The effect of a new bionanocomposite packaging film on postharvest quality of strawberry at modified atmosphere condition

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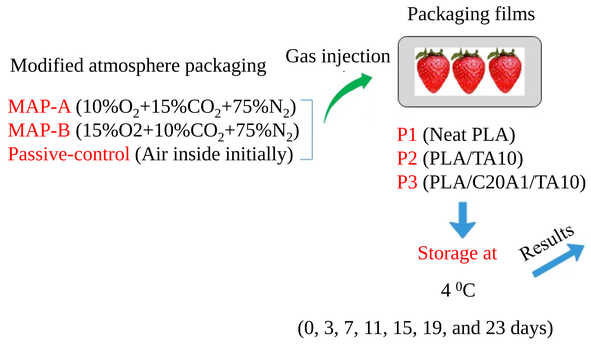
Graphical Abstract



- The PLA-based nanocomposite packaging film and modified atmosphere conditions for shelf-life extension of strawberry at 4 ^{0}C was developed.
- Strawberries under PLA/C20A1/TA10 and MAP-A had lower weight loss and better firmness than other samples
- Nanocomposites with enhanced water vapor and oxygen barrier properties can be an excellent choice for food packaging.
- PLA/C20A1/TA10 and MAP-A minimized the quality loss and increased the shelf-life of strawberries to 23 days.

Methodology

Table 1 Materials formulation to prepare the films

Sample code	Composition	PLA (wt.%)	TA (wt.%)	C20A (wt.%)
P1	Neat PLA	100	-	-
P2	PLA/TA10	90	10	-
P3	PLA/C20A1/TA10	89	10	1

PLA: Polylactic acid; TA: Triacetin plasticizer; C20A: Cloisite 20A. Percentages are determined based on the total weight of 200 g.

Fig 1. The obtained films (a): Neat PLA, (b): PLA/TA10, and (c): PLA/C20A1/TA10

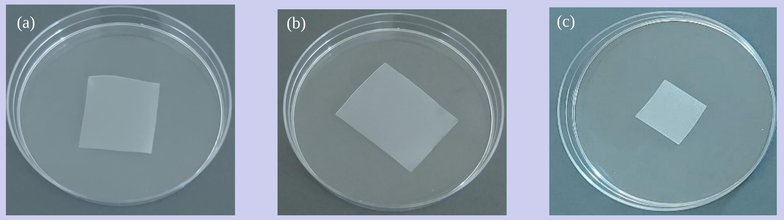


Table 2 Packages of strawberry fruits

Sample code	Composition	Conditions inside packages
P1A1	Neat PLA	10% O_2+15% CO_2+75% N_2 (MAP-A)
P2A1	PLA/TA10	
P3A1	PLA/C20A1/TA10	
P1A2	Neat PLA	15% O_2+10% CO_2+75% N_2 (MAP-B)
P2A2	PLA/TA10	
P3A2	PLA/C20A1/TA10	
P1A3	Neat PLA	Air inside initially (Passive-Control)
P2A3	PLA/TA10	
P3A3	PLA/C20A1/TA10	

Abstract

The highly perishable strawberry fruit has a short shelf life after harvesting limiting its consumption due to reduced freshness. A suitable packaging condition, proper storage, and carefully tuned atmosphere composition inside the package can preserve the quality and extend the shelf life of perishable fruits. It showed that PLA/montmorillonite Cloisite 20A/Triacetin preserved the quality of the packaged fruits compared to neat PLA and PLA/Triacetin films. Furthermore, the gas mixture of MAP-A was more suitable in comparison to MAP-B. We can conclude that using PLA nanocomposite film with MAP provides a more desirable condition for strawberries storaging at a low temperature.

Keywords: Strawberry; Modified atmosphere packaging; Nanocomposite film; Cold storage; Quality parameters

Introduction

The amount of the useful compounds of fresh products decreases remarkably rapidly after harvesting causing a short shelf-life [1, 2]. The main factors in quality loss of strawberry are discoloration, browning, metabolic activity, surface dehydration, microbial molds, and rots. Therefore, it is crucial to provide appropriate methods to preserve the quality and nutritional value of strawberry fruits after harvesting [3]. Besides, plastic packaging is usually used to preserve fresh products from external factors, which leads to environmental issues. Nowadays, biopolymers as packaging materials have attracted a lot of attention due to their renewability and biodegradability [4, 5]. The effects of packaging materials, modified atmosphere, and storage time were studied on the physicochemical properties of strawberries stored at 4 °C for 23 days. Various quality parameters of strawberries such as weight loss, total soluble solid, titratable acidity, pH, and firmness were determined during the storage time.

Novelty

- The effects of PLA-based nanocomposite packaging films and modified atmosphere conditions on postharvest quality of strawberry at 4 ^{0}C were studied.
- This is the first study on developing the packaging film based on PLA, triacetin, and nanoclay for shelf-life extension of strawberry fruits.

Acknowledgement

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Results

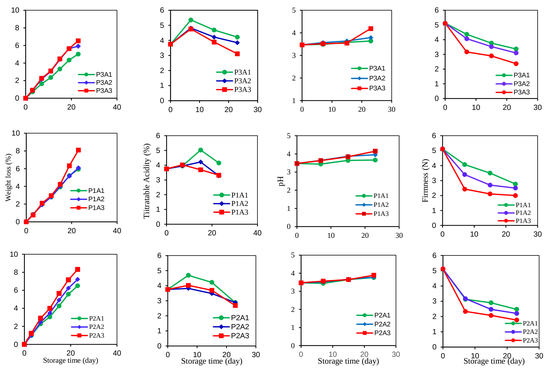

Fig 2. Effects of P, MA, and D on WL, TSS, TA, pH, and F of strawberry fruits at 4 °C

P: Packaging
D: Days (Storage time)
WL: Weight loss
TSS: Total soluble solid
TA: Titratable acidity
F: Firmness

Table 3 Specifications of film samples

Sample code	Composition	TS (MPa)	E (%)	MC (%)	OTR ($cm^3mm^1m^{-2}day^{-1}$)	WVP ($\times10^{-7}$ $gm^{-1}s^{-1}Pa^{-1}$)
P1	Neat PLA	35.1	7.2	0	40.4	6.07
P2	PLA/TA10	22.3	14.3	3.25	56.8	6.79
P3	PLA/C20A1/TA10	28.7	10.1	3.88	25.6	5.31

Discussion

1. The plasticized PLA films have lower tensile strength (TS) and higher elongation (E) values compared to the neat PLA film. On the other hand, the TS value of PLA increased with the addition of nanoclay [6]. The moisture content (MC) value of the neat PLA film increased with the addition of TA plasticizer. In addition, the MC value of the nanocomposite film increased slightly with the addition of nanoclay, probably due to the hydrophilic nature of the nanoclay used in the polymer matrix [7, 8]. Water vapor permeability (WVP) and oxygen transmission rate (OTR) values of PLA decreased with the addition of nanoclay [9].

2. The fruit weight loss and firmness decreased during storage time, while pH value increased. The total soluble solid and tritratable acidity of all the treatments experienced a significant increase throughout the storage time. However, the samples exhibited a significantly lower total soluble solid and tritratable acidity at the end of the storage time. It has been also showed that strawberries packaged in PLA/C20A1/TA10 showed significantly higher quality attributes due to lower water vapor permeability and oxygen transmission rate than other types of packaging [10]. Therefore, the use of nanocomposite film has been kept moisture in strawberry fruit and prevented its weight loss during the storage period.

Conclusion

The results of this study confirm that the use of nanocomposite film with MAP-A gas composition leads to maintain the quality characteristics of strawberries during storage time. In general, this study opens new perspectives for combining MAP with nanocomposites to minimize the quality loss and extend the shelf life of strawberries.

References

1. Tajeddin, B., & Shakerardekani, A. (2022). The effect of packaging and storage time on quality of clustered fresh pistachio. *Journal of food science*.
2. Caleb, O. J., Opara, U. L., & Witthuhn, C. R. (2012). Modified atmosphere packaging of pomegranate fruit and arils: a review. *Food and Bioprocess Technology*, *5*(1), 15-30.
3. Fernández-León, M., Fernández-León, A., Lozano, M., Ayuso, M., Amodio, M. L., Colelli, G., & González-Gómez, D. (2013). Retention of quality and functional values of broccoli 'Parthenon'stored in modified atmosphere packaging. *Food Control*, *31*(2), 302-313.
4. YousefniaPasha, H., Mohtasebi, S. S ,.Tabatabaeekoloor, R., Taherimehr, M., Javadi, A., & Soltani Firouz, M. (2021). Preparation and characterization of the plasticized polylactic acid films produced by the solvent-casting method for food packaging applications. *Journal of Food Processing and Preservation*, e16089.
5. YousefniaPasha, H., Mohtasebi, S. S., Taherimehr, M., Tabatabaeekoloor, R., Soltani Firouz, M., & Javadi, A. (2021). New poly(lactic acid)-based nanocomposite flms for food packaging applications. Iranian Polymer *Journal*, 855-871.
6. Ozdemir, E., & Hacaloglu, J. (2017). Characterizations of PLA-PEG blends involving organically modified montmorillonite. *Journal of Analytical and Applied Pyrolysis*, *127*, 343-349.
7. Ozkoc, G., & Kemaloglu, S. (2009). Morphology, biodegradability, mechanical, and thermal properties of nanocomposite films based on PLA and plasticized PLA. *Journal of Applied Polymer Science*, *11*٤
8. Bharti ,S. K., Pathak, V., Arya, A., Alam, T., Rajkumar, V., & Verma, A. K. (2021). Packaging potential of Ipomoea batatas and κ-carrageenan biobased composite edible film: Its rheological, physicomechanical, barrier and optical characterization. *Journal of Food Processing and Preservation*, *45*(2), e15153.
9. Ebrahimi, H., Abedi, B., Bodaghi, H., Davarynejad, G., Haratizadeh, H., & Conte, A. (2018). Investigation of developed clay-nanocomposite packaging film on quality of peach fruit (Prunus persica Cv. Alberta) during cold storage. *Journal of Food Processing and Preservation*, *42*(2), e13466.
10. Zandi, M., Ganjloo ,A., Bimakr, M., Moradi, N., & Nikoomanesh, N. (2021). Effect of active coating containing radish leaf extract with or without vacuum packaging on the postharvest changes of sweet lemon during cold storage. *Journal of Food Processing and Preservation*, *45* ,(٣)e15252.