Supplementary Information

Polysaccharide-based layer-by-layer edible coatings for shelf-life extension of fresh tomatoes

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Table S1. Physicochemical properties of hydroxypropyl methylcellulose (HPMC) edible films with various concentrations. Values superscripted with different letters within a column are significantly different according to the post hoc t-test with Duncan's multiple range test (DMRT) adjustment ($p \leq 0.05$).

Treatments	**Water vapor permeability** (10^{-11} g/s.m.Pa)	**Color** (ΔE)	**Opacity** (%)	**Tensile strength** (MPa)	**Elongation at break** (%)
HPMC 0.4%	6.98 ± 7.69	3.73 ± 0.47	4.24 ± 1.25^{a}	0.26 ± 0.11^{a}	3.74 ± 3.25
HPMC 0.8%	5.80 ± 9.40	7.93 ± 1.58	5.08 ± 1.16^{b}	0.50 ± 0.11^{b}	3.82 ± 1.70
HPMC 1.2%	3.85 ± 8.34	7.99 ± 0.44	6.52 ± 0.98^{b}	0.59 ± 0.24^{b}	5.06 ± 2.20

Table S2. Physicochemical properties of chitosan edible films with various concentrations. Values superscripted with different letter within a column are significantly different according to the post hod t-test with Duncan's multiple range test (DMRT) adjustment ($p \leq 0.05$).

Treatments	**Water vapor permeability** (10^{-11} g/s.m.Pa)	**Color** (ΔE)	**Opacity** (%)	**Tensile strength** (MPa)	**Elongation at break** (%)
Chitosan 0.5%	1.26 ± 2.04	7.41 ± 2.10	2.44 ± 1.92^{b}	0.23 ± 0.07	11.20 ± 2.51
Chitosan 1.0%	1.22 ± 1.12	9.03 ± 5.89	3.11 ± 0.23^{a}	0.29 ± 0.05	13.34 ± 1.92
Chitosan 1.5%	1.06 ± 4.50	9.98 ± 1.82	4.88 ± 0.68^{a}	0.32 ± 0.08	13.79 ± 4.87

Table S3. Physicochemical properties of chosen edible coating treatments for fresh tomatoes during 24 days storage. Values superscripted with different letter within a column for each parameter are significantly different according to the post hoc t-test with Mann-Whitney U-test adjustment ($p \leq 0.05$). T1, T2, and T3 refer to dipping, air-gun spraying, and manual air-pressure spraying, respectively.

Parameter	Treatment		Day 6	Day 12	Day 18	Day 24
Weight loss (%)	**Control**		5.27 ± 3.35	5.70 ± 0.00	N/A	N/A
	CH/HPMC	**T1**	2.89 ± 0.84	4.25 ± 0.00^{a}	5.95 ± 0.00^{a}	7.42 ± 0.00
		T2	2.67 ± 0.92	7.78 ± 0.00^{a}	7.05 ± 1.91^{a}	7.27 ± 0.00
		T3	4.56 ± 0.97	8.69 ± 0.00^{b}	10.32 ± 0.00^{b}	11.78 ± 0.00
Firmness (N)	**Control**		9.18 ± 0.00	8.27 ± 0.00	N/A	N/A
	CH/HPMC	**T1**	8.56 ± 0.73	8.35 ± 0.00	8.30 ± 0.00	6.32 ± 0.00
		T2	9.59 ± 0.00	7.12 ± 0.86	6.14 ± 0.00	5.44 ± 0.00
		T3	10.34 ± 0.00	10.23 ± 0.00	9.11 ± 0.57	5.24 ± 0.00
Total soluble solids (TSS) (ºBrix)	**Control**		2.90 ± 0.14	3.00 ± 0.00	N/A	N/A
	CH/HPMC	**T1**	4.00 ± 0.00^{a}	3.20 ± 0.00^{a}	3.20 ± 0.00	3.00 ± 0.00^{a}
		T2	4.40 ± 0.00^{b}	3.80 ± 0.00^{b}	3.00 ± 0.00	3.00 ± 0.00^{a}
		T3	5.00 ± 0.00^{c}	4.60 ± 0.00^{c}	4.00 ± 0.00	3.90 ± 0.14^{b}
Vitamin C (%)	**Control**		3.34 ± 0.00	1.94 ± 0.52	N/A	N/A
	CH/HPMC	**T1**	2.90 ± 0.00	2.77 ± 1.18	2.20 ± 0.12	1.76 ± 0.00
		T2	4.93 ± 1.12	3.70 ± 0.00	3.43 ± 0.00	2.90 ± 0.00
		T3	3.43 ± 0.00	2.82 ± 0.00	2.29 ± 0.00	1.58 ± 0.25
Color (△E)	**Control**		0.55 ± 0.35	1.09 ± 0.00	N/A	N/A
	CH/HPMC	**T1**	1.03 ± 0.02	1.03 ± 0.00	1.13 ± 0.00	1.07 ± 0.00
		T2	1.04 ± 0.01	1.13 ± 0.64	1.01 ± 0.81	1.84 ± 0.00
		T3	1.26 ± 0.30	1.58 ± 0.00	1.86 ± 0.00	1.62 ± 0.00

Figure S1. Visualization of edible coating effects on fresh tomatoes during 24 days of storage. Three different coating methods (i.e., dipping, air-gun spraying, and manual air-pressure spraying) have been evaluated in terms of their effectiveness to extend the shelf life of tomatoes. Uncoated tomatoes were used as control samples.

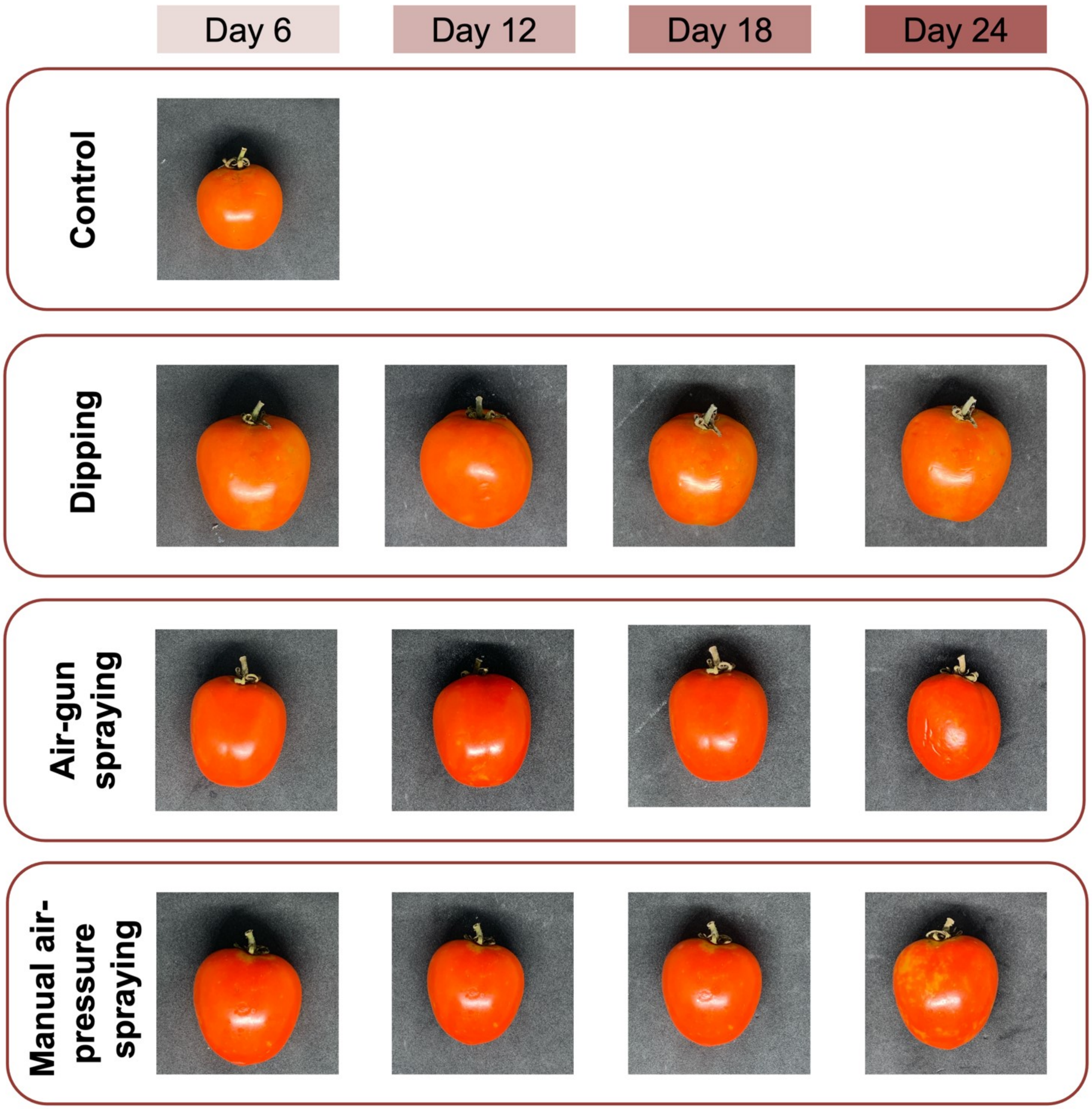

Table S4. Comparative summary between current study and previous studies. Similar studies of chitosan-based edible coating application on tomatoes compared to current work, highlighting differences in coating materials, application methods, storage outcomes, key findings, and specific advances demonstrated by the present work.

Parameter	**Previous studies**			**Current work**
	Perera et al., 2022[1]	**Carrillo-Lomelí et al., 2024[2]**	**Younis et al., 2025[3]**	
Target commodity	Tomato	Cherry tomato	Tomato	Tomato
Coating materials	Chitosan, alginate, and TiO_2	*Opuntia stenopetala* polysaccharides and *Flourensia microphylla* extract	Gum arabic, chitosan, and *S. costus* extract	Chitosan, hydroxypropyl methylcellulose (HPMC)
Application method	Dipping	Dipping	Dipping	Dipping and spraying (Air-pressure spraying and manual air-pressure spraying) comparison
Shelf-life	8 days	15 days (22°C)	30 days (refrigerator)	24 days (25 – 28°C)
Key findings	Improved firmness & delayed quality loss using bioactive-enriched coating	Improved physiological characteristics and enhanced storage stability	Improved barrier, antioxidant, and antimicrobial properties using bioactive-enriched coating	Maintained physicochemical characteristics during 24 days of storage using spraying method
Advances of this study	Introduces a comparison of three application methods (i.e., dipping, air-gun spraying, and manual air-pressure spraying) and evaluates uniformity & scalability	Improves tomato's shelf-life under similar storage conditions (up to 24 days at 25 – 28°C) using an effective application method	Demonstrates clear performance differences across dipping and spraying, provides industrially relevant insight	Novel spraying-based layer-by-layer approach, better uniformity via spraying method, industrial relevance, longest storage window (24 days)

References

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