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NANOBIOTECHNOLOGY INTERVENTION TO ENHANCE POST HARVEST SHELF LIFE OF FRUIT CROPS

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Abstract – The increasing human population creates the demand quality food for health on the globe. Moreover, there is wastage of agricultural commodities like highly perishable fruits during post-harvest management via different channel points from farms to consumers. Therefore, there is a need for some alternative, cost-effective, efficient, green and eco-friendly technology to reduce post-harvest losses of fruit crops, especially for climacteric nature. Meanwhile, nanotechnology can provide a great solution of active, smart and antimicrobial activity-based nano packaging for safe transport and less deterioration of fruit quality during the long-distance market. In the present review, cum short communication will discuss some case studies in brief with reported analysis. Moreover, the biotechnological approach of gene expression at the molecular and cellular level is add insight into delaying in ripening of fruits due to nanotechnology.

INTRODUCTION

At the global level, nearly 1.3 billion tonnes/year of the edible parts of agricultural production for human consumption gets wasted. FAO asserted that yearly, global Food Loss and Waste are nearly 40 to 50% of horticultural crops. Food Corporation of India reported losses ranging from 10 to 15% of the total production of fruits and vegetables. Post-harvest losses mainly occur at different stages of post-harvest and processing levels, due to the highly perishable nature of horticultural crops (Anonymous, 2019). There are major constraints like lack of proper post-harvest management chain, less technological intervention and very poor packaging materials etc. Packaging is a key point to reduce fruit loss. Furthermore, it can protect and preserve the quality of fruit, also facilitate transport and distribution (Kuswandi, 2017). Therefore, to overcome this problem, novel, efficient and biodegradable packaging materials should develop to retain the freshness, durability, and quality of fruits. This can also aid to enhance fruits availability to fight against hunger.

Nanobiotechnology deals with various structures of matter having dimensions of the order of a billionth of a meter. Moreover, it is a discipline in which tools from nanotechnology are developed and applied with the intervention of biological phenomena. Due to very small dimensions, nanomaterials have extremely large surface area to volume ratio, which makes a large to be the surface or interfacial atoms, resulting in more "surface" dependent material properties. Thus, this technology can enhance the properties of presently used fruits packaging materials by incorporating nanomaterials. For instance, Bio based, Active, Improved, and Smart Packaging are different types of nano packaging materials (Kuswandi, 2017). A barrier performance, mechanical strength, thermal stability and antimicrobial strength are major properties of nano packaging materials.

To get insight into this phenomenon, the effect of nanopackaging materials on ripening related gene expressions through RT-PCR, enzyme activity related to the ripening process in peel and pulp of fruit, sensory parameters, antimicrobial studies, biochemical and physiological parameters could be studied for better understanding at a biochemical and molecular level.

CASE STUDIES

Kou *et al.* (2020) evaluated the effect of Calcium chloride and Chitosan/nano-Silica Composite film treatments on the quality of *Zizyphus jujube* Miller cv. Dongzao, especially in reddening by physiological changes in the fresh fruit, soft fruit rate, reddish index, firmness, weight loss, total soluble solids, titrated acid, total polysaccharides, total phenols and total flavonoids were determined. Also, they reported a decline of L-Phenylalanine ammonia-lyase (PAL), Chalcone synthase (CHS), and Chalcone isomerase (CHI) enzyme activities and enhanced nutritional value. Meanwhile, the treated groups retarded the increase in Anthocyanin and Quercetin contents by inhibiting the gene expressions of Flavonol synthase (*FaFLS*), Dihydroflavonol 4 reductase (*FaDF*R), and Anthocyanidin synthase (*FaANS*), while promoting Leucoanthocyanidin reductase (*FaLAR*) expression, which leads to retardation of fruit reddening. Anthocyanins were found to be responsible for post-harvest winter jujube reddening. Thus, results indicated that the treated group delayed the decline of the quality of fruits and extended its shelf life.

Dwivany *et al.* (2019) studied the influence of $n\mathrm{TiO}_2$, a photocatalyst, on ripening related gene *MaACS1* in *banana* cv. Cavendish at room temperature. Fruits were placed in a $n\mathrm{TiO}_2$ coated glass chamber (1.5 L) (10 Days). Fruit ripening in the treated chamber (with UV light-24 h) was delayed compared to the control (without light) by delayed TSS increment and lower pulp to peel ratio. RT-PCR showed that *MaACS1* expression in the treated was relatively down-regulated (approx 3 fold) than control at sixth day. The finding of these studies suggested that the $n\mathrm{TiO}_2$ chamber has the potential to extend the shelf life of banana by delaying its ripening process and decreasing the expression of *MaACS1*.

Hashim *et al.* (2019) synthesized and characterized ecofriendly nanomaterials *i.e.* Silica (140-150 nm), Chitosan, copper NPs (25-35 nm) and their combination Silica/Copper NPs (520-550 nm), Silica/Copper/Chitosan were carried out for storage of grape (veraison stage) at end of cold storage (2 months- 2±1 ^{0}C, followed by 7-day shelf-life at 22±2 ^{0}C). It effectively reduced Botrytis growth *in vitro* by 43, 38, 25, 30 and 43% at 4 mg/ml media, respectively. The effect of those NM's on TSS, TA, TSS/TA ratio and berries colour of grape were not significant. SEM showed that Chitosan and Silica NPs caused inhibition of hyphal growth and/or alteration of hyphal morphology. Meanwhile, NPs interacted with DNA isolated (40 µg/ml) from fungal mats: 10 µl concentrations of Chitosan and Silica NPs affected DNA integrity and led to a significant degradation. Therefore, a single application of Chitosan or Silica NPs was able to reduce gray mold of table grapes.

Kou *et al.* (2019) studied the influence of Abscisic acid (ABA) and a Chitosan/nano-Silica/Sodium alginate composite film on the color development and qualitative properties of harvested jujube (*cv.* Dongzao) stored at 20 ^{o}C and 80% relative humidity. A significant positive correlation between the colour values, weight loss and the malondialdehyde (MDA) content was found. The dihydroflavonol-4-reductase (*DFR*) is the primary gene that highly regulates the expression of anthocyanin in composite coated film. The results indicate that a composite film could prolong the shelf life of post-harvested winter jujube for approximately 1 month, while the ABA treatment induced ripening and reduced the quality.

Lustriane *et al.* (2018) evaluated the effect of different concentrations of Chitosan and Chitosan nanoparticles as edible coating in extending shelf life and maintaining the quality of banana fruits (*Musa acuminate*), treated with 1.15% chitosan, 1.25% chitosan and chitosan NPs (121.2 nm, PDI-0.395) then stored at ambient temperature (25±1 °C). The shelf-life of banana, starch content, weight loss, pulp to peel ratio, total soluble solid, surface morphology of banana peel and sensory evaluation were analyzed. SEM results of the fruits coated with a higher concentration of NPs completely covered the banana surface and blocked the pores and cracks on the fruit surface. The expression level of *MaACS1* and *MaACO* of banana coated with 1.25% CS was lower than the uncoated banana.

Besides, considerations regarding the risk for the consumer associated with migrating Engineered Nano-Objects from Food Consumed Materials were mentioned. Data is lacking about to with concerning all aspects of risk assessment including the fate of migrated ENOs in food and Gastrointestinal tract exposure to ENOs. Interactions of ENOs with food should be further studied along with ENOs characterized in different food matrices. Possible changes in the food matrix by interaction with (migrated) ENOs should be considered (Jokar *et al*., 2017).

CONCLUSION

Chitosan/nano-Silica and incorporated Sodium alginate Composite coating treatment effectively inhibiting the gene expressions responsible for fruit reddening lead to delay the decline of Winter jujube quality. The *n*TiO2 chamber, Chitosan nanoparticles and Chitosan has the potential to extend the shelf life of banana by delaying the ripening process also decreased the expression of *MaACS1* and *MaACO*. The highest concentration of Chitosan and Silica NPs affected DNA integrity and led to a significant degraded Botrytis in grape. Overall, Nano biotechnology has encouraging results to extend the shelf life of fruit crops.

FUTURE THRUST

FDA regulations, evaluations of safety, effectiveness, public health impact, or regulatory status of nanotechnology products should be concern. The regulation and exploration of nanomaterials at the cellular level by different -omics studies, *i.e*. Genomics, Proteomics, Transcriptomics and Metabolomics are much needed. The fundamental studies on toxicity and ecotoxicity, migration assays and risk assessment of NMs should be given priority.

Conflict of Interest: None

REFERENCES

Anonymous, 2019. NAAS-Saving the Harvest: Reducing the Food Loss and Waste, Policy Brief No. 5.

Dwivany, F.M., Esyanti, R.R., Suendo, V., Pratiwi, A.S. and Putri, A.A. 2019. Analysis of ethylene biosynthesis gene expression profile during titanium dioxide (TiO_2) treatment to develop a new banana post-harvest technology. *Indonesian Journal of Biotechnology.* 24(2):88-92.

Hashim, A.F., Youssef, K. and Abd-Elsalam, K.A. 2019. Ecofriendly nanomaterials for controlling gray mold of table grapes and maintaining postharvest quality. *European Journal of Plant Pathology*. 154 (2):377-388.

Jokar, M., Pedersen, G. A. and Loeschner, K. 2017. Six open questions about the migration of engineered nano-objects from polymer-based food-contact materials: a review. *Food Additives & Contaminants: Part A*. 34(3):434-450.

Kou, X., Chai, L., Yang, S., He, Y., Wu, C.E., Liu, Y., Zhou, J., Xue Z. and Wang, Z. 2020. Physiological and metabolic analysis of winter jujube after postharvest treatment with calcium chloride and a composite film. *Journal of the Science of Food and Agriculture*.

Kou, X., He, Y., Li, Y., Chen, X., Feng, Y. and Xue, Z. 2019. Effect of abscisic acid (ABA) and chitosan/nano-silica/sodium alginate composite film on the color development and quality of postharvest Chinese winter jujube (*Zizyphus jujuba* Mill. cv. Dongzao). *Food Chemistry.* 270: 385-394.

Kuswandi, B. 2017. Environmental friendly food nano-packaging. *Environmental Chemistry Letters.* 15(2):205-221.

Lustriane, C., Dwivany, F.M., Suendo, V. and Reza, M. 2018. Effect of chitosan and chitosan-nanoparticles on post harvest quality of banana fruits. *Journal of Plant Biotechnology.* 45(1):36-44.