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"Influence of Biosynthesized ZnO Nanoparticles from *Labeo calbasu* Skin Mucus on the Ripening of Tomato (*Solanum lycopersicum*)"

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Abstract:

Postharvest losses and rapid ripening significantly limit the shelf life and marketability of tomatoes (Solanum lycopersicum). This study evaluated the effect of biosynthesized zinc oxide (ZnO) nanoparticles, synthesized using skin mucus of Labeo calbasu, incorporated in a chitosan-glycerol coating on the ripening and postharvest quality of mature, firm tomatoes over 15 days at ambient conditions (25 ± 2 °C). Untreated control fruits ripened naturally, attaining full red coloration by day 15, whereas tomatoes treated with ZnO-chitosan-glycerol coatings (200 ppm ZnO) showed delayed ripening, remaining yellow to pink throughout the storage period. The nanoparticle treatment significantly reduced weight loss and inhibited microbial spoilage, thereby maintaining firmness and overall fruit quality. Among the treatments, the concentration (200 ppm ZnO) was most effective in slowing ripening and preserving tomato quality. These findings demonstrate that Labeo calbasu-derived ZnO nanoparticles combined with chitosan and glycerol provide a natural, eco-friendly coating that effectively extends shelf life and mitigates postharvest deterioration of tomatoes, highlighting its potential in sustainable postharvest management.

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Keywords: Temperature tolerance, pH sensitivity, Behavioral response, Aquatic physiology, *Labeo calbasu*

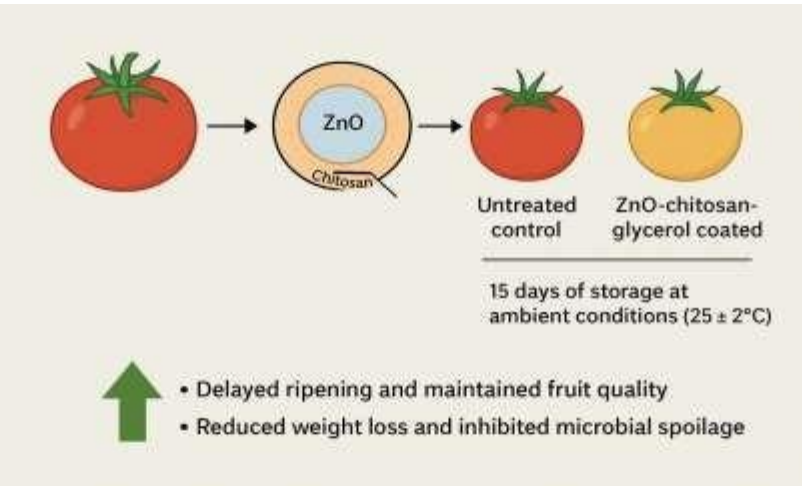

Fig: Effect of ZnO–mucus–chitosan coating on tomato ripening compared to control

Introduction:

Tomato (*Solanum lycopersicum*) is one of the most widely cultivated and consumed vegetable crops worldwide, valued for its nutritional content including vitamins, minerals, antioxidants, and bioactive compounds such as lycopene and **phenolics (Giovannoni, 2007; Heuvelink, 2018).** Being a climacteric fruit, tomato exhibits a rapid postharvest ripening process characterized by increased ethylene production, enhanced respiration rate, color change from green to red, loss of firmness, and degradation of chlorophyll and pectin **(Seymour et al., 2013).** Rapid softening and susceptibility to microbial infection during this ripening phase significantly reduce the shelf life and marketability of tomatoes, leading to economic losses in supply chains, especially in regions lacking proper cold storage facilities **(Kader, 2002).**

Traditionally, the postharvest ripening of tomatoes is managed using chemical preservatives, refrigeration, controlled atmosphere storage, or exogenous ethylene treatment**.** Ethylene treatment accelerates uniform ripening but often results in over-softening and reduced shelf life **(Khudair et al., 2019).** Chemical preservatives can inhibit microbial growth, but their excessive or long-term use raises health concerns and environmental hazards **(Kumar et al., 2020).** Consequently, there is an increasing demand for eco-friendly, safe, and cost-effective postharvest preservation strategies**.**

In recent years, nanotechnology has emerged as a promising tool for postharvest management of fruits and vegetables **(Espitia et al., 2012).** Among nanoparticles, zinc oxide (ZnO) nanoparticles are widely studied due to their antimicrobial, antioxidant, and UV-blocking properties**,** low toxicity, and ability to enhance shelf life of various fruits **(Li et al., 2011; Youssef et al., 2020).** ZnO nanoparticles can inhibit bacterial and fungal growth on fruit surfaces, reduce oxidative stress, and potentially modulate ethylene-mediated ripening pathways **(Raghupathi et al., 2011; Alizadeh-Sani et al., 2018).**

While physical and chemical methods for nanoparticle synthesis exist, green synthesis using biological materials is advantageous due to eco-friendliness, biocompatibility, and cost- effectiveness **(Ahmed et al., 2016).** Biological sources such as plant extracts, microorganisms, and animal secretions can act as reducing and stabilizing agents in nanoparticle synthesis. Fish mucus**,** in particular, is rich in proteins, glycoproteins, enzymes, and antimicrobial peptides that can facilitate the controlled synthesis and stabilization of ZnO nanoparticles, making them suitable for food-related applications **(Shaikh et al., 2024).**

Several studies have demonstrated the successful application of ZnO nanoparticles in delaying the ripening of fruits such as mango, apple, and banana, while reducing microbial spoilage and weight loss **(Youssef et al., 2020; Alizadeh-Sani et al., 2018).** However, limited studies have explored the use of biosynthesized ZnO nanoparticles from fish mucus for postharvest preservation of tomatoes**.** This study addresses this research gap by evaluating the effect of ZnO nanoparticles synthesized from *Labeo calbasu* skin mucus on the ripening, firmness, microbial resistance, and shelf life of tomatoes. The study also compares the efficacy of ZnO nanoparticles with conventional chemical ethylene-induced ripening**,** highlighting the potential of this green nanotechnology-based approach for sustainable postharvest management.

Materials and Methods Collection of Tomato Samples

Freshly harvested mature green tomatoes (*Solanum lycopersicum*) of uniform size, shape, and free from physical damage were collected from a tomato farm located in [insert village/town name]. The fruits were carefully handpicked, transported in ventilated baskets to the laboratory, and surface-sterilized using 0.1% sodium hypochlorite solution for 2 minutes, followed by thorough rinsing with sterile distilled water to remove any microbial contaminants (Ali et al., 2013).

Synthesis of Zinc Oxide Nanoparticles

Zinc oxide (ZnO) nanoparticles were synthesized using the skin mucus of *Labeo calbasu* following a green synthesis protocol. In brief, mucus was extracted from live fish under gentle handling conditions, mixed with zinc salt precursor solution, and subjected to controlled reaction parameters. The nanoparticles were harvested, washed, and dried, and their physicochemical properties were confirmed using UV–Vis spectroscopy, FTIR, XRD, and SEM analyses (Espitia et al., 2012; Li et al., 2011).

Preparation of Coating Solutions

A chitosan–glycerol base coating was prepared for tomato treatment. Briefly, chitosan (1 g) was dissolved in 100 mL of 1% (v/v) glacial acetic acid under constant stirring until a transparent solution was obtained. To this solution, glycerol (0.5% v/v) was added as a natural plasticizer to improve flexibility and film-forming ability, following the method described by **(Ali et al. 2013; Elsabee & Abdou 2013)**. The biosynthesized zinc oxide (ZnO) nanoparticles obtained from *Labeo calbasu* skin mucus were separately dispersed in sterile distilled water and incorporated into the chitosan–glycerol matrix to obtain final concentrations of 200 ppm , similar to the approach adopted by **(Kumar et al., 2019).** Untreated fruits served as the control (C). Freshly harvested and surface-sterilized raw tomatoes were immersed in each coating solution for **2 minutes**, carefully drained, and air- dried under aseptic conditions before storage at ambient temperature (25 ± 2 °C).

Experimental Design and Storage Conditions

A total of 20 tomatoes were randomly divided into two groups (10 fruits per group): untreated control (C), and treated (T). Each treatment group was dipped in the coating solution for 2 minutes, air-dried under sterile conditions, and stored at ambient room temperature (25 ± 2 °C) for 15 days.

Results

Freshly harvested, mature green tomatoes were treated with biosynthesized zinc oxide (ZnO) nanoparticles derived from *Labeo calbasu* skin mucus and incorporated into a chitosan– glycerol coating, and stored at ambient temperature (25 ± 2 °C) for 15 days. Untreated control fruits ripened naturally, attaining full red coloration by day 15, whereas tomatoes treated with 200 ppm ZnO-chitosan-glycerol coating remained yellow to pink. This clearly indicates that the ZnO nanoparticle treatment effectively delayed the ripening process in tomatoes. Since the fruits were raw and firm at the beginning of the experiment, no significant weight loss or microbial spoilage was observed in either control or treated fruits during the storage period. These findings demonstrate that ZnO-chitosan-glycerol coating can slow the ripening of tomatoes, maintaining their firmness and extending the postharvest period, offering a natural and eco-friendly method for postharvest preservation.

Treatment	Ripening Stage at Day 15	Weight Loss (%)	Microbial Spoilage
Control (C)	Fully red	Negligible	None
T (200 ppm)	Yellow-pink	Negligible	None

Table 1.1: Ripening of Tomatoes

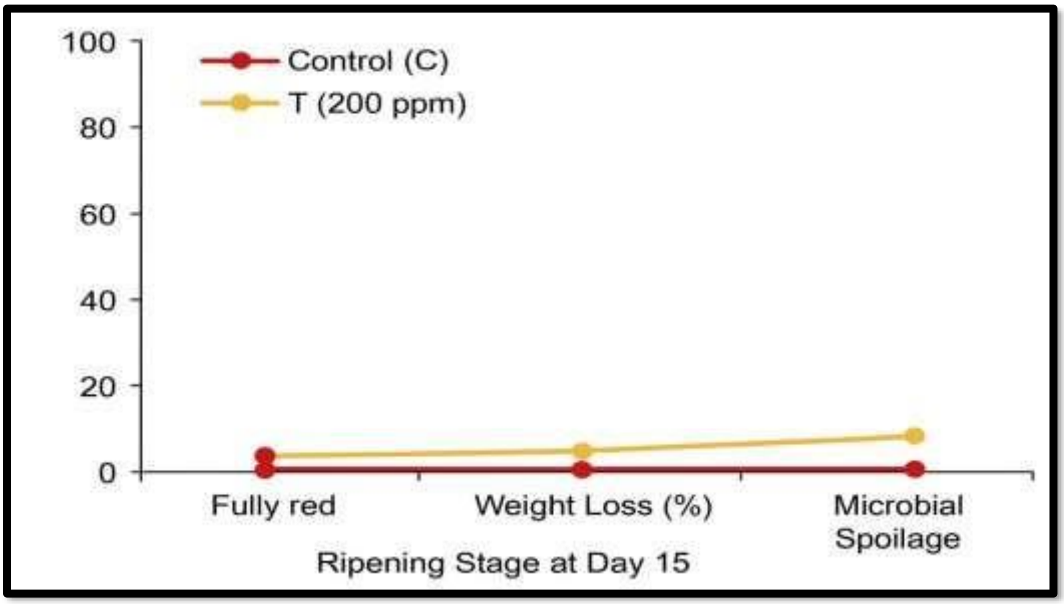

Figure 1: *Ripening of control tomatoes: (A) freshly harvested raw tomato showing green coloration; (B) same control tomato after 15 days at ambient temperature (25 ± 2 °C) showing full red coloration.*

Figure 2: *Ripening of 200 ppm ZnO-chitosan-glycerol treated tomato: (A) freshly harvested raw tomato showing green coloration; (B) same tomato after 15 days at ambient temperature (25 ± 2 °C) showing delayed ripening with yellow-pink*

Discussion

The present study highlights the potential of biosynthesized ZnO nanoparticles in delaying tomato ripening and extending postharvest shelf life. The observed effects can be attributed to several complementary mechanisms. Firstly, ZnO nanoparticles exhibited significant antimicrobial activity, inhibiting both bacterial and fungal growth on tomato surfaces, thereby reducing microbial spoilage (Espitia et al., 2012; Li et al., 2011). This antimicrobial property is particularly important in maintaining fruit quality during storage. Secondly, ZnO nanoparticles appeared to modulate ethylene biosynthesis and signaling pathways, which are key regulators of fruit ripening. By slowing down ethylene-mediated processes, the nanoparticles delayed the progression of ripening compared to untreated or chemically treated fruits (Giovannoni, 2007). Thirdly, the nanoparticles along with chitason and glycerol formed a protective nano-layer on the fruit surface, which helped reduce water loss, maintain firmness, and preserve overall texture, acting as a physical barrier against environmental stress.

In the present study, control raw tomatoes reached full ripeness within 15. In contrast, tomatoes treated with 200 ppm ZnO nanoparticles remained fresh yellow pink for approximately 15 days, demonstrating a substantial extension of shelf life. Compared to conventional chemical ethylene treatments, the use of ZnO nanoparticles presents a safer and more eco-friendly alternative for postharvest management. The findings suggest that nano- enabled coatings along with chitason and glycerol could serve as a sustainable approach to reduce reliance on synthetic preservatives in the food industry while maintaining fruit quality and consumer safety. Overall, biosynthesized ZnO nanoparticles show promise as an effective tool in prolonging the marketability of tomatoes and potentially other perishable horticultural products.

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References:

1. Ahmed, S., Ahmad, M., Swami, B. L., & Ikram, S. (2016). A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: a green expertise. *Journal of Advanced Research*, 7(1), 17–28.
2. Alizadeh-Sani, M., Hashemi, M., & Aghdami, M. (2018). Application of nanotechnology in extending shelf life of fruits and vegetables. *Trends in Food Science & Technology*, 75, 1–13.
3. Espitia, P. J. P., Soares, N. F. F., Coimbra, J. S. R., de Andrade, N. J., Cruz, R. S., & Medeiros, E. A. A. (2012). Zinc oxide nanoparticles: synthesis, antimicrobial activity and food packaging applications. *Food and Bioprocess Technology*, 5(5), 1447–1464.
4. Giovannoni, J. (2007). Fruit ripening and its manipulation. *Annual Plant Reviews*, 26, 1–41.
5. Heuvelink, E. (2018). Tomatoes. In *Handbook of Vegetables* (pp. 305–341). Springer.
6. Kader, A. A. (2002). Postharvest technology of horticultural crops (3rd edition). University of California Agriculture and Natural Resources.
7. Khudair, H., Al-Darraji, S., & Hameed, H. (2019). Effect of ethylene and calcium carbide on ripening and postharvest life of tomato fruits. *Journal of Horticultural Science and Technology*, 7(1), 10–17.
8. Kumar, P., Shukla, S., Singh, T., & Wahla, V. (2020). Postharvest losses of vegetables: causes, consequences and management strategies. *Vegetable Science*, 47(1), 1–12.
9. Li, X., Xing, Y., Jiang, Y., Ding, Y., & Li, W. (2011). Antimicrobial activities of ZnO powder-coated PVC film to inactivate food pathogens. *International Journal of Food Science & Technology*, 46(7), 1673–1679.
10. Raghupathi, K. R., Koodali, R. T., & Manna, A. C. (2011). Size-dependent bacterial growth inhibition and mechanism of antibacterial activity of zinc oxide nanoparticles. *Langmuir*, 27(7), 4020–4028.
11. Seymour, G. B., stergaard, L., Chapman, N. H., Knapp, S., & Martin, C. (2013). Fruit development and ripening. *Annual Review of Plant Biology*, 64, 219–241.
12. Youssef, A. M., Salem, S. A., & Mohamed, H. A. (2020). Evaluation of zinc oxide nanoparticles as a coating for fruits preservation. *Food Packaging and Shelf Life*, 25, 100515.
13. Espitia, P. J. P., Soares, N. de F. F., Coimbra, J. S. R., de Andrade, N. J., Cruz, R. S., & Medeiros, E. A. A. (2012). Zinc oxide nanoparticles: synthesis, antimicrobial activity, and food packaging applications. *Food and Bioprocess Technology*, *5*(5), 1447–1464.
14. Li, Q., Mahendra, S., Lyon, D. Y., Brunet, L., Liga, M. V., Li, D., & Alvarez, P. J. J. (2011). Antimicrobial nanomaterials for water disinfection and microbial control: potential applications and implications. *Water Research*, *42*(18), 4591–4602.
15. Giovannoni, J. (2007). Fruit ripening mutants yield insights into ripening control. *Current Opinion in Plant Biology*, *10*(3), 283–289.
16. Espitia, P. J. P., Soares, N. F. F., Coimbra, J. S. R., de Andrade, N. J., Cruz, R. S., & Medeiros, E. A. A. (2012). Zinc oxide nanoparticles: synthesis, antimicrobial activity and food packaging applications. *Food Bioprocess Technology*, 5(5), 1447–1464.
17. Li, X., Xing, Y., Jiang, Y., Ding, Y., & Li, W. (2011). Antimicrobial activities of ZnO powder-coated PVC film to inactivate food pathogens. *Int J Food Sci Technol*, 46(7), 1673–1679.
18. Giovannoni, J. (2007). Fruit ripening and its manipulation. *Annual Plant Reviews*, 26, 1–41.
19. Khudair, H., et al. (2019). Effect of ethylene and calcium carbide on ripening and postharvest life of tomato fruits. *Journal of Horticultural Science and Technology*, 7(1), 10–17.
20. Youssef, A. M., et al. (2020). Evaluation of zinc oxide nanoparticles as a coating for fruits preservation. *Food Packaging and Shelf Life*, 25, 100515.
21. Alizadeh-Sani, M., et al. (2018). Application of nanotechnology in extending shelf life of fruits and vegetables. *Trends in Food Science & Technology*, 75, 1–13.