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Mini Review

Food Industry Applications of Phyto-Synthesized Silver Nanoparticles

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Abstract

Silver nanoparticles biosynthesized from plants represent an economical option without the use of toxic solvents, so they are friendly to the environment. Within their various applications, these products are used in the food industry as antioxidants and packaging material increasing the preservation time by controlling microbial contamination.

Keywords: Silver nanoparticles, Phytosyntesis, Antimicrobial, Antibiofilm, Antioxidant

Introduction

Silver nanoparticles have characteristics that make them unique, mainly because of their volume and contact surface ratio, which modifies their physicochemical characteristics, increasing their solubility, bioavailability, and protection of active compounds; this characteristic allows their use in various sectors such as medicine, agriculture, textile, cosmetic and food [1].

The synthesis of silver nanoparticles can be performed using physical, chemical and biological methods. The main disadvantage of physical and chemical methods is that they have a high cost in economic and environmental terms because they involve the use of dangerous or toxic substances [2]. Therefore, recent research focuses on developing methods of synthesis of silver nanoparticles, which do not use hazardous substances and are friendly to the environment, which can be achieved using biological systems with microorganisms and plants [3].

The use of plants or their extracts for the synthesis of silver nanoparticles has advantages over the synthesis with microorganisms because the process of maintaining and cultivating the microbial strains is reduced, likewise the particle size can be controlled by modifying the synthesis conditions as the pH, temperature, speed of agitation and concentration of the reducing agent. The Phyto-synthesis of silver nanoparticles has been reported with around 350 plants and their extracts [4].

The applications of Phyto-synthesized silver nanoparticles include applications in the food industry as protectors against contamination by microorganisms, avoid biofilm formation and browning in fresh cut fruits. These applications are very important because it is one of the main problems during the production, transport, and storage of food [5,6]. This review will focus on the applications of Phyto-synthesized silver nanoparticles in food systems as antimicrobial, antibiofilm and antioxidant.

Antimicrobial activity

Silver nanoparticles can penetrate the bacteria cell by increase cell membrane permeability and release silver ions leading the cell to die. There are several products applied in food package or in surfaces during food processing [7-9] (Table 1).

Table 1: Application of Phyto-Synthesized Silver Nanoparticles as antimicrobials [7-9].

Plant used for biosynthesis	Part of plant used	Activity
Cheilanthes forinosa Forsk	Leaves	Antibacterial activity versus *S. aureus.*
Abutilon indicum	Leaves	Antibacterial activity on *E. coli* and *S. aureus.*

Pistacia atlantica	Seeds	Antibacterial activity versus *S. aureus*.
Delphinium denudatum	Roots	Antibacterial activity on *E. coli* and *S. aureus*.
Withania somnifera	Leaves	Antibacterial activity on *E. coli* and *S. aureus*.
Plectranthus amboinicus	Leaves	Antibacterial activity versus *E. coli*.
Aloe	Leaves	Antibacterial activity on *E. coli* and *S. aureus*.
Artocarpus heterophyllus lam.	Seeds	Antibacterial activity versus *S. aureus*.
Olive	Leaves	Growth inhibition of *E. coli* and *S. aureus*.
Bamboo	Leaves	Antibacterial activity on *E. coli* and *S. aureus*.
Wrightia tinctoria	Leaves	Antibacterial activity versus *S. aureus*.
Elaeagnus indica	Leaves	Growth inhibition of *E. coli* and *S. aureus*.
Morinda citifolia L	Leaves	Bactericidal activity on *E. coli*, *Enterococci spp*. And *Enterobacter aerogenes*
Tribulus Terrestris L	Fruit	Growth inhibition of *E. coli* and *S. aureus*.
Ocimum tenuiflorum	Leaves	Antibacterial activity versus *E. coli*.
Catharanthus roseus	Leaves	Growth inhibition of *E. coli* and *S. aureus*.
Garcinia mangostana	Leaves	Growth inhibition of *E. coli* and *S. aureus*.
Acalypha indica	Leaves	Antibacterial activity on *E. coli* and *Vibrio cholera*.
Citrus clementina	Peel	Growth inhibition of *E. coli* and *S. aureus*.
Jack fruit	Seeds	Growth inhibition on *E. coli* and *Salmonella spp*.

Antibiofilm activity

Biofilm formation is common in the food industry, this formation can be developed on different surfaces as well as in the food itself. The presence of this type of bacterial formation indicates nonhygienic conditions which affect the products [10]. Some silver nanoparticles elaborated form plants can prevent the formation of biofilms as presented [11-16] (Table 2).

Table 2: Application of Phyto-Synthesized Silver Nanoparticles as antibiofilm agents.

Plant used for biosynthesis	Part of plant used	Reference
Curcuma longa	Rhizome	[11]
Benzoin gum from *Styracaceae* tree	Resin	[12]
Acacia nilotica	Leaves	[13]
D. viscosa and *H. suoveolens*	Leaves	[14]
Momordica charantia	Fruit	[15]
Gloriosa superba	Leaves	[16]

Antioxidant activity

Table 3: Research examples that prove the antioxidant capacity of nanoparticles.

Plant used for biosynthesis	Part of plant used	Reference
Alternathera sessilis (linn.)	Leaves	[19]
Chenopodium murale	Leaves	[20]
Piper longum	Fruit	[21]
Bergenia ciliata	Leaves	[22]
Rhododendron dauricum	Flowers	[23]
Elephantopus scaber	Leaves	[24]

Antioxidant properties of Phyto-Synthesized Silver Nanoparticles can be applied in the food industry for control the browning, weight loss rate and decay in fruits trough packing material to expand shelf life and improve preservation quality in foods [17,18]. Another application is the production of functional foods with antioxidant activity which improves the health of the population. One of the most used methods to evaluate antioxidant activity is the method known as DPPH, in the following table some works are presented where the antioxidant activity of biosynthesized silver nanoparticles allows (Table 3) [19-23].

Conclusion

The synthesis of silver nanoparticles with plant extracts represent an environmentally friendly option by not using hazardous materials and solvents. Phyto-synthesized silver nanoparticles are used as active packaging, with antibacterial, antibiofilm and antioxidant properties. Thus, besides increasing shelf life, this packaging system does not change the food physical characteristics. However, it is necessary to evaluate the spectrum of antimicrobial action as well as toxicological issues for safety use.

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Conflict of interest

No conflict of interest.

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