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EFFECT OF KENAF FIBER AND INDIAN JUJUBE EXTRACT ON THE MECHANICAL PROPERTIES OF SWEET POTATO STARCH BIOPLASTIC COMPOSITE

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ABSTRACT: In this study, bioplastics composites were developed using starch from sweet potatoes, glycerol, Indian jujube extract (IJE) and kenaf fiber (KF) with different compositions. Based on the tensile test analysis, the optimal ratio for the biocomposite was 15 phr glycerol, 2.5 phr IJE, and 7.5 phr KF. The addition of natural fillers enhanced mechanical properties, having a tensile strength of 4.18 MPa and strain at break 18.5%. Overall, adding KF, glycerol, and IJE into the polymer matrix enhances the mechanical properties of the sweet potato bioplastic composites, making it a suitable option for packaging materials from renewable resources.

KEYWORDS: *Starch, Kenaf Fiber, Indian jujube extract; Bioplastic; Mechanical properties*

1. INTRODUCTION

Environmental pollution has emerged as a critical global issue, largely due to the massive production and use of conventional plastics. The extensive reliance on petroleum-based polymers has led to significant ecological and waste management challenges, as these materials are derived from fossil fuels and are low in biodegradability, persisting and accumulating in the environment over long periods [1,2]. To migitate these probelms, bioplastics have been considered as a potential substitute for traditional plastics. The most common biopolymer is starch as it is widely available, renewable, inexpensive and biodegradable. Fifty percent of bioplastics are produced from starch [3]. Starch-based bioplastics have drawbacks such as brittleness, poor water barrier, and mechanical properties due to greater hydrophilicity and affinity to water. To overcome these issues, additives are added into the composite matrix, such as acids, plasticizers, essential oils, and fibers. The most common plasticizer is glycerol, which improves the flexibility of films. Fibers are abundantly available and have low-density abrasiveness and high mechanical strength, encouraging a lightweight composite matrix. Fibers that are readily available are kenaf, jute and sugarcane. Abotina et al. [4] developed a biocomposite using black seed fiber, and this natural filler enhanced the mechanical properties by increasing tensile strength. Essential oils are a group of volatile aromatic compounds belonging to plant families that provide antimicrobial behavior due to the presence of mono/sesquiterpenes, hydrocarbons and phenolics [5]. Srivastava et al. [5] developed a starch-

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based biocomposite using cinnamon essential oil and rice husk fiber. The essential oil and rice husk fiber increased tensile strength from 0.67 to 2.5 MPa, emphasizing the importance of adding natural fillers.

In this work kenaf fiber (KF) and Indian jujube extract (IJE) will used to develop a sweet potato starch bioplastic composite with different ratios of glycerol, KF and IJE to analyze the effect of the mechanical properties. Kenaf fiber boosts mechanical properties and its widely available and affordable making it suitable as a filler for the polymer matrix, while Indian jujube extract possesses significant antimicrobial properties. These antimicrobial activities are attributed to the presence of various bioactive compounds like flavonoids, saponin, and triterpenoids improving durability and consumer safety [6,7].

2. MATERIALS AND METHOD

The fresh sweet potatoes were harvested from Cheong Vege Sdn Bhd located in Perak, Malaysia. The glycerol (USP C0347) was purchased from HmbG Chemicals, and distilled water was used in this research. Indian Jujube extract powder was purchased from A&T Ingredients Sdn Bhd.

2.1. Preparation of Bioplastic Composite

10 g of sweet potato starch was mixed with 96 ml of distilled water. After the starch was dissolved in the water, the Indian Jujube extract, 5 ml of acetic acid, glycerol, and kenaf fiber were added to the mixture. The temperature gradually increased to 85ºC, and the solution was gelatinized. After gelatinization, the solution was poured into a silicone mold. The sample was dried for 24 hours at 40ºC and then left for two days at room temperature in a fume hood. The above steps were repeated with different amounts of glycerol, kenaf fiber and IJE in phr (parts per hundred resin) as shown in Table 1. The bioplastic samples have been relabeled as CS, S1, S2, and S3, where CS represents the control sample without fillers.

Table 1: Various compositions of bioplastic

Sample	Glycerol (phr)	IJE (phr)	KF (phr)
CS	0	0	0
S1	15	2.5	7.5
S2	30	0	15
S3	30	5	0

2.2. Mechanical Properties

A universal testing machine was used to characterize the mechanical properties of bioplastic films. Mechanical properties of films were measured through ASTM D882-02 [8]. A bioplastic strip (50 mm × 10 mm) was fixed on the machine grip and pulled at 10 mm/min at an effective grip distance of 30 mm [9].

3. RESULTS AND DISSCUSION

Mechanical properties of bioplastic composites are crucial parameters for industrial applications (packaging and agriculture). Tensile strength and strain at break (SAB) were calculated to analyze the mechanical behavior of bioplastic composite films as shown in Table 2. CS has the highest tensile strength and the lowest strain at break due to its brittleness and the absence of glycerol in the sample. These results showed similarity with Enwere et al. [10] where they had a sample with vegetable oil and without glycerin. S1 has high tensile strength and SAB due to the addition of glycerol and natural fillers. S2 and S3 have the highest glycerol content, leading to decreased tensile strength and increased SAB, indicating that the presence of plasticizers disrupts the polymer network, increasing material flexibility and reducing tensile strength [11]. Hazrol et al. [9] explain that the addition of kenaf fiber improves mechanical strength for the polymer composite, and with the addition of glycerol to the matrix, giving a high TS with low SAB (TS from 12 to 17.74 MPa and SAB from 35% to 27.79%. This was in agreement with Majamo and Amibo [12] who used Enset fiber for their bioplastic film. The IJE samples (S1 and S3) showed higher strain at break than CS, due to the extract enhancing flexibility and reducing brittleness [7]. The addition of additives to the polymer matrix, kenaf fiber, and IJE enhances flexibility and reduces brittleness, making them suitable for packaging applications.

Table 2: Mechanical Properties of Bioplastic Composites

Sample	Tensile Strength [MPa]	SAB [%]
CS	21.43 ± 0.25	3.2 ± 0.4
S1	4.18 ± 0.15	18.5 ± 4.2
S2	1.81 ± 0.085	10.7 ± 2.2
S3	0.22 ± 0.045	15.6 ± 2.2

4. CONCLUSION

The sweet potato bioplastic composite was developed by adding plasticizers and natural fillers. By implementing these fillers into the polymer matrix, the resulting bioplastic composite film showed a tensile strength of 4.18 MPa and a strain at break 18.5%. Overall, this study confirms that the fillers enhance the mechanical properties of the bioplastic and that sweet potato starch is a promising and sustainable alternative for eco-friendly bioplastic production.

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