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Analysis of Nanosized Jackfruit Seed powder for Synthesis of Bioplastic and Enhancement of Shelf life using Silver Nanoparticles

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***Abstract* - This study reports on the investigation into the ability of nano sized jack fruit seed powder for the preparation of bioplastic films. Jack fruit seed powder, glycerol and vinegar was used as the raw materials for the starch-based bioplastic film preparation. This method is simple, eco-friendly and cost effective. Characterization of the bioplastic was done using XRD and FTIR analysis. Knowing the importance of bioplastic, we have attempted to improve the shelf life of the bioplastic film by incorporating silver nanoparticles prepared by green method using Ocimum tenuiflorum (Tulsi). An increase in shelf life of the films was observed on storage.**

I.INTRODUCTION

Artocarpus heterophyllus Lam, which is commonly known as jackfruit is a tropical climacteric fruit, belonging to *Moraceae* family, is native to Western Ghats of India and common in Asia, Africa, and some regions in South America. It is known to be the largest edible fruit in the world, which is rich in nutrients like carbohydrates, proteins, vitamins, minerals and phytochemicals [1-2]. Parts of Jackfruit tree like fruits, leaves and bark are extensively used for the preparation of traditional medicines due to carcinogenic, antifungal, anti-inflammatory and wound healing properties. Several food products are also prepared from jack fruit also. In spite of all these benefits, unfortunately the jack fruit seeds are underutilized in commercial scale.

Jackfruit seeds are light brown coloured, rounded, 2-3 cm in length and by 1-1.5 cm in diameter. They are surrounded by the flesh and enclosed in a white aril surrounding a thin brown spermoderm, which covers the fleshy white cotyledon. It has been found that these are rich in carbohydrates and proteins [3-4]. Moreover, Jack fruit seeds have rich native starch content of approximately 8 to 15% by weight of a jackfruit. The recovery yield of starch extracted from jackfruit seeds was about 77%, which implies its possibility of being used as a potent source of starch in food and pharmaceutical industries, as a stabilizer, thickener, and as binding agent. They are extensively used in health sectors, in the production of food products, as antimicrobial agents, in the synthesis of bioplastics etc.

Recently extensive research is focused to replace conventional petrochemical based plastic with bioplastics. The environmental, economic and safety challenges have prompted many scientists to replace part of a petrochemical-based polymer with another biodegradable type, called bioplastics [5-6]. One of the major components of bio plastics is starch. Starch is often used in the form of biodegradable films in a variety of applications as they are renewable, abundant and inexpensive materials. Addition of fillers is also essential to increase the strength, toughness of the bioplastic products.

The introduction of nanotechnology in food packaging industries offer potential solution for the challenges proposed by bioplastic materials like short shelf life, quality of the product and microbial attacks [7]. The incorporation of nanoparticles in the polymer matrix or the fabrication of nanocomposites overcomes the shortcomings of these biodegradable polymers. One of the advantages of using nanoparticles is the ability to tune the rate of biodegradation of the materials. Thus physical, chemical and biological properties of the biodegradable polymers can be tuned for sustainable applications in medicine and related areas [8]. Studies on metallic nanoparticles are done based on Magnesium oxide, copper oxide, zinc oxide, cadmium selenite, cadmium, silver, gold due to their antimicrobial activity [9-10]. These nanoparticles have a high surface to volume ratio and large contact area per unit volume between the polymer and nano particles. Silver nanoparticles are well known for their strong toxicity towards microorganisms, besides some processing advantages such as high temperature stability, antimicrobial and low volatility. Antimicrobial activity of silver nanoparticles is described by different mechanisms: (a) adhesion to the cell surface, degradation of lipopolysaccharides and formation of ‘pits’ in the membranes, largely increasing permeability b) penetration inside bacterial cell, damaging DNA and releasing antimicrobial Ag+ ions by dissolution of silver nanoparticles, can be incorporated into biopolymers. The antimicrobial activity of silver-based systems depends on releasing of Ag+, which binds to electron donor groups in biological molecules containing sulphur, oxygen or nitrogen. Besides the antimicrobial activity, silver nanoparticles have been reported to absorb and decompose ethylene, which may contribute to their effects on extending shelf life of fruits and vegetables [8].

II MATERIALS AND METHODS

A. *Preparation of bioplastic film from Jack fruit seed powder*

Nano sized jack fruit seed powder, glycerol, white vinegar and distilled water are taken in calculated amount and stirred to get a homogeneous solution. The mixture was heated to 10-15 minutes to get a slightly viscous solution. Lumps may begin to form if the mixture gets overheated. Pour the mixture onto a ceramic tile. Spread the heated mixture onto the ceramic tile to let it cool. Allow the plastic to dry for at least two days. It will take time for the plastic to dry and harden [11]. Study of degradation time of the bioplastic was also done.

B. *Green synthesis of silver nanoparticles from Ocimum tenuiflorum (Tulsi)*

Healthy plant samples were collected and cleaned properly in running tap water. The samples were allowed to dry at room temperature. About 40 grams of plant leaves were weighed out and were cut into small pieces. Finely cut pieces were then mixed with 200 ml distilled water. This mixture was kept for boiling for 30 minutes. After cooling to room temperature, it was filtered. 100 ml of the aqueous solution of plant extract was added to 50 ml of 1 molar silver nitrate solution. The solution was allowed to react at room temperature. Silver nanoparticles formed were allowed to settle down. It was then filtered washed and dried [12].

C. *Enhancement of shelf life of bioplastic*

The rate of degradation of the bioplastic made from jackfruit seed powder was studied as a function of time. Silver nanoparticles prepared by green method were incorporated in the bioplastic materials at various concentrations. The bioplastic sheet 1, sheet 2, and sheet 3 were prepared by adding silver nanoparticles in different quantities i.e. 0.02 g, 0.05 g, and 0.1 g respectively. The degradation period of bioplastic sheets after incorporating the silver nanoparticle was also studied.

III RESULT AND DISCUSSION

A. *X-ray diffraction studies of Jackfruit seed powder*

The XRD pattern of the jackfruit seed nanoparticles is shown in Fig: 1. Indexing process of powder diffraction pattern was done and Miller Indices (h k l) to each peak is assigned in first step. A number of Bragg reflections can be seen which correspond to the (111), (200) and (211) reflections. The diffraction peaks are broad which indicate that the crystallite size is very small. The size of the jackfruit seed nanoparticles estimated from Debye–Scherrer formula (Instrumental broadening) is 6.8892 nm.

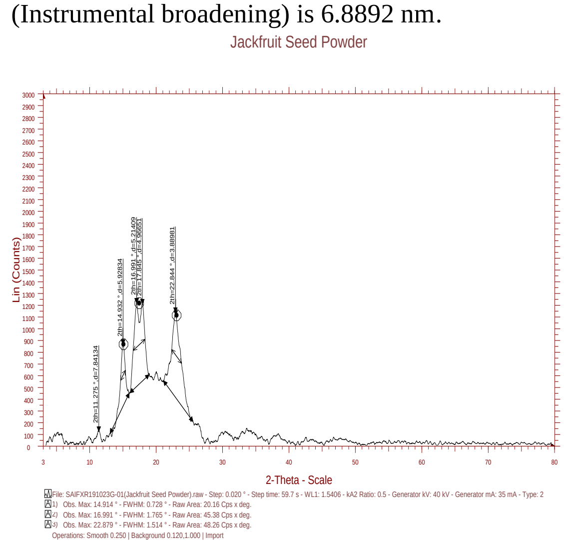

Fig: 1.XRD pattern of the jackfruit seed nanoparticle

The X-Ray diffraction pattern of silver nanoparticles synthesized by green synthesis method from tulsi plant extract is shown in figure 2. The XRD analysis showed diffraction peaks corresponding to FCC structure of silver. Intense peaks were observed at 38.042, 44.212, 64.369, and 77.271 (fig 2), corresponding to 111, 200, 220, and 311 Bragg's reflection, respectively (JCPDS card file no. 03-0921). The broadening of the Bragg peaks indicates the formation of nanoparticles. Full width at half maximum (FWHM) data was used with Scherrer's formula to determine the average particle size. The average particle size estimated was approximately 17.185 nm.

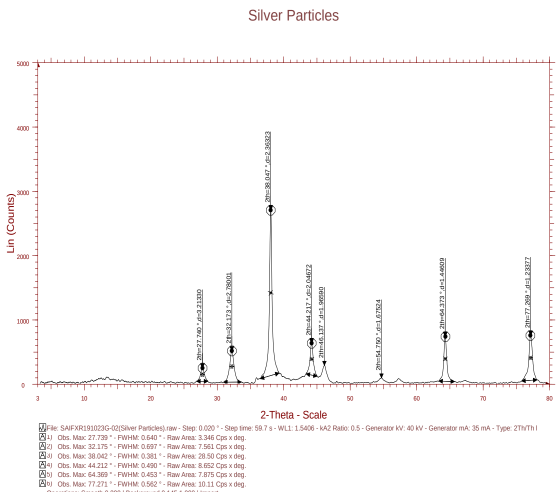

Fig: 2 XRD pattern of silver nanoparticle

B. FTIR Analysis

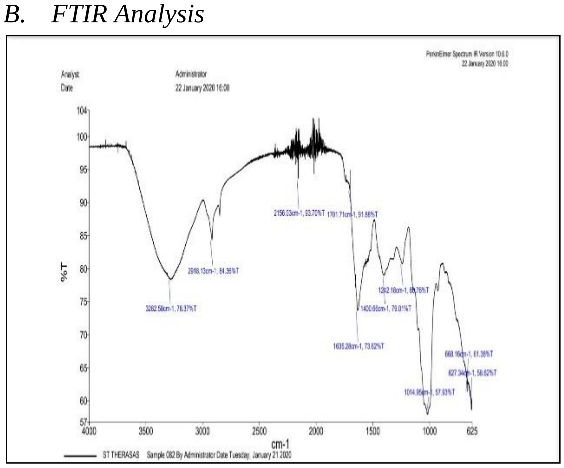

Fig 3: The FTIR spectrum of nano sized jackfruit seed powder

The FTIR spectrum of nano sized jackfruit seed powder is shown in figure 3. FT-IR report is in agreement with XRD report of literature and indicates the presence of carbohydrate. Presence of alkanes, alkenes, aromatics, alcohols, ethers, nitrates, sulfonates and organic halogen compounds are also observed. Aromatic compounds indicate existing of flavanoids. Sulphur derivatives compounds are present in jackfruit seeds which exhibit some anti-microbial properties [13,14].

No	X cm^{-1}	Y% of t	Functional group
1	3282.58	78.37	OH, Carbonyl amide
2	2918.13	84.36	C-H, Acid-OH, Aldehyde=C-H
3	2156.03	93.701	C Triple bond C
4	1701.71	91.88	C=O (Acid)
5	1635.28	73.62	C=C, N-H
6	1400.66	79.01	C-H
7	1242.18	80.76	C-N, C-O
8	1014.95	57.93	C-F, C-O
9	668.16	61.38	C-Cl
10	627.34	58.62	C-Cl

Table 1: FTIR analysis of Jack fruit seed powder

The observed bands for amines, amides, amino acids indicate the presence of protein and the details are presented in Table 1. It is essential to mention here, Jacalin a major protein is obtained from the jackfruit seeds (tetrameric two-chain lectin combining a heavy chain of 133 amino acid residues with a light β chain of 20-21 amino acid residues). Some other absorption bands indicate the presence of bio-molecules like carbohydrates, polysaccharides and lipids [13-16].

C. Preparation of bioplastic using jackfruit seed nanoparticle and study of its shelf life

Thick sheet of bioplastic synthesized from nanosized jackfruit seed powder is shown in figures. The shelf life of the film was observed and its degradation period was studied. The picture of bioplastic taken on day 1, 4 and 8 are shown in fig 4,5,6 respectively.

Fig: 4: Bioplastic sheet prepared from jack fruit seed nanopowder

Fig: 5 Bioplastic sheet after 4 days from the formation date

Fig: 6 Bioplastic sheet after 8 days from the formation date

Microbial attack was observed after 8 days and the bioplastic film starts degrading.

D. Preparation of bioplastic by incorporating silver nanoparticle

The three different thick sheets of bioplastic synthesized from nano sized jackfruit seed powder incorporated with different quantities of silver nanoparticle having antibacterial property was prepared. Degradation study was also done on these samples. Bioplastics incorporated with silver nanoparticles showed an increase in shelf life irrespective of the amount of silver nanoparticle added.

Three different sheets of bioplastic were prepared using jack fruit seed nanoparticle by incorporating 0.02g, 0.05g, 0.1g of silver nano particle. Bioplastics incorporated with silver nanoparticles showed an increase in shelf life of 11 days irrespective of quantity of silver nanoparticle added. This increase in shelf life of bioplastic after adding silver nano particle may be due to the anti-bacterial property of silver nano particle on microorganisms. The advantage of silver nanoparticles as antimicrobial agents is that they can be easily incorporated to several materials, making them useful in wide spectrum applications.

IV. CONCLUSIONS

Jack fruit seed powder could be an effective substrate for the production of starch-based bioplastics and it will be a feasible solution as a substitute for petroleum-based plastics. In this paper we have analysed the jackfruit seed powder by XRD and FTIR analysis. The average particle size was found to be 6.8892 nm. FTIR analysis of nano jack fruit seed powder showed bands for amines, amino acid and amides which indicates the presence of protein and, jacalin a major protein obtained from the jack fruit seeds. Other absorption bands indicate the presence of biomolecules like carbohydrate, polysaccharides and lipids. Bioplastic was prepared from nano sized jackfruit seed powder using standard procedure and its shelf life was studied. The bioplastic was observed to have a shelf life of 8 days only. Knowing the importance of bioplastic, we have attempted to prepare bioplastic from jackfruit seed powder and improvement in shelf life was achieved by incorporating silver nanoparticles prepared by green method. Particle size of silver nanoparticles determined by XRD was 17.185 nm. Different quantities of silver nanoparticles were incorporated into the bioplastic matrix. The shelf life of bioplastic increased to 11 days after incorporating silver nanoparticle irrespective of the amount of nano silver added. Studies reveal that silver nanoparticles enhance the shelf life of bioplastic. It may be due to the effective antibacterial action of silver nanoparticles on the microorganisms.

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