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Preservation of Cauliflower with Moisture-Retaining Bioplastics

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ABSTRACT

This research aims at determining the viability of using bioplastic from organic extracts for enhancing the storage period of cauliflower, which would encourage sustainable and environmentally-friendly means of keeping foods fresh. Bioplastic films were prepared from a basic solution consisting of starch, glycerine, and vinegar along with extracts from banana peels, artichoke peels, and walnut shells. The samples of cauliflower were covered by these films, and then their efficiency was evaluated depending on several aspects, including freshness, texture, and the rate of spoiling. It turned out that there was an apparent difference between the efficiency levels of films tested. Among all films, the most efficient was the one that contained extracts from walnut shells, as it preserved cauliflower much longer because of strong antioxidant and antimicrobial effects of the extract. Meanwhile, the least efficient film was made from artichoke peels, and hence its preservative effect was low. In turn, the average level of efficiency was reached by films from banana peels. This study proves that bioplastic from organic extracts, especially from walnut shells, can be used in future as a sustainable alternative to traditional films.



Plastics

Plastic, in essence, is a generic name that is applied to describe both completely and partly artificial materials made up of polymers that find application in various spheres. Plastics can be observed in various consumer goods including clothes and electrical appliances. Manufactured with the help of natural resources, such as petroleum and natural gas, coal, and cellulose, plastic materials are greatly valued for their qualities that include, but are not limited to, being easily shaped, durable, and light. Plastic can be broadly classified into two categories – thermoplastics and thermosets.

Harms of Plastic in Food Preservation

The issue associated with the problem of plastic wastes is their durability, which makes them remain on Earth for a long time after being utilized. Thus, there emerge environmental problems linked to the improper disposal of this kind of waste; at the same time, its negative influence on the economy cannot be neglected either. Sorting plastic waste properly is thus extremely important, as it contributes to the efficient recycling of this material and its reuse in other purposes. The sorting of various types of plastics implies their further processing, allowing not only saving resources but also decreasing the quantity of waste.

Bioplastics

Bioplastics refer to a type of plastic whose origin is biological, making it either degradable, bio-based, or both. These bioplastics have been created as environmentally friendly substitutes for regular plastic materials made through petroleum products. Bioplastics are made from renewable resources such as cornstarch, sugarcane, potato starch, and vegetable oils. The materials are biodegradable since they come from renewable plant materials such as cornstarch, potato starch, and sugarcane.

Advantages of bioplastics include the ability of these polymers to break down due to the decomposition of natural microorganisms without leaving any waste products in soil and water, as well as helping to fight against climate changes due to the lack of dependency on fossil fuels. Besides, many bioplastics can be obtained from renewable resources, which makes the process of manufacturing even more ecological. Nevertheless, several disadvantages should also be mentioned in relation to bioplastics, among which one can name the low rate of total decomposition under certain environmental conditions and possible influence on the soil quality from the remnants of bioplastic. Another disadvantage that limits the spread of bioplastics includes difficulties in producing materials on an industrial scale, which is linked with cost-efficiency and resource availability issues. In the future, due to the growing popularity of environmentally friendly practices and further innovations within the sphere, bioplastics might replace traditional plastics.

Applications of Bioplastics

Bioplastics are polymers that are either biodegradable, bio-based, or both, made for the purpose of creating more sustainable substitutes for plastic products traditionally made from oil-based resources. They are synthesized using sustainable biomass feedstocks such as corn starch, sugarcane, potato starch, and vegetable

oil. Being biodegradable polymers created from sustainable biological materials like corn starch, potato starch, and sugarcane, they are relatively less energy-intensive to manufacture and emit fewer greenhouse gases than conventional plastics, making them environmentally friendly. Bioplastics are polymers that are either biodegradable, bio-based, or both, made for the purpose of creating more sustainable substitutes for plastic products traditionally made from oil-based resources. They are synthesized using sustainable biomass feedstocks such as corn starch, sugarcane, potato starch, and vegetable oil. Being biodegradable polymers created from sustainable biological materials like corn starch, potato starch, and sugarcane, they are relatively less energy-intensive to manufacture and emit fewer greenhouse gases than conventional plastics, making them environmentally friendly.

Moisture Retention Properties of Foods

Moisture retention of foods can be defined as their ability to remain structurally fresh while avoiding moisture loss and can depend on multiple factors, including water binding capacity, cell structure, fiber content, and surface properties of the product. Moisture retention of foods is associated with slower drying as it inhibits water migration from the cells of the foods and thus helps preserve the freshness of their structure. This property is vital when trying to maintain not only aesthetic but also sensory characteristics of food items. Thus, vegetable fibers and moisture content affect their freshness, making the higher losses of moisture cause faster wilting, shrinking, and spoilage.

Hence, moisture retention is one of the most important parameters to extend food product shelf-life. Additionally, control of moisture retention helps avoid nutritional loss and unwanted changes of food textures and appearance due to the loss of their moisture. Biofilms on the surface of the products or proper storage can help preserve their freshness and avoid excessive moisture loss. Such techniques are actively explored by scientists within the sustainable preservation practices field of study.

Walnut Shell

Walnut (*Juglans regia L.*) is a nut with high nutritional value, and an examination of its chemical composition reveals significant amounts of protein, fat, carbohydrates, and minerals. The composition of walnuts consists of approximately 3.5% water, 15–30% protein, 55–77% fat, 1.5–3% ash, and 5–15% carbohydrates; furthermore, it is rich in essential minerals such as calcium (Ca), phosphorus (P), magnesium (Mg), iron (Fe), sodium (Na), and potassium (K), as well as vitamins A, B1, B2, B6, and C. These nutritional components provide walnuts with high energy content, potent antioxidant capacity, and significant health-related functions (Ceviz Projesi, 2025). These chemical constituents make the walnut a functional natural resource that can be utilized not only for nutrition but also in applications for food preservation, bioplastics, and active packaging.

Banana Peel

Banana peel possesses a structure rich in natural biopolymers and is particularly notable for its cellulose, hemicellulose, lignin, and starch content (PMC, 2023). High levels of potassium, polyphenols, and various antioxidant compounds provide the banana peel with both nutritional and antimicrobial properties (Sakarya Üniversitesi Açık Arşiv, 2021). Furthermore, the **pectin** present in the peel's structure is a natural

polysaccharide capable of gelation, a characteristic that makes banana peel viable for the production of biofilms and bioplastics (Karamanoğlu Mehmetbey Üniversitesi Açık Arşiv, 2020). While the phenolic substances in banana peels have the potential to delay oxidative degradation, its fibrous structure provides advantages in terms of water retention and moisture balancing (Sakarya Üniversitesi Açık Arşiv, 2023). All these chemical properties render banana peels a valuable material.

Method

1. Materials and Formulations

In the production of bioplastic films, a starch matrix was used as the primary structural component, glycerin was utilized as a plasticizer, and vinegar was added to create an acidic environment. Three distinct samples were prepared using three different extract sources:

- **Banana Extract Film (M):** Consists of 60 g starch, 120 mL banana extract, 30 mL glycerin, and 30 mL vinegar.
- **Artichoke Extract Film (E):** Consists of 60 g starch, 120 mL artichoke extract, 30 mL glycerin, and 30 mL vinegar.
- **Walnut Extract Film (C):** Consists of 60 g starch, 120 mL walnut extract, 30 mL glycerin, and 30 mL vinegar.



Fig. 1 and 2. Preparation of bioplastic film

2. Preparation of Extracts

In preparation for this investigation, the bananas, artichokes, and walnuts extracts were produced following similar procedures to avoid variations in the results. First, the raw materials chosen were cleaned and separated before mixing with an appropriate amount of water in the mixture. After that, the mixture was filtered and its liquid phase used as the extract. These extracts were not stored but rather were used immediately in the production of films to conserve their properties during the process.

3. Preparation of the Film Solution (Gelatinization)

For each sample, 120 mL of the respective extract (banana, artichoke, or walnut) was placed in a separate beaker, and 60 g of starch was added gradually. Continuous stirring was performed to prevent clumping.

To create a homogeneous mixture, 30 mL of glycerin was added. Following this, 30 mL of vinegar was introduced to lower the pH level, creating an acidic environment and supporting film formation. This mixture was heated under controlled conditions while being stirred constantly to achieve the **gelatinization** of the starch. The heating process was terminated once the mixture thickened into a homogeneous film solution.

4. Casting and Drying

In order to avoid the formation of air bubbles, the hot film solutions prepared were applied in well-controlled amounts to the surfaces that were used for the castings in such a way that the films would be spread uniformly over them. Upon completion of the castings, the solutions were left to evaporate in well-controlled conditions under ambient temperatures before being placed in an incubator in the lab to ensure proper evaporation. The films were then peeled off without any harm after the drying process had been completed and stored in sealed bottles.

5. Coding and Storage of Samples

The resulting films were coded as **M (Banana)**, **E (Artichoke)**, and **C (Walnut)** based on the type of extract used. To protect them from moisture and adverse environmental factors, the films were kept in a dry and dark environment until the time of analysis.

6. Food Wrapping Application (Cauliflower)

The produced bioplastic films were wrapped around fresh cauliflower pieces of equal size. For comparison, uncoated cauliflower samples were evaluated as **control samples**. All specimens were stored under identical environmental conditions.

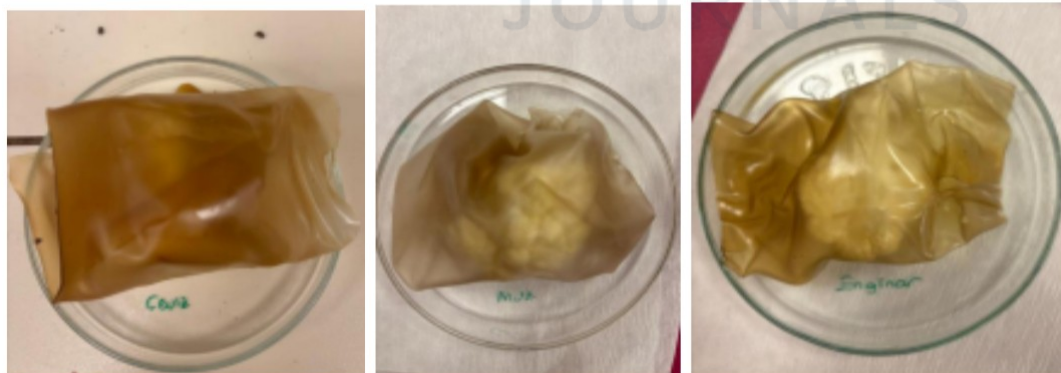


Fig. 3. Cauliflower samples wrapped with different films respectively walnut shell, banana peel, and artichoke

Conclusion

In relation to the purpose of the research performed in the present paper, it is worth saying that it is aimed at analyzing the impact of films created using extracts of bananas, artichokes, and walnuts on preservation of cauliflowers under particular conditions. As can be seen from the findings, it can be suggested that films created from walnut extract are the most effective option from all those offered, while artichoke extract films have no



efficiency, although film created from extracts of bananas may help to a certain extent preserve cauliflowers. This difference in efficiency of these types of films can be attributed to the difference in biological features of the materials utilized for creating them. Also, it should be noted that these findings indicate the significance of choosing proper additives from natural products to increase the efficiency of protecting cauliflowers in bioplastic films.

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