



Application of Sodium Alginate with Noni Leaf Extract (*Morinda citrifolia* L.) as a Potential Preservative for Tomatoes (*Solanum lycopersicum*)

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ABSTRACT

Sodium alginate coatings incorporated with noni (*Morinda citrifolia* L.) leaf extract (NLE) were evaluated as a natural preservative for postharvest tomatoes (*Solanum lycopersicum*). NLE was analyzed using Attenuated Total Reflectance–Fourier Transform Infrared (ATR-FTIR) spectroscopy to identify its major functional groups. Tomatoes were coated with sodium alginate containing 0%, 1%, 3%, and 5% NLE and stored at ambient temperature for 14 days. Weight loss, pH, total soluble solids (TSS), and firmness were determined, and data were analyzed using one-way ANOVA followed by Tukey's HSD test. ATR-FTIR spectra revealed characteristic O–H, C=C, and C–O functional groups, indicating the presence of bioactive compounds. Tomatoes treated with 3% and 5% NLE coatings showed significantly reduced weight loss and improved firmness compared with the control and lower concentrations. In contrast, pH and TSS values were not significantly affected by the treatments. The results demonstrate that sodium alginate coatings enriched with higher concentrations of NLE effectively preserve tomato quality and extend shelf life.

Keywords: sodium alginate; noni leaf extract; tomato preservation; dip coating; natural

INTRODUCTION

Synthetic preservatives are chemicals used to prevent food spoilage or contamination by microorganisms, as well as to enhance the color and taste of food. Scientifically, a growing body of evidence suggests that the use of synthetic chemicals as food additives may have adverse effects on human health¹. In the field of food

preservation, the challenge remains to identify sustainable alternatives to synthetic preservatives while balancing safety, efficacy, and environmental responsibility².

In recent years, edible coatings have emerged as an effective approach for extending the postharvest life of fresh produce. These coatings create a thin, edible matrix on fruit and vegetable



surfaces that moderates water vapor transfer and suppresses microbial proliferation, thereby helping to maintain quality during storage³. Among natural biopolymers, sodium alginate, a polysaccharide derived from brown seaweed, has attracted considerable interest because of its strong film-forming capacity, safety for food applications, and environmentally friendly nature. Alginate-based coatings are extensively applied to horticultural commodities to slow respiration processes, delay ripening, and reduce postharvest deterioration⁴.

Postharvest tomato fruits (*Solanum lycopersicum*) rank among the most commonly consumed horticultural crops globally and are highly prone to microbial spoilage, leading to significant economic losses and food waste⁵. Conventional preservation approaches often rely on synthetic additives, raising concerns regarding consumer health and environmental impact. Consequently, there is an increasing need to explore alternative preservatives that provide both antimicrobial efficacy and ecological sustainability. Natural plant-based preservatives, particularly herbs with antimicrobial properties, can inhibit bacterial and fungal growth and thereby improve food quality and extend shelf life⁶.

Morinda citrifolia L., commonly known as noni, is among the plant-based sources being explored for food preservation. Noni has long been utilized in traditional health practices for various diseases. According to Mubarakah *et al.* (2023)⁸, NLE contains bioactive compounds, including flavonoids, phenolics, and alkaloids, which contribute to its antimicrobial and antioxidant properties. These properties make NLE a promising natural preservative capable of inhibiting spoilage microorganisms and delaying oxidative degradation in tomatoes. The bioactive potential of NLE has been widely reported in the literature⁹, supporting its potential as a safer alternative to synthetic preservatives, which are often associated with health concerns. However, limited studies have investigated the combined application of sodium alginate and NLE in food preservation.

Therefore, the present study investigates the effectiveness of sodium alginate coatings enriched with NLE as a natural preservation strategy for postharvest tomatoes, with the aim of improving

storage quality while reducing dependence on synthetic preservatives.

MATERIALS AND METHODS

Chemicals

All reagents utilized in this work were of either analytical or food-grade quality. A 70% (v/v) ethanol solution was employed as the solvent for extraction. Food-grade sodium alginate was used as the film-forming polymer, while analytical-grade calcium chloride functioned as the cross-linking agent. Glycerol of food-grade quality was incorporated as a plasticizer in the coating formulations.

Sample collection and preparation

Tomatoes (*Solanum lycopersicum*) were sourced from a public market in Talavera, Nueva Ecija. The fruits were selected at the ripening and turning stages, corresponding to 60–90% red surface coloration. Only tomatoes exhibiting uniform color, firmness, size, and shape, and free from physical defects or microbial decay, were included. The selected fruits were washed with distilled water to remove surface debris, then drained and air-dried at room temperature prior to pretreatment. The preparation procedure was adapted, with minor modifications, from the protocol reported by Álvarez-Pérez *et al.* (2025)¹⁰.

Preparation of noni leaf powder

Fresh noni leaves were harvested from Pulong, San Miguel, Talavera, Nueva Ecija. Leaf powder preparation was carried out based on a previously reported procedure by Olatunde *et al.* (2020)¹¹, with minor procedural adjustments. The leaves were thoroughly rinsed under running water and dehydrated at 50 °C until the moisture content decreased to less than 10%. The dried material was then milled into a fine powder using a laboratory blender and passed through an 80-mesh stainless steel sieve to obtain uniform particle size.

Preparation of ethanolic noni leaf extract

A measured amount (100 g) of noni leaf powder was subjected to solvent extraction using 70% (v/v) ethanol at a solvent-to-material ratio of 10:1 (v/w). The extraction was performed by maceration at ambient temperature for 72 hours. The extract was subsequently separated by filtration

through Whatman filter paper to remove solid residues. The collected filtrate was concentrated under reduced pressure at 45 °C using a rotary evaporator. The concentrated extract was then dispensed into sterile containers and preserved at 4 °C until further analysis¹⁰.

Preparation of coating solutions

The coating formulations were developed based on previously reported methods¹²⁻¹³ with minor procedural adjustments. Sodium alginate coatings were prepared by dispersing 1% (w/v) sodium alginate in distilled water, followed by continuous stirring at 70 °C for 1 hour until complete dissolution and clarity were achieved. The solution was allowed to cool to ambient temperature, after which glycerol (1%, v/v) was incorporated as a plasticizer and mixed for 15 minutes to obtain a homogeneous mixture. Ethanolic noni leaf extract was subsequently added to the alginate solution at concentrations of 1%, 3%, and 5% (v/v) and stirred for an additional 30 minutes to ensure uniform distribution. The compositions of the resulting coating formulations are summarized in Table 1.

Table 1: Coating Treatments for Tomatoes

Treatment	Coatings
Control	Uncoated
T1	1% sodium alginate+ 1% glycerine
T2	1% sodium alginate + 1% NLE + 1% glycerine
T3	1% sodium alginate + 3% NLE + 1% glycerine
T4	1% sodium alginate + 5% NLE + 1% glycerine

Application of Sodium Alginate Coating incorporated with NLE to Tomatoes

The tomato fruits were randomly assigned to five experimental groups. Uncoated fruits served as the control, while the remaining groups were treated with 1% sodium alginate coatings supplemented with 0% (T1), 1% (T2), 3% (T3), and 5% (T4) NLE. The fruits were submerged in the respective coating formulations for 2 minutes, then removed and allowed to dry naturally at ambient conditions. To enhance coating stability and adhesion, the coated tomatoes were subsequently immersed in a 2%

(w/v) calcium chloride solution for an additional 2 min to induce polymer crosslinking¹²⁻¹³. All samples were arranged on trays and stored under room temperature conditions for 14 days.

Characterization of NLE

Functional group analysis of the ethanolic noni leaf extract was conducted using Attenuated Total Reflectance–Fourier Transform Infrared (ATR-FTIR) spectroscopy. A small quantity of the extract was applied directly onto the ATR crystal surface, and infrared spectra were collected across the wavenumber region of 4000–400 cm⁻¹¹⁴.

Measurement of Weight Loss

Tomato weight loss over the 14-day storage period was evaluated by measuring the mass of the fruits at the beginning and at the end of storage periods^{15, 25}. Weight loss was calculated and expressed as a percentage using the equation below:

$$\% \text{Weight loss} = \left[\frac{(\text{initial weight} - \text{final weight})}{\text{initial weight}} \right] \times 100$$

pH Determination

Tomato samples were homogenized and filtered through cheesecloth to obtain clear extracts. The pH of the resulting filtrates from both control and treated samples was measured using a calibrated digital pH meter¹⁶.

Total soluble solids (Brix)

Total soluble solids (TSS) were quantified using a handheld refractometer, and results were reported as degrees Brix (°Brix). The refractometer prism was rinsed thoroughly with distilled water and wiped dry between successive measurements to avoid cross-contamination¹⁷.

Determination of Firmness

Fruit firmness was evaluated using a digital penetrometer (Model GY-3) fitted with an 8-mm diameter probe. Penetration tests were conducted by applying uniform pressure to the fruit surface to ensure measurement consistency. Firmness readings were recorded and expressed as kg cm⁻²¹⁸.

Statistical analysis

All experimental data were subjected to

one-way analysis of variance (ANOVA) to assess differences among treatments. When statistically significant effects were observed, Tukey's Honestly Significant Difference (HSD) test was performed for post hoc mean comparisons at a 5% level of significance using SPSS software.

RESULTS AND DISCUSSION

Characterization of NLE

Fourier transform infrared (FTIR) spectroscopy is a widely used analytical technique for identifying changes in the overall biomolecular composition of samples through the detection of functional groups¹⁹.

Table 2: Peak values and functional groups of NLE

S. No.	Wavenumber (cm ⁻¹)	Functional Group
1	3200-3400	O-H stretching for alcohol group
2	1500-1700	C=C stretching vibration
3	1000-1100	C-O stretching

The FTIR profile of the ethanolic extract

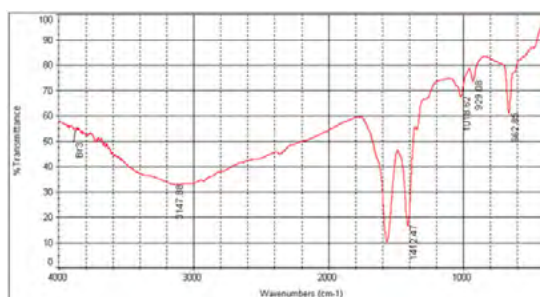


Fig. 1. FTIR spectra for Ethanolic NLE

of noni leaves revealed several distinct absorption bands corresponding to functional groups typically associated with plant-derived secondary metabolites (Figure 1; Table 2). A strong and broad band detected within the 3400–3200 cm⁻¹ region is attributed to O–H stretching vibrations, suggesting the presence of hydroxyl functionalities commonly originating from alcohols and phenolic constituents. Similar broad O–H absorption features have been reported in FTIR

spectra of noni extracts by Yee (2019)²⁰.

Absorption peaks appearing in the 1500–1700 cm⁻¹ range were assigned to C=C stretching vibrations, indicating the occurrence of unsaturated carbon bonds, which corroborates earlier FTIR findings on noni plant materials (Yee, 2019)²⁰. Furthermore, bands observed between 1000 and 1100 cm⁻¹ correspond to C–O stretching vibrations, reflecting the presence of functional groups such as esters, ethers, anthraquinones, and alcohols, as previously reported in phytochemical analyses of plant extracts²¹.

These spectral features confirm that the ethanolic extract of noni leaves contains a diverse range of bioactive compounds, including phenolic compounds, anthraquinones, and flavonoids. These compounds are known to contribute to the antioxidant and antimicrobial properties of noni leaves²².

Physiological loss in weight

Weight loss is a key postharvest indicator reflecting moisture loss primarily driven by respiration and transpiration. The application of sodium alginate coatings supplemented with NLE significantly influenced tomato weight loss during the 14-day storage period (Table 3).

Statistically significant differences in weight loss were observed among treatments ($p < 0.05$). Tomatoes coated with sodium alginate without NLE (T1) exhibited the highest weight loss ($12.98 \pm 1.39\%$), followed by the uncoated control ($8.90 \pm 1.64\%$). In contrast, fruits treated with 5% NLE (T4) showed the lowest weight loss ($5.56 \pm 0.08\%$). A progressive reduction in weight loss was evident with increasing NLE concentration, indicating improved moisture retention.

The superior performance of T4 can be attributed to the combined barrier properties of sodium alginate and the bioactive compounds in NLE, which restrict water vapor diffusion and reduce respiration rates. In contrast, alginate coatings without NLE may be more susceptible to fungal activity, which can disrupt the coating structure and lead to increased moisture loss²³. Similar reductions in weight loss using plant-extract-enriched edible

Table 3: Physico-chemical Properties of Tomatoes Treated with Different Concentrations of NLE

Treatment	Mean Weight loss (%)	pH	°Brix Mean (%)	Firmness (kg/cm ²)
CONTROL	8.90 ± 1.64ab	4.25 ± 0.09a	4.33 ± 0.58a	2.73 ± 0.12b
T1	12.98 ± 1.39a	4.28 ± 0.08a	4.33 ± 0.58a	3.27 ± 0.23b
T2	7.06 ± 0.74bc	4.54 ± 0.48a	4.00 ± 0.00a	3.33 ± 0.50b
T3	8.24 ± 2.01ab	4.17 ± 0.03a	3.67 ± 0.58a	4.47 ± 0.42a
T4	5.56 ± 0.08c	4.20 ± 1.27a	4.33 ± 0.58a	4.87 ± 0.31a

Results are given as averages ± SD (n=3). Values sharing the same superscript letter within a column do not differ significantly at $P > 0.05$.

Treatment concentration: T1 (0% NLE), T2 =1% NLE, T3 =3% NLE, T4=5% NLE

coatings were reported by Zewdie *et al.* (2022)²⁴. The sodium alginate–NLE coating likely formed a semi-permeable film that modified the fruit micro-environment, thereby limiting transpiration and respiration and reducing postharvest mass loss²⁵

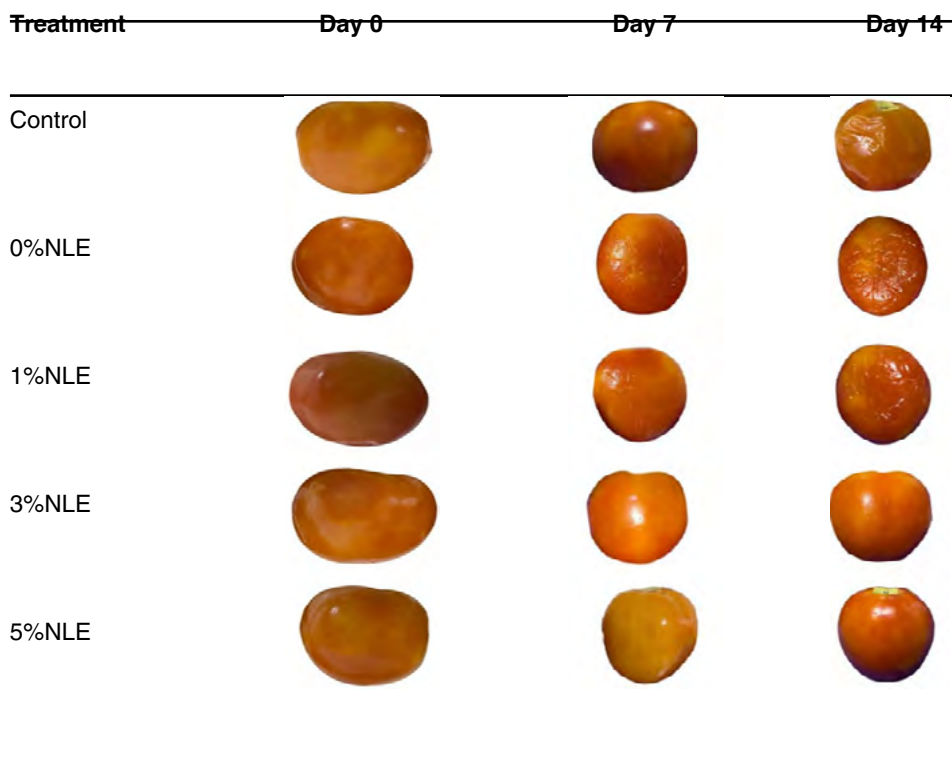
Sodium alginate–NLE coatings effectively created a semi-permeable barrier that modified the micro-atmosphere surrounding the fruit, thereby

slowing transpiration and respiration and reducing postharvest weight loss²⁵.

pH

Fruit pH is an important quality attribute influencing sensory quality, microbial stability, and enzymatic activity during storage²⁶. As shown in Table 3, no significant differences in pH were observed among treatments ($p > 0.05$). pH values ranged from 4.17 (T3) to 4.54 (T2), indicating that

Figure 2: Visual appearance of tomatoes coated with sodium alginate with different concentrations of NLE at Day 0, Day 7, and Day 14 of storage at room temperature



incorporation of NLE did not significantly affect fruit acidity.

All pH values fell within the acceptable range for fresh tomato storage^{26, 27}, suggesting that sodium alginate–NLE coatings preserved fruit quality without adversely affecting acidity or flavor.

Statistical analysis showed no significant variation in pH among treatments ($p > 0.05$). The pH values ranged from 4.17 (3% NLE, T3) to 4.54 (1% NLE, T2), indicating that the inclusion of noni leaf extract did not modify fruit acidity. These results suggest that sodium alginate coatings with NLE do not interfere with organic acid metabolism during storage.

The obtained pH values (4.17–4.54) fall within the optimal range for tomatoes intended for fresh consumption and storage^{26,27}. This indicates that the coatings preserved fruit quality without negatively affecting acidity or flavor attributes.

Total soluble solids

Total soluble solids (TSS), reported as degrees Brix ($^{\circ}$ Brix), are commonly used to assess fruit ripening and sugar accumulation. The TSS values of tomatoes during storage are also summarized in Table 3.

No significant differences in TSS were detected among treatments ($p > 0.05$). Mean TSS values ranged from 3.67 ± 0.58 in T3 (3% NLE) to 4.33 ± 0.58 in the control, T1, and T4. These findings indicate that the addition of noni leaf extract, regardless of concentration, did not significantly influence sugar content during the storage period.

Although sodium alginate–NLE coatings effectively reduced weight loss and maintained firmness, they did not alter the enzymatic conversion of complex carbohydrates into simple sugars. Similar observations were reported by Manozzi *et al.* (2016),²⁸ who noted that edible coatings may preserve internal fruit quality without significantly affecting TSS, particularly during short-term storage.

CONCLUSION

Sodium alginate coatings incorporated with

NLE effectively preserved the post-harvest quality of tomatoes. The 5% noni leaf extract treatment showed the greatest reduction in weight loss and the highest retention of fruit firmness during storage. No significant differences were observed among treatments in terms of fruit pH and total soluble solids, indicating that the coating did not alter the intrinsic physicochemical properties of the tomatoes. These results demonstrate that sodium alginate enriched with noni leaf extract is a promising natural, biodegradable, and safe method for preserving tomatoes, extending their shelf life, and reducing post-harvest losses, with potential applications in sustainable fresh produce preservation.

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Conflict of Interest

The authors declare that there are no conflicts of interest associated with this work.

Author Contributions

Ma. Virgini M. Cuevas contributed to the conceptualization of the study, experimental design, execution of the experiment, data acquisition, and manuscript preparation. Ryan V. Cabanatan provided supervision, guidance, manuscript review, and editing.

Data Availability

Not applicable.

Ethical Approval

This research did not involve human

subjects, animal experimentation, or the use of materials requiring ethical clearance.

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