Design and recent development in novel trashnomics Nanoparticle from recycled biological and food waste

Miss Geetika Deshmukh*[1], Miss. Aashita Sakore[1], Miss. Nehal Bhimjiyani[1], Mr. Ashish Kumar Pandey[1], Dr Achal Mishra[1]

[1]Faculty of Pharma. Sciences, Shri Shankaracharya Technical Campus, Bhilai, C.G. 490020

Corresponding Author: Miss Geetika Deshmukh, Email ID: govindsharma10aug@gmail.com

Abstract

The aim of the study was to biosynthesize nanoparticles using bio/food peel extract (BPE), and to study their all activities. The green synthesis of nanoparticles has received great attention in recent times owing to its advantages such as cost effectiveness, simplicity, eco-friendliness, biocompatibility, and wide applications over the conventional chemical and physical methods. Various kinds of biomolecules from microorganisms and plants have been successfully utilized for the synthesis of metallic and nonmetallic nanoparticles, and these have been well documented. To the best of our knowledge, this is the review on the green synthesis of metallic nanoparticles using diverse agro-wastes, enzymes, and pigments of biological origin. It is envisaged that the compendium will bring to the fore the emerging importance of these bio-resources for nano-biotechnological applications.

Keywords: Agro-wastes; Enzymes; Green synthesis; Nanoparticles; Pigments; Peel; Metallic nanoparticles.

INTRODUCTION

Nanotechnology has been a rapidly advancing field with various applications in medicine, including drug delivery systems, tissue engineering, and diagnostics. Nanotechnology has gotten a lot of attention in recent years. Materials with a diameter of 1–100 nm are classified as nanotechnology Researchers have been exploring novel materials and manufacturing techniques to develop advanced nano-composites for medical applications.

These days synthesis of nanoparticles using biological waste is favored by many terms, as they are safe, clean, inexpensive and so their production can be scaled up easily.

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Recycled biological agro-waste, such as agricultural byproducts or plant-based waste, can offer a sustainable and environmentally friendly source of raw materials for nanocomposite production. The idea of utilizing such waste materials in nanocomposite manufacturing aligns with the principles of green chemistry and circular economy.

Various metal nanoparticles such as silver NP, gold NP, etc. are synthesized by microorganisms like bacteria and fungi [4]. In research, it was revealed that metal nanoparticles produced by plants are more stable as compared to those that are produced by microorganisms

Agro waste can include:

- Crop residues: This includes leftover plant parts such as stems, leaves, husks, and stalks after harvesting crops like rice, wheat, maize, sugarcane, etc.
- Food processing waste: Waste generated during the processing of agricultural products, such as peels, pomace (pulp), shells, and seeds. Examples include fruit peels, vegetable scraps, coffee grounds, and nutshells.
- Animal waste: Waste materials produced from livestock farming, such as manure, poultry litter, and slaughterhouse waste.
- Forest residues: Waste generated from forestry activities, including tree branches, bark, sawdust, and wood chips.
- Agro-industrial waste: Waste produced during various agricultural industries, such as rice husk ash, bagasse (sugarcane residue), and oilseed cakes.

Agro waste, can serve as a sustainable and low-cost source for prepraton of Silver and Gold Nanopartilce. silver ions (Ag+), which can be reduced and stabilized to form AgNPs. This approach aligns with the principles of green chemistry and offers an environmentally friendly alternative to traditional synthesis methods.

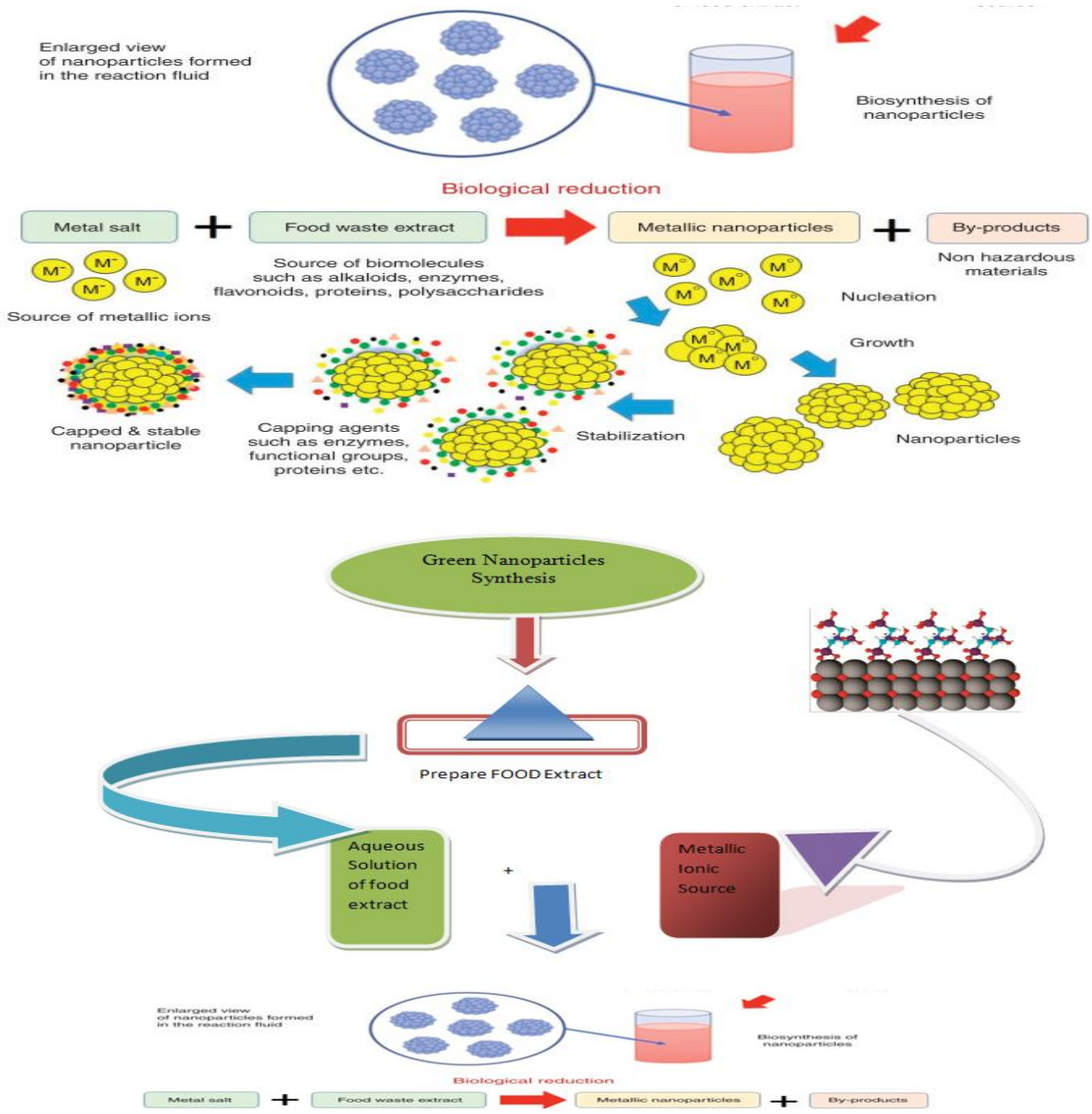
The synthesis of AgNPs from agro waste typically involves the following steps:

Collection and preparation of agro waste: Agro waste materials, such as fruit peels, tea leaves, or agricultural residues, are collected and processed to obtain the desired extract or precursor solution.

Extraction of silver ions: The agro waste extract is mixed with a silver salt solution (e.g., silver nitrate) to facilitate the release of silver ions. The extract acts as a reducing and stabilizing agent.

Reduction and stabilization: The silver ions in the solution are reduced by the components present in the agro waste extract, leading to the formation of AgNPs. The extract also helps in stabilizing the nanoparticles and preventing their agglomeration.

Characterization: The synthesized AgNPs are characterized using various techniques, such as UV-Vis spectroscopy, transmission electron microscopy (TEM), dynamic light scattering (DLS), and X-ray diffraction (XRD), to determine their size, shape, stability, and other properties.



Extract	Reaction condition	Types of nanoparticles	Size (nm)	Shape	Applications
Pomegranate fruit peel	1 mM $AgNO_3$+5 ml of extract for 24 h	AgNPs	5–50	–	Antibacterial
Rambutan peel extract	1 ml extract+10 ml of 1 mM $AgNO_3$	AgNPs	132.6±42	Triangle, truncated triangle, and hexagonal	Free radical scavenger
Rambutan peel extract	$Zn(NO_3)_2 \cdot 6H_2O$+extract. Reaction at 80°C for 2 h	ZnO nanocrystal	–	–	Antibacterial
Rambutan peel extract	0.1 M $Ni(NO_3)_2 \cdot 6H_2O$+10 ml extract under magnetic stirring at 80°C for 2 h	NiO nanocrystal	50	–	Antibacterial
Annonasquamosa peel extract	10 ml of extract+80 ml of 1 mM $AgNO_3$ at 25°C and 60°C, 4 h	AgNPs	35±5	Irregular spherical	–
Oak fruit hull extract	40 g/l extract+1 mM $AgNO_3$, pH 9 and temperature 45°C	AgNPs	40	Spherical	Cancer therapy
Cocosnucifera coir extract	80 ml of 1 mM $AgNO_3$+20 ml extract at room temp, 200 rpm, and 1 h	AgNPs	23±2	Spherical	Larvicidal
Punicagranatum peel extract	100 ml extract+40 ml of 1 mM $H_2PtCl_6 \cdot 6H_2O$ at 90°C, 500 rpm for 30 min	Pt-NPs	16–23	Spherical	Catalyst

Figure 01 agro-wastes used for the biogenic production of nanoparticles.

CONCLUSION

Biosynthesis of metallic nanoparticles has proven to be an effective alternative to the chemical and physical methods. The use of agro-wastes is of great advantage as it is one of the effective waste management processes and constitutes production of high-valued products from cheap materials. Microbial and plant-derived enzymes and pigments have also demonstrated good potential applications in the area of nanotechnology as they have been well utilized in the syntheses of nanoparticles of remarkable properties and applications. Richness of these materials in different biomolecules that can drive the process of synthesis of nanoparticles shall lead to economically viable means to produce nanoparticles on a larger scale through novel green approaches. This review has further underscored the emerging important roles that utilization of agro-wastes, enzymes, and biological pigments can play in the synthesis and applications of biocompatible nanoparticles in diverse areas of human endeavor**.**

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