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Development and Characterization of Bioplastic Synthesized from Ginger and Green Tea for Packaging Applications

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Abstract: The world is suffering from heavy pollution because of synthetic petrochemical plastic used in our daily activities. A possible solution is the use of bioplastic synthesized from natural renewable resources. The present work investigates the development and characterization of polymer bioplastic using ginger tea and green tea to decrease the adverse effect of petrochemical plastic waste for versatile applications. Two kinds of bioplastic samples were produced with two types of tea, ginger tea and green tea, using glycerol, vinegar, starch, and water. SEM (scanning electron microscopy), FTIR (Fourier transformed infrared spectroscopy), mechanical (tensile), TGA (thermogravimetric analysis), DSC (differential scanning calorimetry), and time tests of bioplastic degradation analysis were carried out to evaluate the morphological, mechanical, and thermal behaviors of the synthesized tea bioplastics. The research result showed ginger tea bioplastic had a maximum tensile strength of 2.9 MPa and a minimum elongation of 7.46 mm. More than 78% of degradation occurred in ginger bioplastic within 30 days. Compatible thermal and morphological characteristics are also observed in the prepared bioplastic samples.

Keywords: bioplastic; ginger tea; green tea; environmental remediation; morphology

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1. Introduction

Composites regularly come full circle into lightweight structures, having great firmness and custom-made properties for applications, subsequently sparing weight [1]. Biocomposites are materials made from filaments (standard or engineered) and petroleum-inferred non-biodegradable polymers or biopolymers [2]. However, bio-composites inferred from natural plastics and fibers are eco-friendlier, hence they are among the most desired materials of the 21st century [3]. The non-renewability and non-biodegradability of petroleum resources, depletion of reliable wood products, environmental concerns, and increasing awareness of the carbon footprint are causing research to be directed into natural fiber-reinforced composites for new applications [4]. Due to waste disposal problems and strong environmental regulations, a significant proportion of scientific studies have led to biodegradable eco-composite materials [5]. Composite bioplasticis identified as an emerging material for creating maintainable materials, primarily because of the total biodegradability of composite biodegradable plastic produced for different applications [6–8]. Biopolymer-based materials are necessary to convert into hybrid biopolymer composites to increase their mechanical and tribological properties [9–11]. Biopolymer materials are available at a low price, have excellent mechanical properties, and are biodegradable [12,13]. Starch has been gaining attention since the 1970s. Numerous endeavors have attempted to create starch-based polymers for moderating petrochemical assets and diminishing their natural effects [14]. However, starch-based materials have a few downsides, including long-term steadiness caused by water assimilation, maturing caused by retro degree, and destitute mechanical properties [15]. Plasticizers such as glycerol have allowed us to make improvements in the shelf-life and versatility of items in order to overcome these restrictions [16].

Yam starch bioplastic exhibits better toughness in comparison to small flexible potato starch bioplastic [17]. Additionally, it has exceptionally tall biodegradable properties, with conventional mechanical and thermal properties [18]. Ca_2þ particles in a starch–water suspension with and without warming impact its physicochemical properties [19]. Starch–water suspensions warmed without Ca_2þ delivered custard without kinematic consistency; this was reflected in the immaculate flexible behavior of the mechanical test [19]. In contrast, the closeness of divalent particles of Ca_2þ in these suspensions prompts the arrangement of a hydrogel [20] with a far better mechanical quality, Young's modulus, water dissolvability, and contact point; this is accomplished with 4% energy natural product peel expansion, combined with 32 to 38 wt % glycerol from 80 to 120 rpm screw speed [21]. Its pliable quality confirms that the bioplastic of jackfruit starch, percent stretching, Young's modulus, and glycerol produce a film with great mechanical properties [22]. Starch is suitable because of its for low cost, availability, renewability, biodegradability, on-abrasiveness, and low density [22]. However, starch-based materials have a few disadvantages, including long-term steadiness caused by water assimilation, maturing caused by retro degree, and destitute mechanical properties [23]. Plasticizers such as glycerol have allowed us to make strides in the shelf-life and versatility of items in order to overcome these impediments [15]. Filler is the foremost successful strategy to extend this inclination [16]. Some cost-effective fortifications are natural renewable assets [24], lyocell [25], brief abaca [26], paper mash [27,28], jute [29], bamboo [30], microcrystalline cellulose [31], pineapple [32], Cordenka [33], flax [34], sisal [35], and kenaf [36]. PLA is an attractive prospect due to its, renewability, biodegradability, moo thickness, non-abrasiveness, and its moo-fetched quality [37]. A selection of studies on the mixing of PLA/starches [38] such as wheat starch, corn starch, and cassava starch [39] have been investigated.

Acidification, hydrolysis, and microbial fermentation are the most common chemical or biological processes used to make bioplastic from different natural resources such as vegetable oil, potatoes, corn, and wheat [40,41]. Starch is considered one of the most-utilized sources by researchers among natural resources. Starch is basically formed by amylase and amylopectin. The linear structure of amylase provides highly flexible and strong mechanical properties. However, the branched structure of amylopectin provides lower resistance to tensile strength and elongation properties [42]. Among natural resources, starch is inexhaustible, renewable, and has a low price [43]. Different types of tea are mixed with starch nowadays to improve the quality of bioplastics. They are biodegradable and can improve the properties of bioplastics. The literature shows several examples of the preparation of bioplastic from tea [44].

Ginger is a flowering plant that is around one meter tall. Its rhizome and roots are widely consumed as a spice and folk medicine. It is traditionally used as medicine for menstrual pain, osteoarthritis, migraine, rheumatoid arthritis, diabetes, cardiovascular disease, metabolic disorder, etc. in different parts of the world, especially in China and the Indian subcontinent [45,46]. It is also popular for cooking. Edible fresh ginger contains