

Production of nano-composites from agriculture and industrial waste. A green approach

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significant contribution in fulfilling the basic human need, sustaining life and strengthening the economy of any country. Developing and developed countries are trying to increase crop by investing minimum cost. But as the productivity increases there is also increase in amount agro-waste. Likewise, every year about 1.3 billion tonnes of biowaste is (2018) and is quite costly to dispose of these wastes as lot of money is required for collection, transportation and utilizing biowaste. So easy alternate is either used as animal feed or turned due to the unavailability of cheaper suitable machinery. Agro-industrial wastes are mostly underutilized, untreated and thus in most cases disposed off by burning, incineration, landfilling which causes a serious environmental pollution and adversely affect human and animal health. According to Sadh *et al.*, 2018 agro-industrial wastes can be defined as "wastes from agricultural field, process residues and industrial residues".

Pineapple is the second largest cereal crop generates grains and huge amount of agriculture waste in the form of straw, bran, husk, ash, broken rice. Likewise, *Ananas comosus* (Pineapple) produces large quantities of waste. The residues generated during the processing includes fresh peel, core, base and crown of the pineapple. However, such wastes contain variability in composition like rich in carbohydrates, proteins, vitamins, minerals, etc. Therefore, they should not be considered as “wastes” but raw materials for other industrial processes.

During the last few years, a lot of attention worldwide and nanoparticles are produced using these biowaste. This green nanotechnology-based approaches using agro-industrial waste have been found to be a cost-effective method with various biomedical applications. The rice by-products are used for production of nano structured materials such as carbon nanostructure tubes (CNTs), silica nanoparticles (SiO₂), silica nanowires (SiO₂ NWs), magnetic mesoporous silica MCM-41, UV-curing nano silver conductive ink, Nanocrystalline forsterite (Mg₂SiO₄) (CNFs), Luminescent silica nanoparticles (SiO₂). Similarly, *Ananas comosus* peel waste was also used for the synthesis of ultra-small silver nanoparticles (average size 14–20 nm), Carbon Quantum Dots (CQDs), cellulose nanocrystals. Therefore, in this paper we are discussing about the utilization of cheap by-products into valuable products using green nanotechnology.

Table 3: Nanomaterials produced from rice by-products

Chemical composition (% w/w)					
Cellulose	Hemicellulose	Lignin	Ash (%)	Moisture (%)	
5–40	20–24	8–12	14–16	4.8	Chaturvedi <i>et al.</i> , 2021
0–43	-	-	10-11	9-11	Rosniyana <i>et al.</i> , 2015
2-37	29-32	24-30	14–20	5-16	Kalita <i>et al.</i> , 2015

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Table 3:- Nanomaterials produced from rice by-products

By products of rice	Nanomaterials produced	Reference
Straw	cellulose nanofibrils, nano-composite-polymeric membrane	Jiang <i>et al.</i> , 2016; Bhattacharya and Mandal, 2018
husk	carbon nano tubes, Nanocrystalline-forsterite (Mg ₂ SiO ₄), mesoporous silica MCM-41	Mathur <i>et al.</i> , 2018; Kamari and Ghorbani, 2021
Ash	silica nanowires (SiO ₂ NWs), luminescent Si nanoparticles	Bathla <i>et al.</i> , 2018; Matsumoto <i>et al.</i> , 2018

Table 4:- Nanomaterials produced from pineapple by-products

By products of pineapple	Nanomaterials produced	Reference
Crown	of cellulose nanocrystals, carbon modified with iron nanoparticles (CFe), iron carbide (CarFe)	Faria <i>et al.</i> , 2020; Gutierrez-Muñiz <i>et al.</i> , 2013
Peel	Blue emissive carbon quantum dots (CQDs), ZnO nanoparticles	Rajamanikandan <i>et al.</i> , 2021; Mirgane <i>et al.</i> , 2021

Nanoparticles from by-product of rice:- Agricultural wastes can be used to produce value-added products. Green nanotechnology has gained huge attention over time. The by-products of agriculture waste have been used for the production of nanoparticles. The fundamental component of nanotechnology is the nanoparticles between 1-100 nanometres in size and are made up of carbon, metal, metal oxides or organic matter. The formation of value-added product such as nanoparticles are reviewed and discussed here.

Using rice straw cellulose, thinner cellulose nanofibrils (CNFs). (Jiang *et al.*, 2016), nano-composite polymeric membrane comprising polyether-polyamide block co-polymer (PEBA) (Bhattacharya and Mandal, 2018). Likewise, carbon nano tubes using microwave oven (MO) technique, Nanocrystalline forsterite (Mg₂SiO₄) (Mathur *et al.*, 2018), the mesoporous silica MCM-41 and the magnetic mesoporous silica MCM-41 were synthesized using rice husk (RH). Similarly, rice husk ash were used for synthesizing amorphous silica nanowires (SiO₂ NWs) (Bathla *et al.*, 2018) and luminescent Si nanoparticles via the Mg reduction of SiO₂.

Nanoparticles from by-product of pineapple:- Pineapple by-products were used for the production of nanoparticles. However, production of cellulose nanocrystals (Faria *et al.*, 2020), carbon modified with iron carbide (CarFe) (Gutierrez-Muñiz *et al.*, 2013) from pineapple crown has been studied in recent researches. Similarly, blue emissive carbon quantum dots (CQDs) (Rajamanikandan *et al.*, 2021), ZnO nanoparticles from pineapple peel extract (Mirgane *et al.*, 2021).

Conclusion:- Agro based wastes or residues are rich in nutrient composition and bioactive compounds. Such wastes contain variability in composition like rich in sugars, minerals and proteins; therefore, they should not be considered as “wastes” but raw materials for synthesis of other products such as production of nanoparticles. The use of agricultural and agro based industry wastes as raw materials for nanoparticles production can help to reduce the waste and protects environment from pollution.

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Nanoparticles structures

