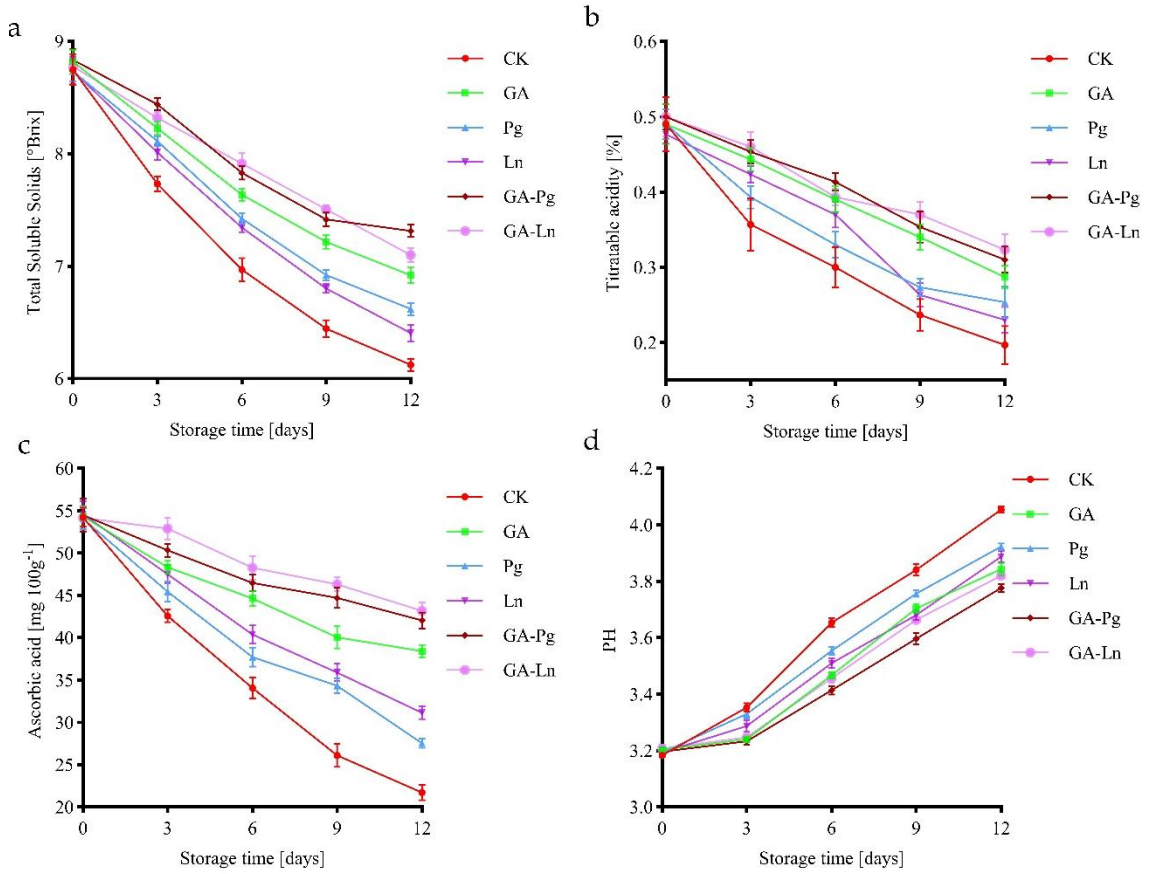

Figure 3: Changes in (a) total soluble solids (TSS), (b) titratable acidity (TA), (c) ascorbic acid, and (d) pH of strawberry fruit during 12 days of storage under different postharvest treatments. Treatment abbreviations are: CK (control), GA (gum Arabic), Pg (*Psidium guajava* leaf extract), Ln (*Laurus nobilis* leaf extract), GA-Pg (gum Arabic with Pg extract), and GA-Ln (gum Arabic with Ln extract). Data points depict the mean, and error bars represent the standard deviation (SD).

Total Flavonoid Content (TFC)

Flavonoids are a huge assortment of pigments present in certain plants, particularly in fruits, vegetables, nuts, and drinks. Commonly present in human food, flavonoids exert many biological activities associated with beneficial outcomes, including anti-inflammatory, anticancer, and antiviral characteristics. Berries, in particular strawberries, are reputed to be a rich source of flavonoids (Hannum, 2004; Karaaslan *et al.*, 2018). The total flavonoid content exhibited a different pattern compared to phenolic compounds (Figure 4b). Interestingly, TFC illustrated an initial augmentation at the initial six days of storage in most treatments, peaking at day 6, before declining thereafter. The GA treatment displayed the most stable flavonoid retention, maintaining 36.97 mg QE/100g FW at day 12, while the control showed the greatest decline to 32.09 mg QE/100g FW. Flavonoid content after 12 days of storage was significantly higher in the GA-Pg and GA-ln treatments, continuing beyond that of the control. Initial storage enhancement in flavonoid content has been reported by others, as possibly due to the continuing production of flavonoids in consequence to stress caused by storage (Dávila-Aviña *et al.*, 2014; Jin *et al.*, 2011; Shirzad *et al.*, 2021). Much higher retention of TFC in GA and extract combination treatments may be due to the collaborative effect of extract and Arabic gum in the coating matrix. Likewise, Choudhary *et al.* (2025) noted the collaborative effect of citric acid and GA for the preservation of flavonoid content during storage in strawberry fruits. This kind of retention of flavonoid content by edible coatings has also been previously observed in other fruits like mandarins (Baswal *et al.*, 2021)

Total Anthocyanin Content (TAC)

Anthocyanins, the dominant pigments accountable for the red color of strawberries, showed significant preservation advantages from the applied treatments (Figure 4c). The control treatment presented the most severe decline, dropping to 38.62 mg/100g FW by day 12,

representing a 42.9% loss of TAC. The GA-Ln treatment serves the best anthocyanin maintenance, preserving 52.92 mg/100g FW at day 12, followed by GA-Pg (50.43 mg/100g FW). Individual extract treatments (Ln and Pg) also showed superior anthocyanin retention compared to the control, with values of 45.65 and 43.49 mg/100g FW, respectively, at day 12. Anthocyanins are the most dominant phenolic compounds present in the outer cell layers of various fruits, making up 40% of total phenols in certain strawberry cultivars, with pelargonidin 3-glucoside being the primary anthocyanin in strawberry (Bortolini *et al.*, 2022; Skrovankova *et al.*, 2015). The anthocyanin deterioration during storage is mainly due to enzymatic browning and oxidative processes (Holcroft and Kader, 1999). Storage conditions and postharvest treatments have an impact on anthocyanin and phenolic component concentrations, as well as antioxidant potential in fruits and vegetables (Bhaskara Reddy *et al.*, 2000; Holcroft and Kader, 1999). The highest preservation of anthocyanins in extract-treated samples, Pg and Ln, can be attributed to the antioxidant characteristics of the applied extracts. Vijayakumar *et al.* (2019) indicated that flavonoids obtained from *P. guajava* leaf displayed considerably diminished lipid peroxidation quantities and improved glutathione levels, a fundamental endogenous antioxidant, which alleviates oxidative damage induced by reactive oxygen species. In the same way, *L. nobilis* has antioxidant, antibacterial, and antifungal properties (Alejo-Armijo *et al.*, 2017; Güler *et al.*, 2018). The preservation of such sensitive pigments in GA and combined GA and extract treatments could be due to the coating's oxygen barrier, which limits oxidation, and its capability to preserve a lower pH, a condition in which anthocyanins are more stable (Wani *et al.*, 2021).

DPPH

The DPPH test outcomes demonstrated the antioxidant capacity of the strawberry samples throughout storage (Figure 4d). The GA-Pg treatment exhibited the highest antioxidant activity preservation, maintaining 63.08% RSA at day 12, representing only an 18.3% decline from initial values ($P < 0.05$). The GA-Ln treatment also demonstrated excellent antioxidant capacity retention (58.02% RSA), while individual treatments (Ln and Pg) showed intermediate preservation levels with RSA 47 and 50 % respectively. Antioxidant capacity (RSA%) decreased from 76–78 % initially to 42 % in CK after 12 d.

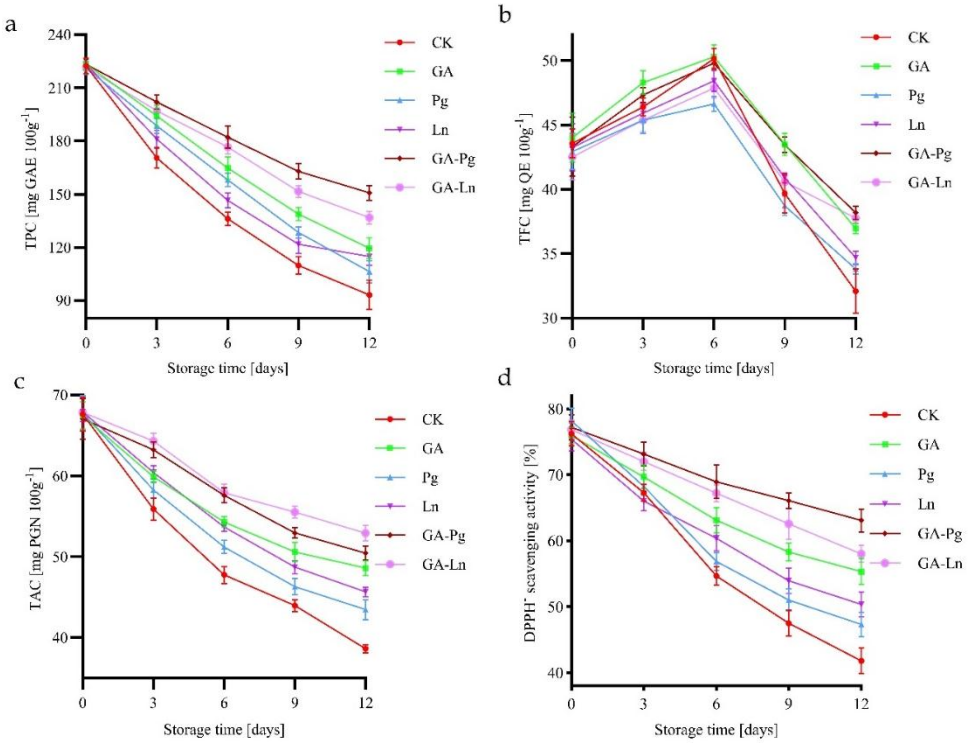

Figure 4: Changes in phytochemical content and antioxidant capacity of strawberry fruit over a 12-day storage period. Panels show (a) Total phenolic content (TPC), (b) Total flavonoid content (TFC), (c) Total Anthocyanin Content (TAC), and (d) DPPH scavenging activity. Data are shown as the mean ± standard deviation (SD). Treatments are defined as: CK, control; GA, gum arabic; Pg, *Psidium guajava* extract; Ln, *Laurus nobilis* extract; GA-Pg, gum arabic combined with Pg extract; GA-Ln, gum arabic combined with Ln extract.

The maintenance of higher antioxidant activity in treated samples correlates well with the preservation of phenolic compounds, flavonoids, and anthocyanins, as those substances are the primary contributors to the antioxidant capacity of strawberries (Chedea and Pop, 2019; de Oliveira *et al.*, 2018).

The trend in antioxidant activity closely mirrored the changes noted in the TPC. Antioxidant activity declined across all groups during storage, which is consistent with the degradation of antioxidant compounds like phenolics and anthocyanins (Rababah *et al.*, 2011).

Pectin-esterase (PE) and Pectin-lyase (PL) expression

Fruit softening is a natural process that affects the postharvest shelf life of strawberries. This process is mainly driven by the enzymatic disassembly of the cell wall, in which pectin-degrading enzymes play a pivotal role. To comprehend the molecular foundation of how the applied treatments preserved fruit quality, the relative expression of the genes encoding two key pectin-modifying enzymes, pectin lyase (PL) and pectin esterase (PE), was quantified.

The expression of genes encoding enzymes responsible for cell wall degradation is elevated as fruit ripens and enters senescence (Brummell, 2006). As shown in Figures 5a and 5b, the relative expression of both PL and PE genes increased substantially across all experimental groups throughout the 12-day storage duration, reflecting the natural progression of the ripening process.

This up-regulation was most exaggerated in the control (CK) fruits. The expression of the PL gene in the CK group elevated to a peak of 1156.30-fold by day 6, indicating fast and aggressive degradation of the cell wall. Similarly, PE gene expression in the control fruits reached a maximum of 166.67-fold by day 9. In contrast, all postharvest treatments significantly suppress the expression of both genes at all time points ($p < 0.05$).

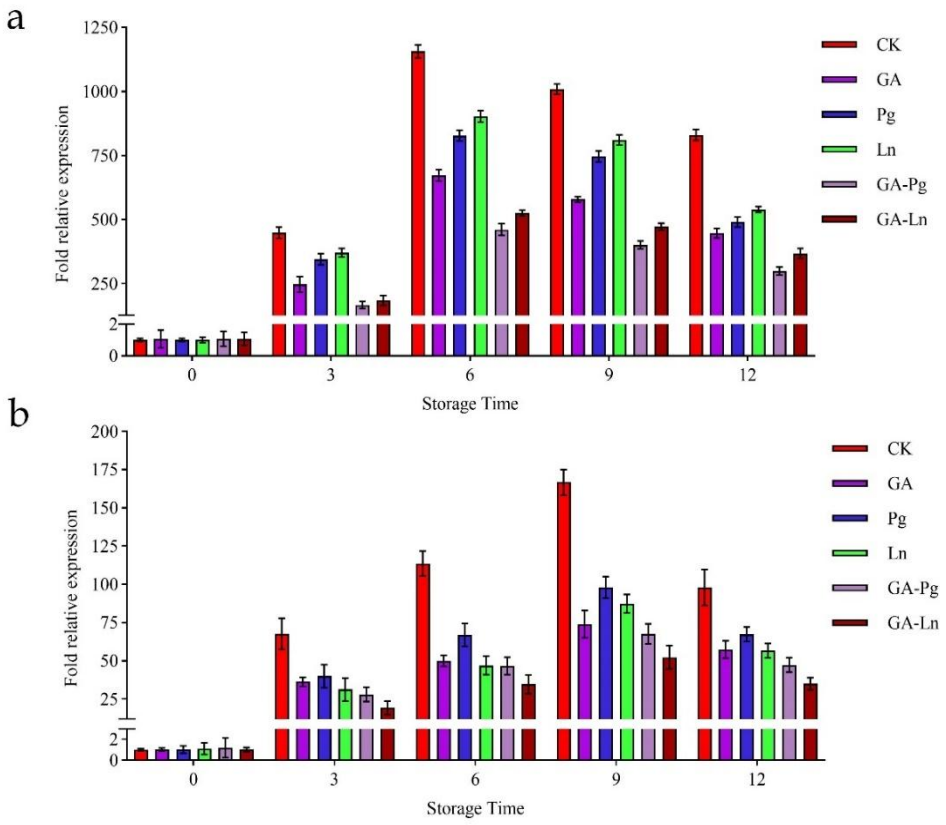

Figure 5: Relative gene expression of (a) pectin lyase (PL) and (b) pectin esterase (PE) in strawberry fruit during 12 days of storage under different postharvest treatments. Fold expression is shown relative to the treatment at Day 0. Bars depict the mean, and error bars represent the standard deviation (SD). Treatment abbreviations are as follows: CK (control), GA (gum Arabic), Pg (*Psidium guajava* extract), Ln (*Laurus nobilis* extract), GA-Pg (gum Arabic with Pg extract), and GA-Ln (gum arabic with Ln extract).

The composite coatings displayed the most potent suppressive effects. The GA-Pg treatment was outstandingly efficient at down-regulating the PL gene, maintaining its expression at a significantly lower level of 298.67-fold by day 12. For the PE gene, the GA-Ln treatment was most effective, reducing its expression to just 35.00-fold upon the completion of the storage duration.

The observed suppression of PL gene expression is of high practical significance as it directly correlates with the maintenance of fruit firmness. This link has been corroborated in previous molecular studies. For example, research involving the antisense repression of PL genes in transgenic strawberries culminated in significantly firmer fruit and an extended shelf life, confirming that downregulating PL is a viable strategy for quality preservation (Jiménez-Bermúdez *et al.*, 2002; Sesmero *et al.*, 2007). The ability of natural plant extracts to reach similar outcomes at the transcriptional level, as shown in this study, highlights their potential as a non-GMO approach to quality management. The results align with broader research indicating that natural compounds can effectively modulate the expression of genes central to cell wall metabolism and fruit ripening (He *et al.*, 2019).

This strength reduction of PE transcription is a vital mechanism for lacking the pectin degradation cascade at its inception. By restricting the initial de-esterification process, the pectin polymer is despite being a weak substrate for subsequent attack by depolymerizing enzymes like PL and polygalacturonase (PG), effectively preserves the cell wall's structural integrity (Zhang *et al.*, 2022). The successful downregulation of PL and PE gene expression by natural coatings is consistent with findings from other advanced preservation technologies. For example, He *et al.* (2019) report that chitosan-based coatings have been shown to inhibit strawberry softening by suppressing the expression of both pectate lyase, pectin esterase, and endoglucanase. Also, Badawy *et al.* (2017)) reported that polygalacturonase (PG) and pectin-lyase (PL) enzyme activity were significantly triggered in the uncoated fruit inoculated by *B. cinerea*, which agrees with our results, while' fruits coated with chitosan incorporated with thymol in addition to starch and sorbitol highly suppressed cell wall degrading enzymes (PG and PL). The pronounced impact of the *L. nobilis* and *P. guajava* extracts, probably due to their phytochemical content, may interfere with the complex signaling networks that activate PE transcription. These networks are often controlled by phytohormones such as abscisic acid (ABA) and auxins, which are known to be master regulators of ripening and cell wall modification (Nardi *et al.*, 2016). These polyphenols in the extracts probably interact with the signaling pathways (e.g., ethylene biosynthesis or perception) or straight hinder the transcription of cell wall hydrolase genes like PL and PE (Lin *et al.*, 2023; Paniagua *et al.*, 2014).

The true strength of the combined GA-Ln and GA-Pg treatments lies in their ability to achieve a coordinated downregulation of both PL and PE genes. This dual inhibition represents a comprehensive strategy for upkeep cell wall integrity. By targeting both the initial substrate preparation step (catalyzed by PE) and the subsequent structural cleavage (catalyzed by PL), the treatments effectively disrupt the entire pectin degradation pathway. This multi-target approach is inherently more robust and effective than inhibiting a single enzyme, leading to superior maintenance of fruit firmness(Zhang *et al.*, 2022).

This molecular information highly correlates with the observed preservation of fruit quality and delayed decay in these treatment groups. The primary mechanism behind this gene suppression is the innovation of an altered atmosphere through the gum Arabic edible coating. The semi-permeable film reduces oxygen availability and elevates carbon dioxide levels around the fruit, which slows the overall metabolic rate, including respiration and ethylene biosynthesis pathways (Velickova *et al.*, 2013). Since ethylene is a crucial hormone that stimulates the expression of several genes associated with ripening, including those for cell wall-modifying enzymes, the coating's barrier effect indirectly down-regulates PL and PE expression. These findings are strongly supported by previous research. For example, Zhang *et al.* (2022) mentioned that strawberry ultrasound treatment boosted ROS scavenging and elevated JA biosynthesis, which served as a signal to postpone the activation of the ET signaling pathway, as a result restricting the operation of pectin-degrading enzymes PE and PG, and eventually restraining postharvest softening.

CONCLUSION

This study presents leaf extracts of *Psidium guajava* and *Laurus nobilis* as natural antifungal alternatives against B. cinerea and, when incorporated into a gum Arabic edible coating, markedly reduce post-harvest decay and preserve the physicochemical and nutritional properties of strawberries stored at 4°C. Guava extract, richer in phenolics and radical-scavenging capacity, outperformed bay laurel in vitro, but both extracts—especially in combination with gum Arabic—significantly lowered DI and DS, minimized weight loss, postponed the decline in TSS, TA, ascorbic acid, and bioactive compounds, and stabilized pH. These advantages were strengthened by a marked

down-regulation of the softening-related genes pectin lyase (PL) and pectin esterase (PE). The dual action of gum Arabic as a physical barrier and sustained-release carrier for plant-derived antimicrobials offers a practical, consumer-acceptable alternative to synthetic fungicides, helping to mitigate food waste and improve food safety in the soft-fruit supply chain.

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الملخص العربي

التوصيف الجزيئي لأعفان الفراولة والإمكانات المضادة للفطريات لمستخلص *Psidium guajava* و *Laurus nobilis* للحفاظ على جودة الثمار ما بعد الحصاد

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تؤدي اعفان ما بعد الحصاد، وخاصة العفن الرمادي الناجم عن فطر *Botrytis cinerea* ، إلى الحد من العمر الافتراضي لثمارالفراوله (Fragaria × ananassa Duch) بشكل كبير مما ينتج عنه خسائر اقتصادية كبيرة. تهدف هذه الدراسة إلى التحقيق في إمكانية استخدام مستخلصات أوراق الجوافة (Pg) Psidium guajava واللوري Laurus nobilis (Ln)كوسائل طبيعية مضادة لفطر اعفن الرمادي، سواء بشكل فردي أو داخل طبقة صالحة للأكل من الصمغ العربي(GA) ، للحفاظ على جودة الفراولة. أظهر التحليل الكيميائي النباتي أن مستخلص Pg كان غنيًا بالمركبات الفينوليه 63.14 مجم/GAE جم، بينما كان مستخلص Ln أعلى في مركبات الفلافونويد 29.15 مجم/QE جم، وكلاهما يظهر خصائص كبيرة مضادة للأكسدة ومضادة للفطريات ضد *B. cinerea*. في تجربة أجريت على ثمار الفراولة، تمت معالجة الفراولة وتخزينها عند درجة حرارة ٤ °C لمدة اثني عشر يومًا. كان خليطGA-Pg مستخلص الجوافة مع الصمغ العربي هو الأكثر فعالية. وقد أدى ذلك إلى خفض معدل حدوث التعفن (DI) إلى ٤٢,٢٢% وشدة التعفن (DS)

إلى ١٥,٥٦%، وهو تحسن كبير مقارنة بالفاكهة المرجعية، والتي وصلت إلى ٩٧,٧٨ DI %و٥٨,٣٣ .DS %علاوة على ذلك، تفوقت هذه المعاملات المركبة من المستخلص و الصمغ العربي في الحفاظ على سمات الجودة، بما في ذلك إجمالي المواد الصلبة الذائبة(TSS)، والحموضة القابلة للمعايرة (TA)، وحمض الأسكوربيك، والمحتوى الكيميائي النباتي (الفينولات الكلية، والفلافونويدات الكلية، والأنثوسيانين الكلية)، وبالتالي الحفاظ على قدرة أعلى مضادة للأكسدة. على المستوى الجزيئي، تعمل معالجات GA-Pg و GA-Lnعلى تثبيط التعبير النسبي للجينات المحللة للبكتين، وهي البكتين لياز (PL) والبكتين استريز (PE) ، المسؤولة عن تحلل البكتين ونضج الفاكهة. توضح هذه النتائج أن الطلاء المركب الصالح للأكل من الصمغ العربي مع مستخلص P. guajava أو L. nobilis هو استراتيجية واعدة وصديقة للبيئة لمعاملات ما بعد الحصاد للحد من اضرار الفطريات، والحفاظ على جودة الفاكهة، وإطالة عمر الفراولة.