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DEVELOPMENT AND EVALUATION OF EDIBLE COATING FROM FLAXSEED MUCILAGE, FINGER MILLET STARCH, AND GRAPE SKIN POWDER

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ABSTRACT

This study focuses on developing an edible coating from flaxseed mucilage, finger millet starch, and grape skin extract as a sustainable solution for food preservation. The coating's effectiveness was evaluated by measuring weight loss reduction, solubility, chemical stability, antioxidant activity, anti-inflammatory potential, and microbial safety. Results showed that coated produce had significant reductions in weight loss compared to uncoated samples: carrots (4.85% vs. 7.22%), tomatoes (4.24% vs. 5.48%), and ivy gourd (10.41% vs. 13.41%). The coating was fully soluble in water, 1–2% in oil, and 70–80% in alcohol, with a pH of 6.4. Grape skin extract enriched the coating with polyphenols, enhancing antioxidant properties. Anti-inflammatory activity increased with higher coating concentrations, showing inhibition from 7.3% (100 µL) to 76.1% (1000 µL), and an IC_{50} value of 661 µL. Microbial load was 30 × 10^1 CFU/mL, within acceptable limits. This edible coating shows promise as a natural preservative, reducing post-harvest losses while offering functional benefits.

Keywords: Edible coating, Antioxidant, Flaxseed, Grape skin powder, Finger millet

INTRODUCTION

Food spoilage is a major concern, leading to economic losses and food wastage. Perishable foods, like fruits and vegetables, are susceptible to moisture loss, microbial contamination, and oxidative degradation. Food spoilage and deterioration are critical challenges in the food industry, leading to significant economic losses and global food wastage. Perishable foods, particularly fruits and vegetables, are highly susceptible to moisture loss, microbial contamination, and oxidative degradation, which affect their quality, safety, and shelf life. To address these issues, various preservation techniques such as refrigeration, modified atmosphere packaging (MAP), and chemical preservatives have been widely employed. However, these conventional methods often have limitations, including high costs, environmental concerns, and potential health risks associated with synthetic additives **[1],[2]**.

In recent years, edible coatings have emerged as a promising eco-friendly and sustainable approach for extending the shelf life of perishable foods. Edible coatings are thin layers of edible materials applied to food surfaces to create a protective barrier that reduces moisture loss, delays microbial growth, and minimizes oxidative damage. These coatings can be formulated using biopolymers such as proteins, lipids, and polysaccharides, along with functional bioactive compounds like antioxidants or antimicrobial agents that enhance their protective properties **[3],[4]**. Unlike synthetic packaging materials, edible coatings are biodegradable and align with the principles of green technology and sustainable food processing **[5]**.

Edible coatings not only serve as a barrier to gases, moisture, and contaminants but also help maintain the sensory attributes of food products such as flavor, aroma, texture, and color. They can significantly reduce spoilage rates by slowing respiration rates and delaying ripening processes in fruits and vegetables. For instance, studies have shown that polysaccharide-based coatings can extend shelf life by maintaining firmness and reducing weight loss in produce **[6],[7]**. Additionally, the incorporation of bioactive compounds like polyphenols enhances the antimicrobial and antioxidant properties of these coatings **[8]**.

The environmental benefits of edible coatings are noteworthy. The use of plastic packaging materials for preserving fresh produce has led to severe environmental challenges due to plastic waste accumulation. Moreover, microplastics from synthetic packaging can penetrate food products, posing health risks to consumers. Edible coatings composed of renewable biomaterials such as lipids, proteins, polysaccharides, and plant extracts offer a sustainable alternative to synthetic packaging. By controlling the transfer of oxygen, carbon dioxide, aroma compounds, and moisture in food systems, edible coatings enhance food quality while reducing dependency on harmful chemicals **[9],[10]**.

Several studies have demonstrated the effectiveness of polysaccharide-based edible coatings in preserving fresh produce quality. These coatings have been shown to extend shelf life by lowering respiration rates, maintaining firmness, reducing weight loss, protecting bioactive compounds (e.g., phenolics and flavonoids), decreasing microbial growth (e.g., fungal or bacterial), maintaining sensory properties (e.g., flavor and aroma), and imparting antioxidant activity **[11],[12]**. For example, chitosan-based coatings have been widely studied for their antimicrobial properties and ability to delay browning in fruits like apples and bananas **[13]**.

This study focuses on developing an edible coating using flaxseed mucilage for its excellent film-forming ability and water-holding capacity; finger millet starch for its structural integrity; and grape skin extract for its rich phenolic content with strong antioxidant properties. The combination of these components is expected to result in a functional coating that preserves food quality while reducing dependency on synthetic additives **[14],[15]**.

MATERIALS AND METHODS

This study developed an edible coating using flaxseed mucilage, finger millet starch, and grape skin powder. The raw materials, including brown flax seeds, finger millet grains, and black round grapes, were procured from local markets, with selection criteria prioritizing ripeness and lack of physical damage. Food-grade glycerol was used for coating solutions, and other chemicals were of analytical grade.

Processing of Raw Materials

Raw materials were processed to extract key components. Flaxseed mucilage was extracted by mixing flaxseeds with distilled water at a ratio of 1:30, stirred at 1000 rpm and 80–100 °C for 3 hours, strained through muslin cloth and cooled at room temperature, and then strained again. Finger millet starch was isolated by soaking finger millet grains in 0.1% NaOH solution for 12–24 hours to soften the grains. They were rinsed, made into slurry and filtered through a muslin cloth, after which the starch was allowed to settle. The supernatant was discarded, the starch washed, dried at 40–50°C, and stored. Grape skin powder was made by separating grape skins from the flesh, washing and draining, drying in a hot air oven at 60–80°C for 6–8 hours, grinding into powder, sieving, and storing.

Formulation of Coating Solution

To 100 mL of flax seed mucilage, 7g of finger millet starch dissolved in 10ml of water and 3g of grape skin powder was added. The mixture was heated at 50–60°C for 15 minutes with constant stirring, with the addition of 5 mL of glycerol.

Application of Edible Coating

Carrots, tomatoes, and ivy gourd were selected for coating. Each item was washed, drained, dried, and weighed. One from each pair was dipped in the coating solution for 30 seconds, drained and dried at room temperature for 30 minutes. Coated and uncoated samples were kept in a desiccator.

Physical Analysis

Moisture loss was evaluated by weighing coated and uncoated samples daily for 7 days, recording changes as a percentage. Solubility was tested by dissolving a measured weight of the coating in water, oil, and alcohol.

Chemical Analysis

The pH of the coating solution was measured directly with a calibrated pH meter. Acidity was determined by titrating a sample with 0.005 N NaOH using phenolphthalein indicator, and calculated using standard formulas. Antioxidant activity was assessed using a DPPH assay, with absorbance measured at 517 nm. Anti-inflammatory activity was determined by the inhibition of albumin denaturation technique and measured at 660nm by UV-Visible Spectrophotometer.

Microbial Analysis

The microbial load of the edible coating was assessed using the total plate count method and incubated at 35 °C for 48 h.

RESULTS

Moisture Loss Analysis: The edible coating significantly reduced moisture loss in coated samples compared to uncoated ones over seven days of storage. **Figure 1** presents the moisture loss of coated and uncoated samples. Results showed that carrots exhibited the least weight loss (4.85% for coated vs. 7.22% for uncoated), followed by tomatoes (4.24% vs. 5.48%) and ivy gourd (10.41% vs. 13.41%). The results confirm that the coating acts as a moisture barrier, with coated produce retaining firmness and texture longer than uncoated samples, which showed visible signs of shriveling by Day 4. The coating was fully soluble in water, sparingly in oil, and partially in alcohol.

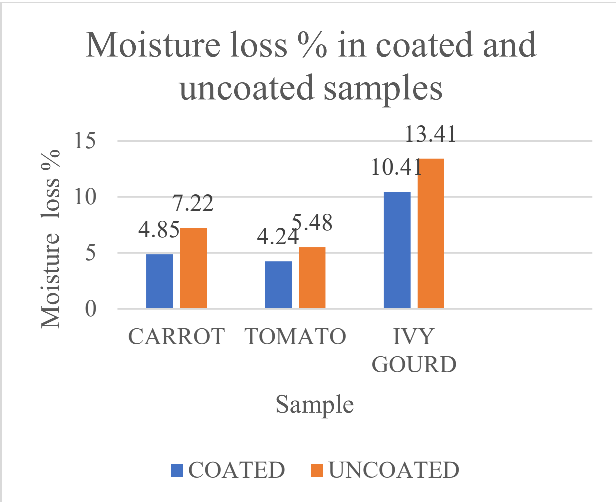

Figure 1: Moisture loss% coated v/s uncoated

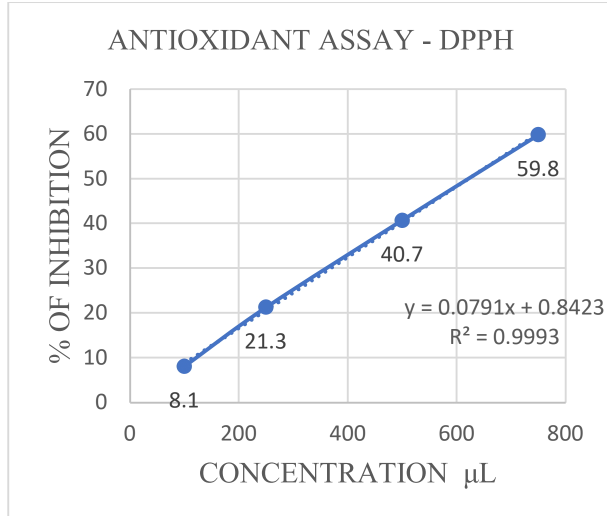

Figure 2: Antioxidant Activity of Coating Solution

Chemical Analysis

pH Analysis: The pH of the edible coating was slightly acidic at 6.4, which is ideal for food applications as it does not alter the natural pH of produce.

Acidity Analysis: The acidity of the edible coating was measured at 0.01%, indicating low acidity that contributes to maintaining product freshness and reducing microbial spoilage.

Antioxidant Assay: The developed coating exhibited promising antioxidant activity, confirmed by the DPPH assay. The percentage of inhibition increased with higher coating concentrations, (**Figure 2**) ranging from 8.1% at 100 µL to 79.0% at 1000 µL. The IC50 value was determined to be 625 µL, suggesting moderate antioxidant strength derived from natural antioxidants found in grape skin extract, which enhanced the coating's functional properties.

Anti-inflammatory Assay: The coating demonstrated anti-inflammatory potential, assessed via egg albumin denaturation inhibition. (**Figure 3**) The percentage of inhibition was concentration-dependent, increasing from 7.3% at 100 µL to 76.1% at 1000 µL. The IC50 value was 661 µL, indicating moderate anti- inflammatory activity provided by anti-inflammatory compounds naturally present in grape skin extract.

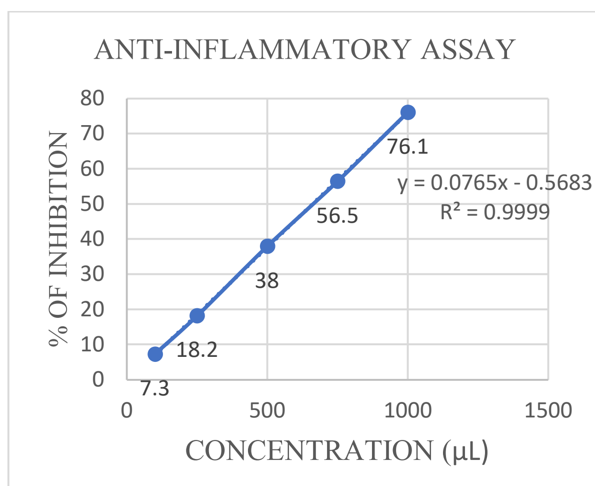

Figure 3: Anti-inflammatory activity of Coating Solution

Microbial Analysis: The microbial load of the edible coating was found to be 30 × 10+ CFU/mL, which is within acceptable limits for food applications.

CONCLUSION

The results highlight the potential of the edible coating as a natural preservative. The reduced weight loss in coated produce indicates its effectiveness in preventing moisture loss. The inclusion of grape skin extract provides antioxidant properties. The anti-inflammatory activity suggests potential health benefits. The low microbial load ensures safety.

The edible coating developed from flaxseed mucilage, finger millet starch, and grape skin extract shows promise as a sustainable solution for food preservation. It effectively reduces weight loss, provides antioxidant and anti-inflammatory properties, and maintains microbial safety. This coating presents a viable alternative to synthetic preservatives and plastic packaging.

FUTURE SCOPE

Future research could optimize coating formulations, explore applications with different produce types, and investigate the coating's impact on sensory qualities and nutritional content. Further studies could analyze the shelf life of coated products under different storage conditions.

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