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Enhanced mechanical and physical properties of starch foam from the combination of water hyacinth fiber (*Eichhornia crassipes*) and polyvinyl alcohol

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ABSTRACT

Water hyacinth (*Eichhornia crassipes* (Mart.) Solms.) is considered an environmental threat due to its rapid growth and spread. Various studies have utilized water hyacinth fiber (WHF) as a reinforcement to strengthen the mechanical properties of biocomposites. A previous study reported that adding 5% of WHF improves the mechanical properties of the starch foam. The effect of applying a higher concentration of WHF with a combination of polyvinyl alcohol (PVA) on the properties of the starch foam is still unclear. This study investigates the effects of the addition of various concentrations of WHF, with and without polyvinyl alcohol, on the physical and mechanical properties of the starch foam. The foams were produced through a baking process with a thermo-pressing machine at lower and upper mold temperatures of 170 °C and 180 °C for 100 s. Five different WHF concentrations were tested, namely 0%, 5%, 10%, 15%, and 20%, with and without the addition of 10% polyvinyl alcohol. The products were then tested for their characteristics, including mechanical (compressibility) strength, water absorption, morphological structure, density, color appearance, and biodegradability. The results showed that the addition of 10% WHF improved the physical and mechanical properties of the foams. However, over-supplementation (15% or more) had some weakening effects, such as lowering the compressibility strength, increasing the water absorption, and darkening the physical appearance of the products. The addition of 10% PVA also contributed positively to their compressibility, density, and water absorption characteristics.

1. Introduction

Over the years, there has been an increase in people's dependence on plastics (Diyana et al., 2021). Furthermore, its annual global production has increased by 230 times since 1950. A production rate of 350 Mt/year was recorded in 2020 (Bucknall, 2020), where 34% of this number was contributed by Asian countries (Liang et al., 2021). Plastic waste has a huge negative impact on environmental sustainability, especially the aquatic ecosystem and human health (Mohammed et al., 2021). Several studies have reported that 11% of these wastes are disposed into the aquatic ecosystems (Borrelle et al., 2020). Consequently, there have been several efforts to reduce plastic pollution, including replacing synthetic chemicals with organic materials, such as cellulose and starch.

Expanded polystyrene (EPS) is one of the most widely used plastics, and it accounts for more than 6% of all plastics (Hidalgo-Crespo et al., 2020). It is also a superior packaging material due to its economical price, rigidity, lightweight, water resistance, chemical stability, shock resistance, thermal insulation, and flexibility in molding. However, its polymers are not easily degraded naturally due to their incredible stability. Hence, several natural polymers have been investigated as alternatives to produce degradable EPS-like foams (Engel et al., 2019; Glenn et al., 2001; Iriani et al., 2015; Kaisangsri et al., 2019; Machado et al., 2020; Mello and Mali, 2014; Salgado et al., 2008; Vargas-Torres et al., 2017; Vercelheze et al., 2012).

Biodegradable foams are often produced by baking a moisture dough containing starch and fiber. They are formed when the starch is gelatinized and inflated into a hollow object by vapor. However, the starch-based foam has low-quality mechanical properties and decreased

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