A Study of Biodegradable Plastic Utensils from Mango Kernel

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Abstract: The diminishing of petroleum has cause worldwide researchers to study on other materials that can replace the non-renewable source. In addition, landfill is suffering from having too much waste especially those that are considered degrade resistance such as plastics. Thus, studies on biodegradable plastics which is produced from various type of plants have been a popular trend. In this research paper, mango which act as a plant-based plasticizer is utilized to produce plastic utensils. Plastic utensils is a popular item used in daily life by all walk of life around the world. Plus, plastic utensil is one of the items that cannot be recycled as it is not cost effective. Therefore, a solution is proposed on overcoming this issue by producing biodegradable utensils from mango kernel in order to reduce waste by increasing degradation rate. The ratio used is 60-75% of starch, 25-30% of plasticizer, and 10-15% of magnesium silicate in order to produce the utensil.

Keywords: Biodegradable utensils, Mango starch, Renewable sources, Natural Resources

1. Introduction

Economic development changes people’s lifestyle from various aspect. The changes do not only apply on the positive side instead it includes negative effect that are harmful to surrounding. One of the changes in people lifestyle is the widely usage of plastic utensils where it can be found at the restaurant that provide take-away services. Lifestyle alteration claimed modern eating utensils such as paper, plastic and Styrofoam types of plates, bowls, cups, spoons, forks, tissue paper and chafing dishes are to have modified the consumption of foods [1]. These utensils ease and decrease the usage of manpower in cleaning the food ware. Metal, glass, and paper are increasingly replaced by plastic packaging, particularly for foods. By 2009, plastic packaging accounted for 30 percent of packaging sales [4]. It is different from the old day tradition which prefer to serve using steel and glass food ware. The easiness came with price that had to be paid by the environment. Plastic-based product such as the plastic utensils are harmful to environment.

Plastics are human-made materials manufactured from polymers, or long chains of repeating molecules. About 4 percent of the world’s petroleum is used to make plastic, and another 4 percent is used to power plastic manufacturing processes [4]. It is a hard to degrade material. The hazard that polythene causes to the environment is very serious. Non-degradable pollutants create problems because they are toxic and persistent in the environment [7]. We need to deal non-degradable pollutants to reduce the quantity released into the environment either by recycling them for reuse before they are disposed of or by curtailing their production. Plastic is recyclable materials. However, it is not practicable for plastic utensils as it is not cost effective. It becomes especially harder when they are often commingled with organic wastes food scraps, wet paper, and liquids, making it difficult and impractical to recycle the polymer without expensive cleaning and sanitizing procedures [7].

Crude oil, coal and gas are the main resources for world energy supply. However, the sources cannot be forever utilized as it may have diminished. In addition, exploitation of fossil fuel release greenhouse gases which then lead to anthropogenic climate change [5]. Thus, the researcher studies on producing biodegradable plastic utensils from mango kernel – natural starch, instead of continuously utilizing fossil fuel in plastic utensils production. Biodegradable plastics are seen by many as a promising solution to overcome excessive plastic waste problem because they are environmentally-friendly. They can also be derived from renewable feedstock, thereby reducing greenhouse gas emissions.

The researcher has set a few objectives to be achieved in the research on production biodegradable utensils from mango kernel. Basically, the researcher target on measuring the degradation period of the product as it is expected to take less degradation period compare to conventional synthetic plastic utensils. Next, the goal is to design product that is environmentally safe and healthy by replacing fossil fuel which act as main substance in conventional plastic utensils production as it is known that usage of fossil fuel is harmful.
to environment and human. Lastly, the objective is to identify the production cost.

1.1 Structure Chemical Composition of Synthetic Plastic

Plastics are derived from natural, organic materials such as cellulose, coal, natural gas, salt, crude oil, and several are hazardous. The polymers are made by polymerizing monomers into macromolecular chains. In a meantime, recent research has proposed that polyethylene terephthalate that can be found in synthetic plastic might yield endocrine disruptors under conditions of common use which is harmful to living things and environment.

The number one ingredient in plastic is the hydrocarbon, which comes from oil or natural gas. The extraction of crude oil is an intensive engineering process along with continuously growing in national and international contention. Extraction of crude oil itself gives negative impact to environment other than the issue of source depletion. Thus, another solution should be proposed to minimize the negative effect cause by this activity.

1.2 Plastic Conventional Plastic Utensils

Plastic utensils are typically made out of two types of plastics polypropylene and poly styrene. However, most conventional plastics such as polyethylene, polypropylene, polys tylene, poly (vinyl chloride) and poly (ethylene terephthalate), are non-biodegradable, and their increasing accumulation in the environment has been a threat to the planet. In addition, recycling awareness is still low among Malaysian which make it more difficult to depend on the idea of plastic recycling.

1.3 Degradable Plastic

Biodegradable utensil is used to ease waste management. Biodegradable plastics are made from renewable resources is an important material innovation because it decreases dependence on petroleum and reduces the amount of waste material, while still yielding a product that provides similar benefits of traditional plastics. Thermoplastic aliphatic polyester that is generally derived from agricultural products. Biodegradation takes place through the action of enzymes and/or chemical deterioration associated with living organisms. This event occurs in two steps. The first one is the fragmentation of the polymers into lower molecular mass species by means of either abiotic reactions, such as oxidation, photodegradation or hydrolysis, or biotic reactions, i.e. degradations by microorganisms. This is followed by bioassimilation of the polymer fragments by microorganisms and their mineralization.

Biodegradable plastics decompose through the action of micro-bacteria and fungi to produce a humus-like material, along with water, carbon dioxide and/or methane. Some types of plastic are hydro-degradable (broken down by water) or photodegradable (broken down by sunlight) (Bioenergy Education Initiative, 2018). Decomposition can occur aerobically (with oxygen) through composting or anaerobically (without oxygen) in landfills. The starch obtained from plant is used to produce natural polymer for plastic production through fermentation. Then, when the product has been used and being disposed, it will degrade and releasing CO2 and H2O to the atmosphere where these gaseous helps in photosynthesis process. A lot of researches have been done from various plant starch in order to produce plastic utensils. Plants such as horse chestnut, peach palm, and tapioca are some of the materials that have been researched in replacing conventional plastic. Aside from researches on starch that can replace petroleum-based plastic, there are also researches on way to increase the strength of plant-based product which is by adding filler that can be found from nature such as sugarcane bagasse, durian husk, and peanut husk.

1.4 Usage of Starch in Replacing Petroleum Product

Starch is a biodegradable and widely available natural resource, and constitutes the main source of carbohydrate reserves in plants. This polysaccharide is found in different parts of the plants and can be isolated from seeds, fruits, leaves, tubers, and roots. In addition, starch is a natural polymer, inexpensive and readily available resource, and is often used as a filler for the replacement of petroleum-derived synthetic polymers to decrease environmental pollution.

The negative environmental impact caused by synthetic polymer wastes, denominated plastic materials is well known and there is now a growing interest in biodegradable materials like starch to substitute the conventional plastic materials, such as polyethylene and polystyrene. A number of studies have reported the use of starch in the manufacture of fast food utensils and packaging material.

1.5 Mango (Mangifera indica L.)

The large amount of waste produced by the food industries causes serious environmental problems and also results in economic losses if not utilized effectively. In this case, mango kernel is used to produce utensils. The use of fruit and vegetable waste recently has becoming more popular to be studied by taking into account that these residues are one of the important sources of polyphenols (Ibrahim, Kamarrudin, Suhizaque, & Abd Hashib, 2017). Different research reports have revealed that food industry by-products can be good sources of potentially valuable bioactive compounds. As such, the mango juice industry uses only the edible portions of the mangoes, and a considerable amount of peels and seeds are discarded as industrial waste. Moreover, most people consumed the mango flesh only but other parts of mango such as peel and kernel are being thrown as waste. Apparently, mango waste contains a very significant number of phytochemicals, which can be utilized for value-added applications in functional foods and nutraceuticals (Ibrahim et al., 2017). There are a lot of benefits of mango kernel such as anti-dandruff, reduces risk of diarrhea, minimizing risk of cardiovascular disease, maintain hair health, good for skin, and may be good for diabetics (Amazon Super & Day Value, 2018).

1.6 Methodology

Biodegradable plastics are made from all-natural plant materials which specifically mango kernel in this study. Traditional plastic is made with chemical fillers that can be harmful to the environment when released when the plastic is melted down. With biodegradable plastic, you get a substance made from natural sources that does not contain these chemical fillers, and does not pose the same risk to the environment.

The process of making biodegradable plastics begins with the melting down of all the materials. That mixture is then poured into moulds of various shapes such as plastic water bottles and utensils. The method used in producing this product can be briefly explained by extracting the starch and producing the product. Then, it is tested with a few test such as water absorption, and burial test.
1.6.1 Materials and preparation of Mango Starch

Mango seeds were obtained from the waste generated from Mango Shake at UTHM Pagoh Residential College’s cafe. The mango seeds are washed with clean water before being peeled to take out the kernel from inside. The kernel is then cut into small pieces before blending in the mixer. After mixing process, starch slurry was filtered and later placed in a beaker for settling that took at least 30 minutes. Starch sediment was separated from the slurry and then washed again with distilled water. After the second settling, starch sediment was dried using a drying oven with temperature of ±160°C for removal of free water. After the starch has dried, it is then being grinded to powder.

1.6.2 Production of Utensils

In order to produce a utensil, the starch powder is mixed with sorbitol and tale according to specific ratio. Then, a mould is made by using aluminium foil. After that, it is put into drying oven with temperature of 200°C for approximately 15 minutes.

1.7 Result and Discussion

The starch obtained was weighted to identify the percentage starch contained in the mango kernel. 100g of clean mango kernel was weighted. Then, after the process of starch extraction, the starch powder is weighted again. The starch powder obtained is 27g. From the weight obtained, it can be conclude that the mango kernel used in this research contain 27% of starch.

The water absorption test is conducted on two utensils, where one is made up of glycerol while another one is made up of sorbitol. Table 4.1 and 4.2 show the weight of utensils within 30 minutes and the percentage of water absorption.

Table 4.1 Water absorption of utensil made up of glycerol and sorbitol

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>2.5g glycerol</th>
<th>2.5g sorbitol</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8.36</td>
<td>8.99</td>
</tr>
<tr>
<td>5</td>
<td>8.91</td>
<td>9.96</td>
</tr>
<tr>
<td>10</td>
<td>9.25</td>
<td>10.28</td>
</tr>
<tr>
<td>15</td>
<td>9.55</td>
<td>10.44</td>
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<td>20</td>
<td>9.78</td>
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<td>25</td>
<td>9.98</td>
<td>10.92</td>
</tr>
<tr>
<td>30</td>
<td>10.24</td>
<td>11.02</td>
</tr>
</tbody>
</table>

Table 4.2 Percentage of water absorption

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>2.5g glycerol</th>
<th>2.5g sorbitol</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>6.58</td>
<td>10.79</td>
</tr>
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<tr>
<td>30</td>
<td>22.49</td>
<td>22.58</td>
</tr>
</tbody>
</table>

From the graph obtained in Figure 1, it can be analysed that both utensils have about the same percentage of water absorption. The utensils made from glycerol has more consistent pattern compare to the utensil made from sorbitol. However, start from 10 minutes, the water absorption percentage of utensil made from sorbitol is started to be consistent, while the researcher found that utensil made from sorbitol is better in withstand water absorption compare to the utensil made from glycerol. The reason is because the glycerol shows consistent increase in water absorption percentage where the interval is between 2-4, while the percentage interval for sorbitol starting from 10 minutes is only between 1-2.

Figure 4.1 Graph of percentage of water absorption

The production and testing of utensils are carried out manually because of time constrain and lack of equipment. It is recommended to use centrifuge in order to extract the starch. Centrifuging is better compare to the manual method as the starch obtained will be purely starch and it save time. Centrifuge is a laboratory machine that spin samples in order to separate solids out of liquid chemical solution.

Besides, the polymerization should be conducted in an extruder machine where the machine will turn the starch composition into sheet. Plastic extrusion is a high-volume manufacturing process in which raw plastic material is melted (plasticized) and formed into a continuous profile. Extrusion produces a variety of products, such as pipe/tubing, weather stripping, fence, deck railing, window frames, adhesive tape and wire insulation [2].

Other than that, moulding machine is required to force the molten plasticized materials into utensil. In this research, the researcher use manual method where the researcher mould the utensils using aluminium foil and put it into drying oven with temperature of 200°C. The manual method is less preferable as it did not produce exactly as the intended shape. The resin is injected into the mold by a reciprocating screw or a ram injector. With the reciprocating screw, the melt is thoroughly mixed, which then resulting in a uniform melt. The mould is the part of the machine that receives the plastic and shapes it appropriately. The mold is cooled constantly to a temperature that allows the resin to solidify. The mold plates are held together by hydraulic or mechanical force. The clamping force is defined as the injection pressure multiplied by the total cavity projected area [2]. Moulding process is carried out to shape the plastic into desirable shape.
1.8 Conclusions

Plastics are present in most waste, and before trends in accumulation of plastic can be explained, it is important to first consider waste generation and disposal. The vast majority of monomers used to make plastics, such as ethylene and propylene, are derived from fossil hydrocarbons. None of the commonly used plastics are biodegradable. As a result, they accumulate, rather than decompose, in landfills or the natural environment. Global recycling and incineration rates have slowly increased to account for 18 and 24%, respectively, of non-fiber plastic waste generated in 2014 [2]. However, people awareness is low that make recycling is not effective to certain countries. Thus, in consideration of waste elevation, continuous researches on biodegradable plastic have been widely done. The waste might not be able to decrease, but a shorter degradation period can be a big help in handling the waste problem. The researches on this matter should be widely proposed from various other renewable resources to avoid competition in using only one source. Other than that, it is necessary to use more than one source to avoid source extinction. A successful introduction of bio-based packaging in the market requires a safe and long-lasting supply of raw material. With increase in volume the production costs are likely to be decrease.

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References


