Chapter in Book

Wast-Plas: An Innovation of Bioplastic from Paper Waste & Fruit Waste for Various Applications

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Abstract: *Biodegradable waste such as paper waste (newspaper, magazine, egg trays, empty tissue roll, and cardboard) and fruit waste (fruit rind & peel) abundantly found in our landfill. Paper industry contributes to deforestation and environmental pollution due to paper processing. Food industries also contribute to serious source of pollution that come from non-utilized part of fruit (peel or rind). Egg tray (ET) is used to keep the eggs that can be found abundantly at supermarkets, grocery stores and food stalls. Empty tissue roll (ETR) is a type of material that can be found inside of the tissue roll. Jackfruit rind (JR) is outer part of jackfruit that normally disposed as fruit waste. Cellulose acetate (CA) is a valuable ester considering its biodegradability, renewable source, low cost, non-toxicity and very poor flammability property. CA can be extracted and produced by the reaction of cellulose with acetic acid and an excess of acetic acid anhydride in the presence of different types of catalyst such as iodine and sulphuric. This reaction is called acetylation reaction. Acetylation reaction modified the structure of cellulose by substituting -OH group in cellulose with acetyl group. Hence, the hydrophilicity of the cellulose can be reduced and the hydrophobicity properties of the cellulose can be improved. By turning this non-utilized waste (paper waste and fruit waste) to a valuable one (Cellulose Acetate), the environmental pollution can be controlled and resulted more sustainable earth. Wast-Plas films is a bioplastic which derived from CA (ET, ETR and JR) and gelatine. Wast-Plas films is an innovation of the current plastic in market that exhibited improve hydrophobicity, low solubility and low moisture uptake. Wast-Plas film has a potential to be applied as packaging (seedlings bag) and kid toys (stress ball & squishy toys).*

Keywords: Biodegradable waste; cellulose acetate; acetylation reaction.

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1. INTRODUCTION

Paper industry contributes to deforestation and environmental pollution due paper processing.Food industries also contribute to serious source of pollution that come from non-utilized part of fruit (peel or rind).Egg tray (ET) is used to keep the eggs that can be found abundantly at supermarkets, grocery stores and food stalls. Empty tissue roll (ETR) is a type of material that can be found inside of the tissue roll. Jackfruit rind (JR) is outer part of jackfruit that normally disposed as fruit waste (Toppinen et al., 2017). Cellulose acetate (CA) is a valuable ester considering its biodegradability, renewable source, low cost, non-toxicity and very poor flammability property (Gaan et al., 2011; Sun et al., 2013; Candido & Goncalves, 2016). CA is produced by the reaction of cellulose with acetic acid and an excess of acetic acid anhydride in the presence of different types of catalyst such as iodine and sulphuric. This reaction is called acetylation reaction. Acetylation reaction modified the structure of cellulose by substituting -OH group in cellulose with acetyl group. Hence, the hydrophilicity of the cellulose can be reduced and the hydrophobicity properties of the cellulose can be improved (Chen et al., 2017). ET, ETR (used for making DIY crafts or recycle to produced back paper product) and JR have been thrown away after fruit processing. These non-valuable ET, ETR & JR can be turn into valuable products. Besides, the current bioplastic film exhibit low properties due to the high hydrophilicity behaviour of the cellulose itself. By turning this non-utilized waste to a valuable one, the environmental pollution can be controlled and resulted more sustainable earth. Green house effect & emission of CO_2 can be reduced. The recycling process at landfills also can be decreased. Moreover, cellulose extracted from this waste can be converted into CA. As a result, the hydrophilicity of the current bioplastic can be decreased. Therefore, bioplastic with low solubility and low moisture uptake can be produced and can be applied as packaging (seedlings bag) and toys (stress ball & squishy toys). It is an alternative to replace current stress ball and squishy toys that have been created from harmful chemical. Through this innovation, CA/gelatin film from wastes have been produced and the properties of the products (Wast-Plas) have been characterized and analyzed.

2. METHOD & MATERIAL

Wast-Plas products have been developed from many steps. The steps include preparation of raw materials, extraction of cellulose from raw materials, acetylation of extracted cellulose to produce cellulose acetate (CA), preparation of Wast-Plas films by using solution casting method and characterization of the products by solubility and moisture uptake test.

2.1 Preparation of Raw Materials

Preparation of raw materials involved cleaning, drying & grinding process to produce powder. This powder is stored in closed container for further treatments and analysis.

2.2 Extraction of Cellulose

In this extraction process, chemical used are acetic acid, sulfuric acid, hydrogen peroxide & sodium hydroxide (ET & ETR samples). In other hand, acetic acid has been use for extraction of cellulose from JR sample.

2.3 Acetylation of Cellulose

Acetylation of cellulose for ET, ETR & JR samples involved the application of glacial CH_3COOH, acetic anhydride and H_2SO_4 (acts as catalyst). Through this process hydroxyl group at cellulose backbone is converted into acetate group via acetylation process.

2.4 Preparation of Wast-Plas Films

Preparation of Wast-Plas films can be done via solution casting methods. CA powder from (ET, ETR & JR) & glycerol were added into gelatine solution. This solution was added into 20 mL glacial CH_3COOH, heated at 75 ^{o}C, 1 h. Finally, this solution is mixed & homogenized and casted on acrylic plate to produce bioplastic for packaging application. The solution is poured into certain mould to produce squishy toys and stress ball.

2.5 Characterization of Wast-Plas Films

Wast-Plas films derived from egg tray (ET), empty tissue rolls (ETR), jackfruit (JR) rind and gelatine as matrix has been characterized based on solubility test and moisture uptake test. Solubility test of film samples covers the determination of the time required for a water soluble films to break apart and dissolved. Moisture uptake test measures the quantity of water absorbed by the films at certain given time. It was carried out by immersion of samples in water at room temperature for certain time.

3. FINDINGS

(a)

(b)

(c)

Figure 1. Wast-Plas Films derived from (a) ETR-CA/gelatin; (b) ET-CA/gelatin; (c) JR-CA/gelatin

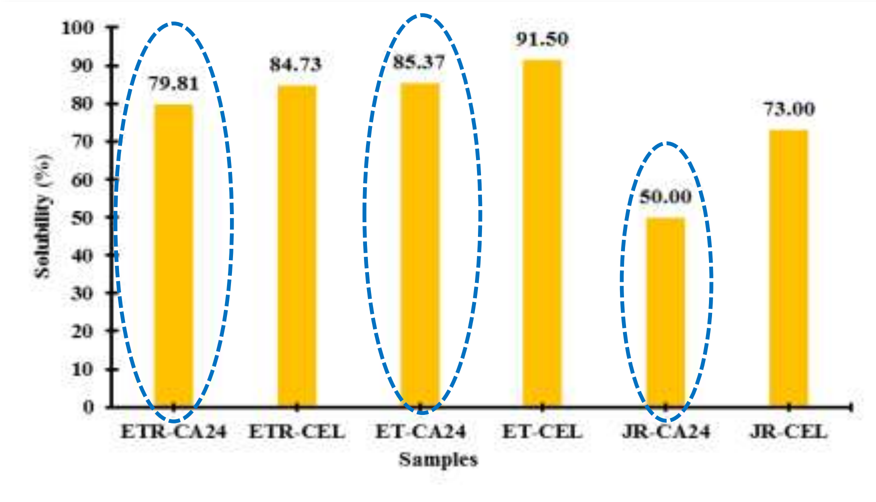

Figure 2. Percentage of solubility (%) of Wast-Plas Films derived from ETR-CA, ET-CA and JR-CA

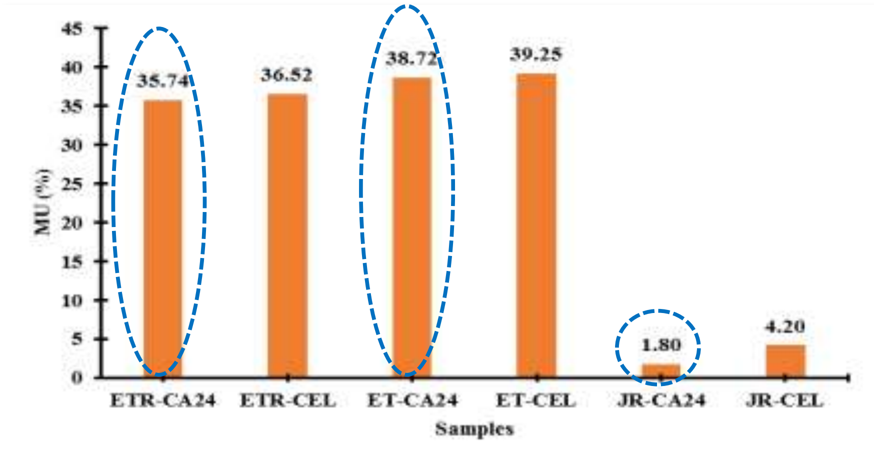

Figure 3. Percentage of moisture uptake (%) of Wast-Plas Films derived from ETR-CA, ET-CA and JR-CA

4. DISCUSSION

Figure 1 (a) – (c) show the Wast-Plas films derived from ETR-CA/gelatine, ET-CA/gelatine and JR-CA/gelatine. Figure 2 shows the percentage solubility of the bioplastic. The blue-dotted circles represented the sample of ETR-CA, ET-CA and JR-CA. Both samples show values of 79.81%, 85.37% and 50% of moisture uptake. Percentage of solubility for ETR (empty tissue roll) & ET (egg tray) are higher compare to JR (jack fruit rind). Figure 3 shows the percentage of moisture uptake (MU) of the bioplastic. The blue-dotted circles represented the sample of ETR-CA, ET-CA and JR-CA. Both samples show values of 35.74%, 38.72% and 1.80% of moisture uptake. MU for ETR (empty tissue roll) & ET (egg tray) are higher compare to JR (jack fruit rind). Various type of products can be tailored based on this different values. Low MU is suitable for packaging application (food wrapping). Meanwhile, high value of moisture uptake is suitable for application as seedlings bag. Higher moisture uptake promoted high biodegradation rate which can make seedling bag easy to biodegrade naturally in soil.

5. CONCLUSION

Wast-Plas Films derived from different type of waste (paper waste and fruit waste (rind)) have been successfully developed via solution casting method. Films with various solubility values and moisture uptake values can be tailored based on various application. Low MU is suitable for packaging application (food wrapping). Meanwhile, high value of moisture uptake is suitable for application as seedlings bag. Higher moisture uptake promoted high biodegradation rate which can make seedling bag easy to biodegrade naturally in soil.

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