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Article

Biofilm of potato starch and silver nanoparticles

Biopelícula de almidón de papa y nanopartículas de plata

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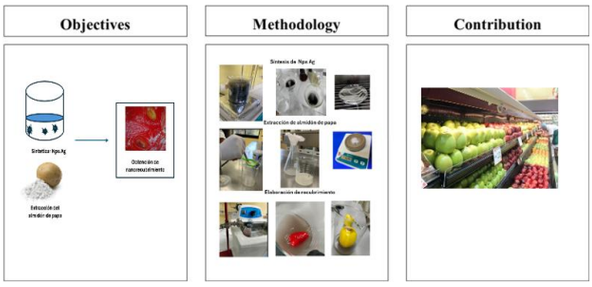
Abstract

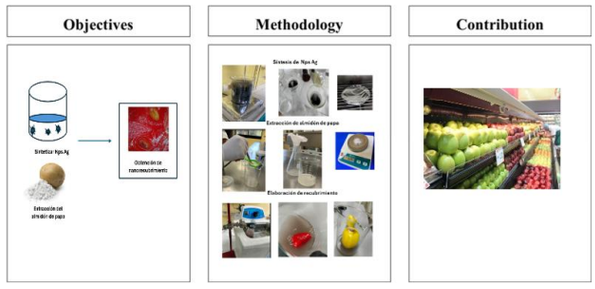
The biofilm and covering have been used to promote the change and improve the natural peel of diverse fruits, to prevent the loss of humidity, to allow the interchange of gases, to provide sterility and conservation. Therefore, in recent years a growing interest in the organic films has emerged, this organic films are very diverse, highlighting the potato starch based biofilms. In this investigation some silver nanoparticles were synthesized by the chemical reduction process and were used as covering in fruits to avoid the growing of bacteria in strawberry and apples in conditions of room temperature to maximize the lifetime in shelf of this perishable fruits.



Synthesis, Silver nanoparticles, Nanocoating

Resumen

Las películas y recubrimientos se han empleado para promover el reemplazo y reforzar las capas naturales de diversos frutos, para prevenir la perdida de humedad, permitir el intercambio de gases, proporcionar esterilidad y la conservación. Por lo tanto, en los últimos años ha surgido un creciente interés en las películas de origen orgánico, las cuales pueden ser muy variadas, destacando las biopelículas a base de almidón de papa. En este trabajo se sintetizaron nanopartículas de plata mediante el proceso de reducción química las cuales fueron usadas como recubrimientos para frutas y así evitar el crecimiento bacteriano en frutas como la fresa y la manzana a temperatura ambiente para maximizar la vida de anaquel de estos perecederos.



Síntesis, Nanopartículas de plata, Nanorecubrimiento

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Introduction

The biofilm and covering have been used to promote the replace and strengthen the natural peel of diverse fruits, to prevent the loss of humidity, to allow the interchange of gases, to provide sterility and to preserve the fruits. (Torrenegra 2016; Vazquez-Ovando,2013) In recent years a growing interest in the organic films has risen, this films are very diverse, specially the biofilms based in potato starch which stand out from others. (Reyes, 2019)

This product can be used to manufacture of bioplastics derivate from alternative compounds instead of petroleum with a lower impact in the environment with their production contributing to the climate change. (Cortez-Mazatan, 2011)

The use of nanotechnology to prolong the lifetime of the fruits and reduce the loss during these are transported, is an innovative concept for the food industry. Is expected that the nanomaterials will have a high impact in the development of the society. For this the application of the nanotechnology in the food conservation, like fruits, is innovative and with a high potential to improve the food safety and reduce the food waste. (Lira-Saldívar 2018)

The development of nano-biofilm to conserve fruits using nanomaterials is considered highly innovative. The application of nanotechnology in the food industry to solve conservation problems and food quality is a new approach with a high potential to impact the society and the food supply chain. (Lopez, 2020)

The nanomaterials are characterized to have dimensions in an atomic scale or in the range of 1 to 100 nanometers. This dimensions could give remarkable and significant properties in comparison with bulk materials.

Some of the nanomaterials properties, like the surface area, the spatial confinement and the reduction of imperfections give them a significant potential of innovation in different applications. The study of metallic nanoparticles has a high interest due to the possible applications from the optoelectronics to medical science, highlighting the silver nanoparticles in the case of medical science due to antimicrobial properties. (Nazario-Naveda, 2022; lopez-Carrizales, 2022)

The project is focused in apply nanotechnology to conserve of fruits, specifically strawberries and apples. The use of nano-biofilms based on potato starch and silver nanoparticles to coat this fruits has the purpose of keep the freshness and optimize the lifetime.

Methodology

The project was focused in the development of a nano-biofilm based on potato starch doped with silver nanoparticles to use in the conserve of fruits, especially strawberry and apples. The objective of this application is to extend the lifetime of these fruits and reduce the loss and waste while transport and storage.

Synthesis of silver nanoparticles

The synthesis was done using the chemical reduction method the $AgNO_3$ at 1M dissolved in water was used as precursor, the solution was agitated at constant temperature, when the 100°C was reached $Na_3C_6H_5O_7$ was added to the solution. Subsequently the temperature and agitation were constant of 1 hour, after the solution was filtered and send to dry at 60°C for 24 hours.

Coating application

The fruits were obtained with a state of maturity, these where selected to keep free of any defect that could affect the result of the coating. The fruits were washed, dried and storage at room temperature.

The microbial activity was observed with the use of an optical microscope.

Results

A nano-biofilm was elaborated using potato starch, with silver nanoparticles incorporated. In Figure 1 you can see the scanning electron microscopy (sem) analysis in which you can observe the good dispersion of the nanoparticles with a polymer matrix, showing the growth axis of the almost spherical crystals. It is important to say that with this technique only 2 micrometer particles could be observed since this was the first analysis and better characterization technologies are contemplated, as is observed in the figure 2

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Box 1

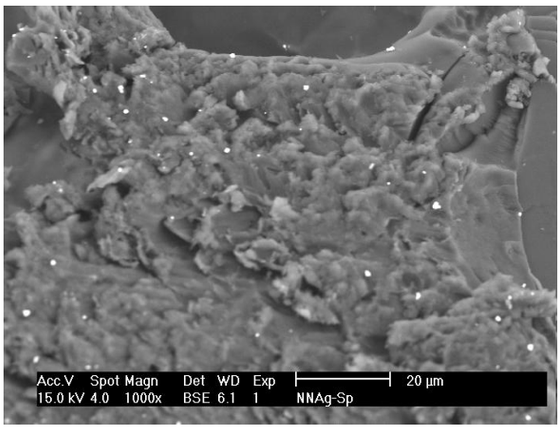

Figure 1
SEM image of the dispersion of silver nanoparticles in potato starch

Box 2

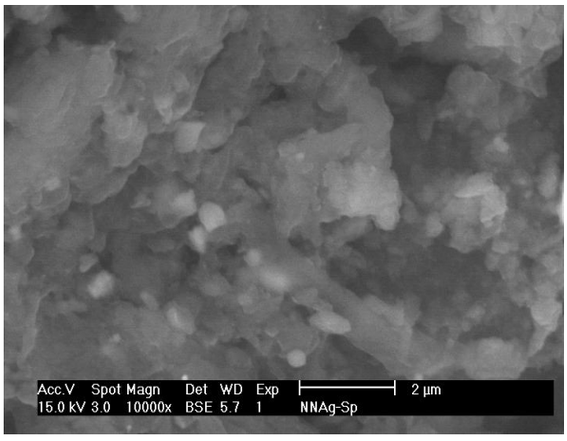

Figure 2
SEM image of the morphology of silver nanoparticles in potato starch

By infrared spectroscopy technique it could be observed the different caracteristic signals for starch. The wave length gap of 3000-3900cm^{-1} corresponds to the OH group, in the 2000-2850cm^{-1} gap is the corresponding for C-H strain. There are also typical signals for C-O straining in the 1251-1255cm^{-1} gap, this corresponds to what Figueroa and collaborators have reported in 2016 when they made the corresponding to potatoe starch characterization, as is observed in the figure 3.

Box 3

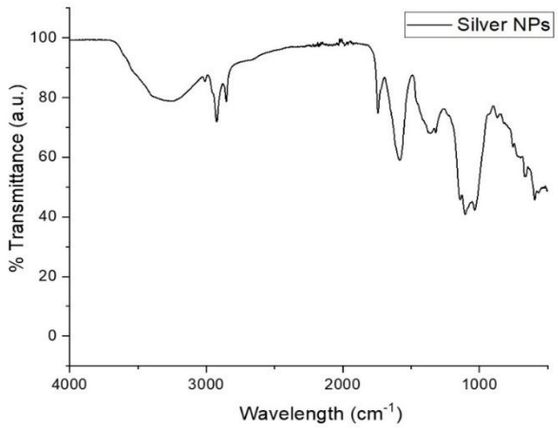

Figure 3
Infrared spectrum of potato starch samples doped with silver nanoparticles
Source: [Origin 2018]

Coating on strawberry

The strawberries were covered with the nano-bioparticle developed and it was compared with strawberries without coating, during a period of 14 days at room temperature. The experiment was monitored by a series of photographs of both samples. In the figure 2 it could be observed a comparative of the products along the specified time observing that after 4 days the sample with coating had a good appearance while the sample without coating developed fungus after 3 days. It was observed with an optical microscope that the fruit with nano-biofilm coating showed a better conservation. The film acted like a barrier that retarded the growth of bacteria and fungus, extended the lifetime of the strawberries, as is observed in the figure 4.

Box 4

a) **b)**

Figure 4
a) Strawberries without coating
b) Strawberries with nano-biofilm coating

With the optical microscope was observed that the strawberries covered with the nano-bioparticles present a better conservation.

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The biofilm acted like a barrier that retarded the growth of bacteria and fungus, extended the lifetime of the strawberries, in the figure 5 it is observed the changes in the strawberries along 14 days.

Box 5

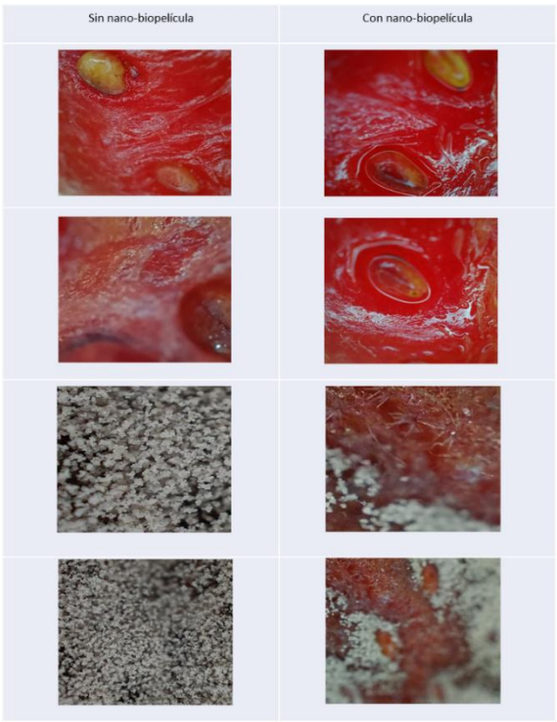

Figure 5
Monitoring of the strawberries using optical microscope

Coating on apples

The nano-biofilm was applied to apples to compare their appearance with apples without coating. The result shown that the apples with coating had an intense coloration and brightness in comparison with the non-coating apples.

Box 6

a) **b)**

Figure 6
a) Apple without coating
b) Apple with coating

Through the monitoring performed with an optical microscope, some wáter drops were identified on the surface of the coated apples, it indicated the presence of nano-biofilm. It contributes to the improvement of the conservation of the apples.

Box 7

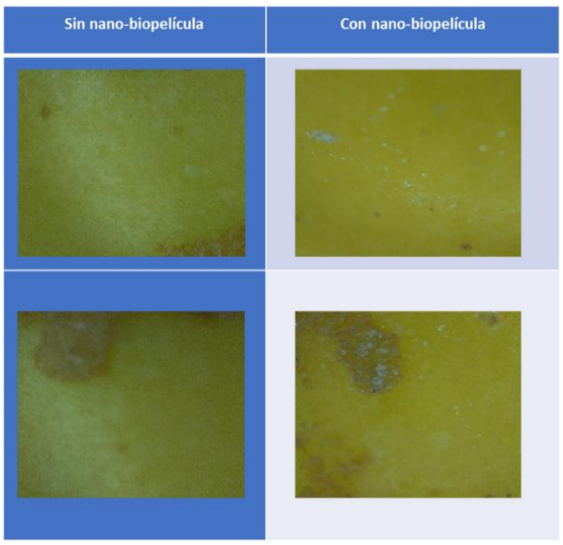

Figure 7
Monitoring of apples through optical microscope

The initial results shown a significant improvement in the time of conservation of both fruits when the nano-biofilm is applied. The presence of the film acted as a barrier that slow down the growth of bacteria and fungus, increasing the lifetime of the fruits.

Conclusions

The development of the nano-biofilm based in the potato starch and silver has demonstrated to be a solution in the conservation of strawberries and apples. With the passing of the test and improvements, this product has a potential to change the food industry with the reduction of losses during the transport and storage, it would contribute to satisfy the increasing demand of food in a constant growth market.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence in this chapter.

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Author contribution

Díaz-Silvestre, Sergio: Contributed to the project idea, bibliographic review and writing of the document.

Ramírez-Mendoza, Arizbeth: Contributed to the project idea, synthesis and characterization of nanoparticles, application and monitoring of nanobiocoating.

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Abbreviations

SEM	sweep electronic microscopic analysis

References

Background

Torrenegra A, M., León M, G., Matiz M, G., Pájaro C, N., & Sastoque G, J. (2016). Evaluación de un biorecubrimiento comestible a base de almidon de ñame modificado. Revista Chilena de Nutricion: Organo Oficial de La Sociedad Chilena de Nutricion, Bromatologia y Toxicologia, 43(3), 8–8.

Alfredo Vázquez-Ovando Lourdes Adriano-Anaya Rosmeri Méndez-De León Salvador Figueroa Miguel. (2013). Elaboración y caracterización física de biorecubrimientos compuestos basados en quitosán. Quehacer Científico en Chiapas, 8(2013), 26–34.

Reyes Torres Uriel, (Diciembre 2019). Efecto de las nanopartículas de plata en la memoria de forma del almidón de papa termoplástico. Instituto Politécnico Nacional.

Cortez-Mazatán, G. Y., Valdez-Aguilar, L. A., Lira-Saldivar, R. H., & Peralta-Rodríguez, R. D. (2011). Polyvinyl acetate as an edible coating for fruits. Effect on selected physiological and quality characteristics of tomato. Revista Chapingo. Serie: Horticultura, XVII(1), 15–22.

Lira-Saldivar, R. H., Argüello, B. M., Villarreal, G. D. L. S., & Reyes, I. V. (2018). Potencial de la nanotecnología en la agricultura. Acta universitaria, 28(2), 9–24.

Basics

López, M. L. (23 de Octubre de 2020). Recubrimiento de Poli(Acetato De Vinilo-Co-Alcohol Vinílico) Adicionado con Nanopartículas de Óxido de Calcio y su Efecto en la Poscosecha de Pepino (Cucumis sativus). Centro de Investigación en Química Aplicada.

Support

Lopez-Carrizales, M., Pérez-Díaz, M. A., Mendoza-Mendoza, E., Peralta-Rodríguez, R. D., Ojeda-Galván, H. J., Portales-Pérez, D., Magaña-Aquino, M., Sánchez-Sánchez, R., & Martinez-Gutierrez, F. (2022). Green, novel, and one-step synthesis of silver oxide nanoparticles: antimicrobial activity, synergism with antibiotics, and cytotoxic studies. New Journal of Chemistry, 46(37), 17841–17853.

Differences

Nazario-Naveda, R., Delfin-Narciso, D., Juárez-Cortijo, L., Rojas Flores, S. J., Castillo-Ramírez, A., Chavín-Castillo, C., & Duran-Zambrano, M. (2022). Incorporation of biosynthesized silver nanoparticles in active biodegradable films of potato starch. Proceedings of the 20th LACCEI International Multi-Conference for Engineering, Education and Technology: "Education, Research and Leadership in Post-pandemic Engineering: Resilient, Inclusive and Sustainable Actions".

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