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Physicochemical and microbiological properties of fruits enriched by nanoparticles as an edible coating

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Abstract

One of the promising technologies on fruit treatment is packed under the edible coating enriched by nanoparticles. It has many strength benefit, namely to extend shelf life, inhibit quality changes, maintain nutritional composition, increase antimicrobial and antioxidant activity, reduce the rate of respiration, inhibit ethylene formation, weight loss, pH, hardness, and total soluble solids. This review content summarized the effect of the treatment of edible coating enriched by nanoparticles on the physicochemical and microbiological properties of bananas, grapes, guava, tomatoes, mangoes, strawberries, and fresh-cut apples. Enriched nanoparticles edible coating treatment produces a longer shelf life by increasing antimicrobial activity. It could be applied on fruit industry to improve the physicochemical and microbiological properties of the fruit. Fruit treated with an edible coating enriched with nanoparticles retains more hardness, ascorbic acid, antioxidants, anthocyanin, and sensory quality than untreated fruit. Therefore, enriched nanoparticles edible coating technology can be an alternative for getting fruit with high nutritional quality and longer shelf life.

Keywords: Fruits; Coating; Enriched; Nanoparticles

1. Introduction

Fruit contains many important nutrients for humans and is planted throughout the world. However, the fruit has a relatively short shelf life because it is a commodity that is easily damaged or perishable food. Climacteric fruit will experience changes in the rate of respiration and increased ethylene production in large quantities even though it has been harvested. This causes the climacteric fruit to continue to experience the maturation process [1-3]. While non-climacteric fruit has a stable respiration pattern and does not indicate a significant increase in respiration production, marked by the decay process [4]. Therefore, the handling of fruit becomes the main focus for delaying the damage process. Delaying damage to the fruit is possible through post-harvest technology such as cold storage, modified atmosphere, and edible coating [5]. The use of edible coating is considered a safe, inexpensive, and simple approach to extending the shelf life of fruit [6].

The edible coating has been widely used to maintain quality and extend the shelf life of fruits because of its ability to create a barrier that inhibits microbial growth, reducing the level of respiration and transpiration, loss of humidity, and maintaining color, organic acids, sugar, and flavor components [7-9][5]. In addition to its preservatives, the edible coating can be formulated with many additives such as antioxidants, antimicrobials, enzymes, probiotics, vitamins, and flavorings to achieve active packaging [2, 3]. The main components of edible coatings are polymers, which include polysaccharides, proteins, lipids, pectin, alginate, and carrageenan [6, 10]. In recent years, research from Edible Coating proposed the combination of active compounds in the submicron size system using nanotechnology techniques [11, 12].

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Nanostructure is known to improve the functional properties, morphology, and stability of the polymer matrix used. Uneven polymer distribution in polymer matrices and interaction between faces can improve mechanical properties, thermal barrier, and gas properties [13]. Silver metal particles have been known for their antimicrobial activity since ancient times. AgNPs have been used as a promising reinforcement agent in the polymer matrix because of their nature for high surface area, high ion release rate, small particle dimensions, and good antimicrobial activity [14]. Nanoparticles of Zinc Oxide (ZnO) are known to inhibit microbial growth. ZnO nanoparticles have selective toxicity for bacteria and a negative effect on human cells. Because of their antimicrobial properties, ZnO nanoparticles are increasingly being used in the food industry [15]. Titanium dioxide is an inert chemical and is used in various food, medical, and biological products. TiO_2 (titanium dioxide) has reportedly shown ethylene and antimicrobial photodegradation activities. It was reported by [1], that the Chitosan-TiO2 nanocomposite improves tensile stretch and better barrier properties, as well as the ability of ethylene photodegradation.

Many researchers have reviewed the application of a nano-edible coating to fresh fruit that is processed to a minimum [9]. However, there are no exclusive reviews available that examine the physicochemical and microbiological properties of fruits enriched with a nano-edible coating. In this case, the purpose of this review is to provide in-depth information about the effect of edible coating treatment that is enriched with nanoparticles on the physicochemical and microbiological parameters of bananas, grapes, guava, tomatoes, mangoes, strawberries, and fresh-cut apples.

2. Methodology

The method used in this study is the Systematic Literature Review (SLR) method. Researchers identify, study, evaluate, and interpret all available studies. This study used 27 articles from Scopus-accredited international journals obtained from Publish or Perish (PoP). The article chosen has similar research, which is then analyzed and summarized.

3. Results and discussion

3.1. Bananas

Banana is one of the most important food plants in the world and contains many important nutrients such as minerals, vitamins, carbohydrates, flavonoids, and phenolic compounds. However, bananas have a relatively short shelf life because they are vulnerable to infectious diseases, causing a shorter shelf life for bananas. Research by [6], reported that the addition of ZnO nanoparticles to edible coating showed a significant improvement in the quality and longer shelf life of bananas. Bananas coated with CH/GA+0.5%ZnO treatment have a smooth surface and significantly slow down the maturation process. This is also supported by research [16, 2], that the structure of nano in the edible coating can reduce the level of ethylene production and has a low respiration rate. The addition of chitosan nanoparticles can increase the shelf life of bananas by 30 days. In addition, this treatment is effective in minimizing weight loss and delaying color changes.

3.2. Grapes

Grape is one of the non-climacteric fruits that is very easily damaged with limited shelf life due to loss of firmness, decreased berries, changes in stem color, drying, and decay by microorganisms. In addition, the existence of microorganisms can reduce the quality of the final product. To control the decay, fruit contamination, and the risk to the health it causes. It was reported by [17], that the chitosan nanoparticles are effective in maintaining the quality of the physicochemical, sensory, and microbiological properties of grapes. Nano chitosan particles provide an inhibitory effect on pathogenic bacteria, delay the process of fruit maturation, and decrease weight. Research [14], also reported that nanoparticles Ag showed good mechanical strength and antimicrobial activity against pathogenic bacteria and extended the shelf life of grapes. The addition of nano-ZnO to the CS-CAP mixed matrix affects the mechanical properties of the film, resulting in optimal stiffness and tensile strength. In addition, the transmission rate of water vapor and oxygen is significantly lower, it shows the ability to protect from UV, and it has antimicrobial activity [18].

3.3. Guava

Guava is considered an important fruit because it has a high nutritional value derived from polyphenols, carotenoids, and ascorbic acid. Guava is a climacteric fruit, and the maturation process continues even after it is harvested. In addition, it shows a high level of respiration due to metabolic activity that contributes to the quality and shelf life of guava. The nano-edible coating is used as a postharvest technology to prevent microbiological damage and minimize the physiological and biochemical changes of fruit. Research by [3], reported that the addition of nano-ZnO into edible coating can inhibit the appearance of rotting in guava which shows antimicrobial activity. Coating with

chitosan/alginate/nano-ZnO treatment affects delaying the process of maturation, protecting fruit, preventing decreased weight, and increasing shelf life. This is also consistent with research [19,20], which shows that nanotechnology can improve the functionality of edible films in food by allowing respiration rates to be reduced while maintaining physiological and nutritional quality. In addition [11], reported that nanoparticle lipids provide effects such as preventing changes in pH, browning, and loss of firmness. This is caused by nanoparticles, which have a positive effect on changes in metabolism, enzyme activity, and respiration.

3.4. Tomatoes

Tomatoes are a commodity that is easily damaged and the most widely planted horticultural plant because they have a unique umami taste and a pleasant aroma, and they contain phytonutrients such as ascorbic acid, phenolic compounds, and carotenoids. After being harvested, tomatoes experience a series of complex physiological and biochemical reactions. During ripening, tomatoes have increased physiological responses to increasing the rate of respiration and ethylene biosynthesis and increasing their vulnerability to microbial infections [9]. Research by [1], reported that nanocomposite chitosan-titanium dioxide showed tensile strength and good barrier and ethylene photodegradation ability rather than films that were not given the addition of nano-titanium dioxide. In addition, it has the effect of delaying the ripening process and extending the shelf life of tomatoes [5]. This is also supported by [7], reported that the addition of nano titanium dioxide produces an increase that is significant in thermal stability and UV barrier properties. In addition, it also shows significant antimicrobial activity on gram-positive, negative, and fungal bacteria.

3.5. Mangoes

Mango is a tropical fruit that is highly nutritious and has considerable economic value. However, mango is a climacteric fruit that experiences rapid postharvest change, so it has a relatively short shelf life and is easily damaged. Mango is a fruit that depends on the climate, is quickly matured and softened after harvesting, and can suffer physical and biological damage. Therefore, post-harvest technology approaches such as nano-edible coating have been studied widely to extend the shelf life of the fruit. Research by [21] reported that mangoes are coated with chitosan/nano-titanium dioxide efficient in maintaining the quality of mangoes during storage. In addition, research by [13] reported that mangoes coated with nanocomposites carrageenan-Nano ZnO can maintain the firmness of the fruit, delay color changes, and prevent damage. Nano-ZnO significantly increases tensile strength, decreases the level of water vapor transmission, and increases antimicrobial activity. This is also supported by research [22], the nano multilayer layer can prevent weight loss and has lower total soluble solids and higher titratable acidity compared to non-coated mangoes.

3.6. Strawberries

Strawberry is a non-climacteric fruit that is included in the most popular fruits consumed, both in fresh and processed forms. Apart from color and taste, strawberries are also a good source of ascorbic acid and antioxidant compounds such as anthocyanin. However, strawberries are classified as easily damaged fruit and are very sensitive to fungus decay due to high levels of metabolic activity. Enzyme activity such as polyphenol oxidase and peroxidase reduces the anthocyanin and polyphenol content, which causes browning in fruit and reaps antioxidant activity [23]. To maintain the quality of the strawberries in good condition, so that it is done in nanocomposite packaging during storage. According to [24], adding nano-ZnO has an advantage in preventing decreased weight, firmness, percentage of decay, and ascorbic acid content, as well as a positive effect in maintaining anthocyanin and antioxidant compounds. This is also by research [25, 14], that samples coated with nanocomposite films are efficient in terms of changes in physical, chemical, and mechanical properties during storage.

3.7. Fresh-Cut Apples

Fresh-cut apples containing antioxidants and other nutritional components recently became a popular food in food service, school, and family consumption. However, the preservation of fresh-cut apples is the hardest part because fresh-cut fruit undergoes a fruit deterioration process after minimum processing that can cause fruit spoilage. In addition, due to enzymatic browning, tissue softening, and microbial growth in fresh-cut apples, they generally have a short shelf life. To increase the shelf life of fresh-cut apples, edible coating treatment is effective in maintaining quality and extending the fruit's shelf life [26]. Research by [15] and [27], reported that the addition of nano-ZnO particles to nanocomposite showed good thermostability. In addition, it has higher water vapor and opacity permeabilities and lower oxygen permeabilities. The PBS/Nano-ZnO nanocomposite treatment also shows antimicrobial activity and extends the shelf life of fresh-cut apples. This can also be seen in the study of [8], Nanoparticle chitosan showed better antimicrobial activity than conventional chitosan and control layers. Even chitosan nanoparticle coatings are effective in inhibiting microbial growth for both bacteria and fungi.

4. Conclusion

Consumer demand for high-quality, healthy fruit that is rich in natural bioactive compounds such as vitamin C, phenolic compounds, and pigments increases dramatically. Fruit treatment with a nano-edible coating is one of the alternative packaging technologies with great potential to be able to extend shelf life, inhibit changes in fruit quality, maintain nutritional composition, increase antimicrobial and antioxidant activity, reduce the rate of respiration, inhibit ethylene formation, weight loss, pH, hardness, and total soluble solid content. Fruit with an edible coating treatment enriched with nanoparticles can maintain hardness, ascorbic acid, antioxidants, anthocyanin, and sensory quality better than fruits not treated. The impact of an edible coating enriched with nanoparticles causes an increase in antimicrobial activity, thereby extending the shelf life and maintaining the quality of the fruit.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors declare that there is no conflict of interest.

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