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PRODUCTION OF NATURAL PLASTIC WITH CRANBERRY FRUIT (VACCINUM SUBG. OXYCOCCUS)

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KeyWords
Carrenberry fruit- antioxidant-bioplastic-waste-biowaste

ABSTRACT

Plastics are non-biodegradable materials in nature that cause environmental pollution. Plastics are formed by the chemical combination of monomers to form large structured polymers. They are also preferred in the industry due to their heat-resistant types. Polyvinylidene chloride (PVDC), a type of plastic widely used in food packaging, is known to contribute to the formation of microplastics in nature, leading to water and soil pollution. These microplastics accumulate in marine organisms and eventually enter the human system, causing health problems. Natural plastics produced from starch are currently an area of research. In this project, bioplastics were made using starch, taking advantage of the antioxidant properties of red fruits. Cranberry, which has a high antioxidant content among red fruits, was selected. In the future stages of the project, work will continue to preserve protein-rich foods. The bioplastic made with cranberries used a minimal amount of chemicals. Starch, glycerin, and grape vinegar were used to create an environmentally friendly packaging. The product obtained had the typical texture and consistency of plastic. It was created in a form suitable for use in food packaging.

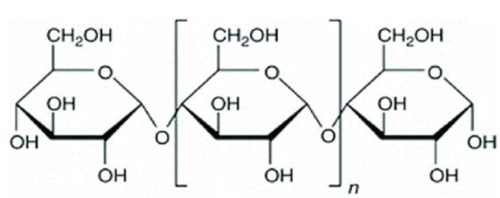
Aim

The aim of this project is to create an alternative product to the use of plastics, which contribute to environmental pollution. Research has shown that plastics can transform into microplastics and lead to water pollution. In this century, where water sources are decreasing, the aim is to reduce the pollutants that cause this situation and how it can be achieved.

Introduction

1. Starch

Starch is the most abundant polymer in the world. According to the 2012 data, 75 million tons of starch were produced worldwide using different methods (Knauer 2014). Starch is a semi-crystalline material, consisting of both crystal and amorphous regions (Ratnayake and Jackson 2006). Starch is composed of small-sized crystals, with dimensions ranging from 0.5 to 10 µm. These starch crystals are situated on a small and flat surface. The crystal surfaces contain the amorphous regions and the bonds. The crystal surfaces are hydrophobic and constitute the majority of the starch. When starch crystals are heated, the amorphous regions melt, and the bonds within these regions break [1].



Titani et al. (2016) obtained bioplastic from a mixture of tapioca starch. Acetic acid was used as a catalyst during the synthesis of this bioplastic. Plastic was formed using glycerol and water [2].

2. Polymers

Polymers are high molecular weight substances formed by the chemical bonding of simple molecules called monomers. Polymers are composed of large molecules. The formation of large molecules by the chemical bonding of repeated small molecules is possible through polymerization reactions. These small molecules that come together are called monomers. (Bahattin Baysal. Polymer Chemistry.)

The structural units of polymers are monomers. In a polymer molecule called a macromolecule, thousands or more of these structural units are connected to each other. Most of the polymers prepared in the laboratory and practical applications have molecular weights ranging from 5,000 to 250,000. (Bahattin Baysal. Polymer Chemistry.)

Natural polymer materials are the basic components of food, clothing, construction materials, and paper. Almost all the materials that humans benefit from in their daily needs and daily life are obtained from natural organic products. (Bahattin Baysal. Polymer Chemistry.) [3].

2.1. Plastics

In the century we live in, plastic has become one of the most important products that enhance people's quality of life and comfort. It has been extensively used in industries such as automotive, consumer electronics, electrical cables and devices, computers, mobile phones, toy manufacturing, aviation, packaging and agriculture, kitchenware, and the food industry, as well as in targeted applications in the healthcare sector [4].

Plastics can easily break down into micro-sized particles and spread into environments such as water, soil, and air, causing environmental pollution through their dissolution (Divrik, Karakaş & Divrik, 2018). According to research conducted in 2018, it was estimated that plastic waste would reach 205 million tons (Kömürcü, 2018). To address this issue, practices such as the Packaging Waste Control Regulation have been adopted to prioritize the preservation of the environment and health (ÇŞB, 2019).

3. Bioplastics

Many natural polymers such as cellulose and starch are used as biodegradable plant materials in the production of next-generation plastics, known as bioplastics (Aranda-Garcia et al., 2015).

The main sources of bioplastics produced worldwide are corn, sugarcane, potatoes, and castor oil. Animal feed containing cellulose and corn stalks are also significant sources of bioplastics [5].

The biodegradability of bioplastics is influenced by their physical and chemical structures. Environmental conditions they are exposed to also play a significant role in their degradation (Emadian et al., 2016). Factors such as environmental conditions, pH, moisture, oxygen level, and temperature can contribute to their degradation. The higher the sugar content, the higher the biodegradability. Starch, consisting of amylose and amylopectin, is a polysaccharide widely used in bioplastic production (Reddy et al., 2013, p. 1659). Polysaccharides, such as cellulose and starch, are abundant in nature and play important roles in bioplastic production (Harini et al., 2018, p. 231). In the production of plastic from starch, plasticizers such as water, glycerol, and sorbitol are commonly used, and the molecular structure of starch is degraded by heating under specific conditions. The addition of acid provides a catalytic effect, and this process is called gelatinization. The resulting material is known as thermoplastic starch (TPS). Gelatin, a water-soluble protein derived from collagen, is known for its ability to form transparent gels. This protein has been widely used in food and pharmaceutical applications (Reddy et al., 2013, p. 1659–1661).

Bioplastics are used in various fields such as home textiles, clothing and footwear industry, packaging, food services, automotive, consumer goods, and household appliances (Grancarić et al., 2013, pp. 11–12). They are biodegradable in nature and have much lower environmental impact compared to other polymers [7]. The use of biowaste materials has relatively less harmful environmental effects; it is cost-effective and also helps reduce dependence on fossil fuels. Raw materials obtained from biowaste have a wide range of applications in the energy storage industry (Divyashree & Hegde, 2015, p. 88344).

4. Cranberry Fruit (Vaccinium subg. Oxycoccus)

Cranberry is a fruit that can be easily grown in various geographical regions of our country and naturally thrives in cold climates (-35°C). Its structure is rich in antioxidants, minerals, and vitamins, which makes it a fundamental component for a healthy lifestyle. While traditionally consumed in our country, its structure and compositional characteristics have led to an increasing use in various fields such as the food industry, health, and pharmaceuticals, in addition to direct consumption in scientific research. This product, commonly known for its consumption as jam or marmalade, is also used in the industry as an additive that enhances diversity, nutritional value, vitamins, fiber, and sensory properties in yogurt production. Besides its use as a flavor enhancer in fruit juices and as a thickening and acidity regulator in jam and marmalade production, it is also used in the field of medicine. It is utilized for treating urinary tract infections and regulating blood sugar in muscle and liver cells[8].

Method

The production of bioplastic involves the use of corn starch, vinegar, glycerin, and distilled water.

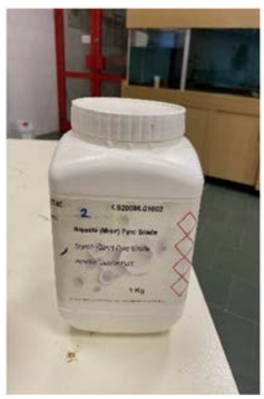



Image 1 Image 2 Image 3

A 300 mm tall water-filled cylinder has been prepared. 50 g of cornstarch (Image 2) was added to the water, followed by 25 ml of vinegar (Image 1) and 25 ml of glycerin (Image 3) on top. The mixture was cooked while stirring on the stove for 10 minutes (Image 4). Once the mixture turned into a gel-like substance, it was spread onto an aluminum foil surface and left to dry for 1 day (Image 7).

Image 4

The bioplastic production from rose hips involved boiling 50 g of rose hips on top of 300 ml of pure water (Image 5). In a separate container, 50 g of starch, 25 ml of vinegar, and 25 ml of glycerin were combined. After boiling, the mixture was strained and separated, and then poured onto the container containing 50 g of starch, 25 ml of vinegar, and 25 ml of glycerin. The mixture was heated and stirred until it turned into a gel-like consistency. After heating, it was spread onto the surface of aluminum foil and left to dry for one day (Image 6).

Image 5

Image 6

Image 7

Job Description	September	October	November	December	January
Literature Review	x	x	x	x	x
Field Study	x	x	x	x	x
Data Collection and Analysis	x	x	x	x	x
Project Report Writing	x	x	x	x	x

Project Timeline

Findings

Sample Name	Initial Mass (g)	Final Mass (g)	Solubility Time In Water
Bioplastic	0.25	0.15	20 sec
Cranberry-Infused Bioplastic	0.5	0.21	35 sec
Plastic Bag	0.1	0.1	unsolved

The initial masses and dry masses of bioplastics and plastics sold in the market were measured. A decrease in mass was observed when they lost their water content. However, there was no mass decrease in the plastic refrigerator bag. The dissolution times in water were compared. Bioplastics dissolved faster. Bioplastics with cranberry extract dissolved more slowly.

Conclusion and Discussion

The following conclusions were drawn from the study on cranberries. Bioplastic with cranberry content dissolved more slowly in water due to the sugar present in cranberries, which made the bioplastic structure firmer. This extended the dissolution time. When dissolved in water, the only pollutant was cranberry fruit pieces. Since they can naturally integrate into the ecosystem, they do not create pollution.

On the other hand, the refrigerator bag did not dissolve in water. This proved, as shown in previous research, that plastics do not easily disappear in nature and contribute to environmental pollution.

Suggestions

In this project, an alternative to a specific type of bioplastic has been sought. To enhance its range of applications, bioplastic infused with cranberry extract has been developed. By harnessing the antioxidant properties of cranberries, a natural plastic material has been created that is edible, biodegradable, and capable of preserving proteins for a longer period of time. The next phase of this project aims to extend the storage time of white and red meat in refrigerators without the need for plastic. In fact, this project can also be explained as an opportunity for every individual to create their own packaging without relying on plastic. If it becomes wide-spread in society, it could be a step towards eliminating plastic waste that contributes to environmental pollution.

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