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Edibile Coating for Fruits and Vegetables

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***Abstract*—Because of their high-water content, fruits and vegetables are extremely perishable and susceptible to microbial spoiling, dehydration, and rapid quality degradation after harvest. Edible coatings provide a sustainable and efficient way to preserve food while extending its shelf life and preserving its nutritional and sensory qualities. This study investigates the creation and assessment Comprising potash alum and aloe Vera-based edible coatings used on a range of fruits (apple, mango, orange, grapes) and Vegetables (tomato, capsicum, and potato). Alum offers astringent and antifungal qualities, while aloe Vera contributes antioxidant and antibacterial qualities. Different formulations of coating solutions were made, and their physical characteristics—such as pH, viscosity, homogeneity, appearance, and microbial resistance—were assessed. Over a 28-day storage period, the fourth (F4) tested formulation performed the best in terms of preserving freshness and postponing spoiling. The results show that aloe Vera and coatings based on alum are effective natural alternatives to artificial preservatives, effectively extending the shelf life and maintaining the postharvest quality of fresh fruit.**

***Index Terms*—Antimicrobial properties, Antioxidant coatings, Hydrocolloids, Glycerol plasticizer**

I. INTRODUCTION

Fruits and vegetables contain 80–90% water by weight, making them highly perishable. Without cuticle, the product's shelf life is shortened since the water quickly begins to evaporate. Examples of internal impacts include temperature, other stressors, and atmospheric composition; examples include species, cultivar, and growth stage.

(O2, CO2, and ethylene ratios) are examples of external elements. **(**Dhal RK *et al;*2013).

Fruits and vegetables are essential parts of a daily diet and have gained popularity among most people in recent years. Since they are repositories of vitamins, essential minerals, antioxidants, bio-flavonoids, dietary fiber, and flavourings, they are easily impacted by both biotic and abiotic stressors. Microorganisms, insects, respiration, and transpiration all contribute to substantial losses during the post-harvest phase, and fruits and vegetables are highly perishable. (Raghav PK *et al;*2013).

Edible coatings, which can alter the internal gas composition similarly to storage in a changed environment, can provide an additional layer of protection for fresh items. Recently, a variety of edible coatings have been successfully employed to preserve fruits such as apples, oranges, and grapefruits. However, edible coatings weren't always effective. In fact, the fruit's quality decreased. For edible coatings for fresh products to be effective, the composition of the internal gases must be controlled. This article seeks to support the development of systematic techniques for selecting edible coverings in order to maximize the quality and shelf life of fresh fruits and vegetables. (Akhtar J *et al;*2015).

One innovative way to mitigate this problem is to use edible films, coatings, or packaging. By providing moisture and gas barrier properties and preventing microbiological deterioration, these materials can add an additional layer of protection to fresh food, increasing its shelf life. Research into edible packaging methods is increasing yearly since consumers today prefer healthier and less processed foods. Edible films and coatings are designed to be the primary packaging medium for foods that contain edible ingredients in order to maintain sensory attributes including flavour, fragrance, and look.

Fruits and vegetables wrapped in edible films mature more slowly and have a longer shelf life. (Mitelut CA *et al;*2021).

II. DRUG USED IN EDIBLE COATING

Aloe Vera Line, sometimes referred to as Aloe barbadensis Miller, is a very important herbal treatment that has been extensively researched for usage in food, medicine, and cosmetics. (Maan *et al.,* 2018). According to Bejar et al. (2019), Aloe Vera belongs to the class Monocotyledon, indicating it is a monocot plant with a single embryonic leaf. It falls under the subclass Liliidae, which is known for comprising herbaceous flowering plants. The order Asparagales includes a variety of plants, many of which are used in traditional medicine and horticulture. Aloe Vera is part of the Asphodelaceae family, and more specifically, the Asphodeloideae subfamily. Within this subfamily, it belongs to the tribe Aloeeae, and the Aloe genus. The species is identified as Aloe Vera, a succulent plant renowned for its medicinal and cosmetic applications.

With their extensive knowledge, the Siddha's learned how to extract these minerals from their ore, their remarkable purifying methods, and their signs of different illnesses. Inorganic substances known as minerals can be found in nature in both pure and impure forms. (Gajbhiye S et al;2025).

With its ores, India's soil is rich in a variety of minerals, and in addition to its commercial value, it has great therapeutic potential for treating illnesses. Alum is used in Siddha literature to cure stomatitis, eye disorders, bleeding, leucorrhea, menorrhagia, diarrhea, vomiting, and wound cleansing. (K Vignesh, *et al*.,2019).

Potassium alum, commonly referred to as potassium aluminium sulphate, is an inorganic compound with the chemical formula $KAl(SO_4)_2 \cdot 12H_2O$. Because of its adaptable chemical characteristics, it is widely used in many different sectors. The chemical usually manifests as a white crystalline solid or powder, with a molar mass of 258.192 g/mol. Because of its well-known astringent, antibacterial, and preservative qualities, potassium alum finds usage in everything from food preservation and cosmetics to water purification.

Fig No.01Image of Aloe

Fig No 04: Potash Alum.

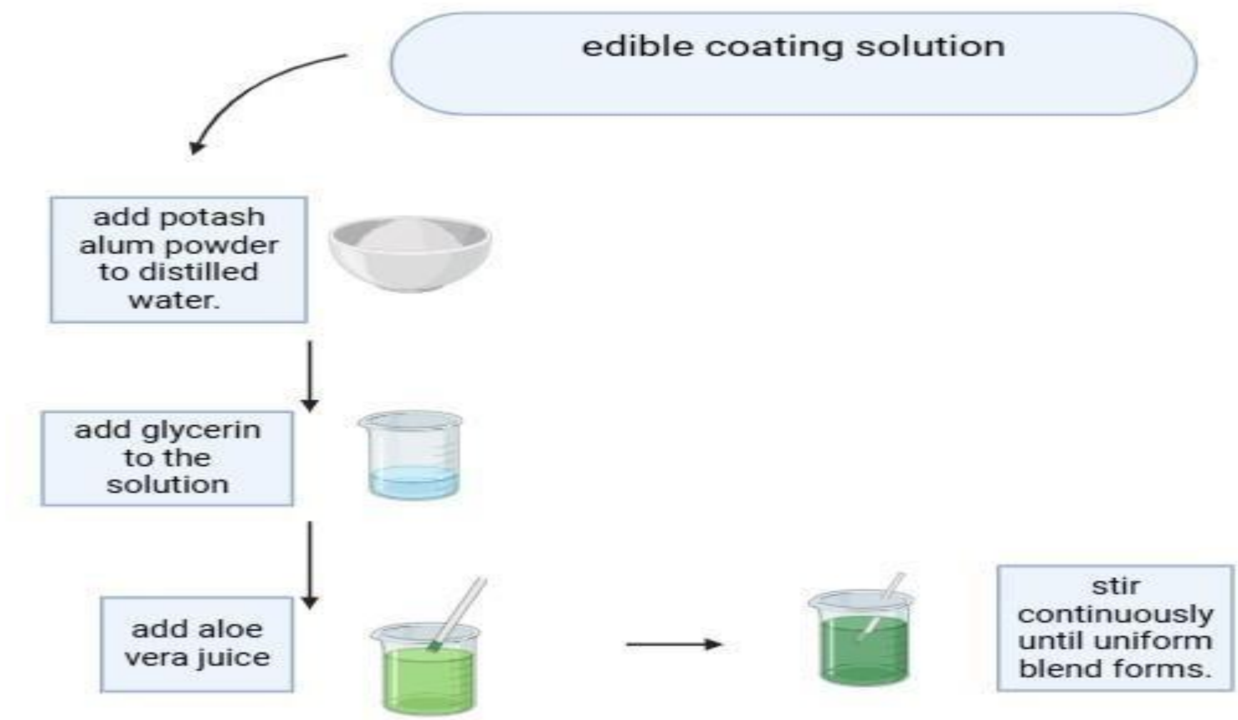
III. MATERIALS

Aloe Vera Gel: Fresh aloe leaves were collected, washed, and processed to extract the gel. Alum (Potassium Aluminium Sulphate): Food-grade alum was obtained from a local supplier.

Fruits and Vegetables: Samples of fresh apples, cutted fresh apple, mango, grapes, Tomato, mango, orange, potato, fresh cutted potato and Capsicum were selected for coating.

Other Chemicals: Distilled water, glycerol (plasticizer) were used.

IV. METHOD OF PREPARATION OF EDIBLE COATING SOLUTION



Flowchart: Preparation of Potash Alum-Based Coating.

Formulation

Formulation of Aloe Vera-Based Edible Coatings Using Glycerol and Potassium Alum.

Formulation no:	Aloe- Vera gel solution (ml)	Distilled Water +Potash Alum Powder	Glycerol(ml)
F1	75 ml	25 ml+ 1.25 g	1(ml)
F2	75 ml	50 ml +2.5 g	2(ml)
F3	50 ml	25 ml+ 1.25 g	1(ml)
F4	50 ml	50 ml +2.5 g	2(ml)

Table No: Formulation of Edible Coating solution.

Methods for Application of Edible Coating:

Dipping:

Vegetables are submerged in an aloe Vera-based coating solution containing potash alum, glycerol, and citric acid for uniform coverage. (Mengjie Ma *et al*;2024)

Brushing:

he coating mixture is applied manually using a brush to ensure an even layer on the vegetable surface. (Vidyarthi VE *et al;*2024)

Extrusion:

The coating formulation is processed through an extruder to form a thin film, which can then be wrapped around vegetables. (Suhaga R *et al*;2020)

Spraying:

Vegetables are sprayed with a fine mist of the edible coating solution to create a thin, uniform layer of protection. (Sheetal *et al*;2023)

Solvent Casting:

he solution is spread onto a surface, dried to form a film, and later applied to vegetables as a protective coating. (Vazquez PA *et al;*2023)

 A spraying method is used to coat fruits and vegetables.

Fig No.05: Edible Coating Solution.

Physical Evaluation:

- Weight loss or Moisture content: Measures moisture loss over time, indicating the coating's ability to reduce dehydration
- . Texture: Determines the structural integrity of the produce during storage.
- Colour changes: Evaluates visual appeal and potential degradation due to oxidation or enzymatic reactions.
- Flavour(Mouthfeel) and odour: Monitors potential off-flavours or undesirable changes caused by coating components
- pH and Acidity: Monitor pH stability and total acidity to assess preservation effectiveness.
- Viscosity: Determines the thickness and ease of application. Measured using a viscometer.
- Homogeneity: Ensures even distribution of all ingredients, analysed via microscopic imaging or visual inspection.
- It is determined that the fourth formulation is utilized for coating with the aid of the evaluation parameter.

V. RESULT & DISCUSSION

Physical Evaluation:

Parameters	Observation	Inference
Colour changes	Compare colour values using a colorimeter or visual inspection	Minimal colour changes signifies reduced oxidation and enzymatic browning
our(Mouthfeel) and odour	nsory evaluation by trained panellist	Off flavour or undesirable odour suggest chemical reaction or microbial activity
pH and Acidity	easure PH over storage periods	Stable PH & acidity indicate preservation effectiveness &reduced microbial spoilage
Viscosity	Measure coating viscosity using a viscometer	Optimal viscosity ensure uniform application & adherence to the produce surface
Homogeneity	Assess coating uniformity using microscopic imaging or visual inspection	A homogenous coating ensure even otection and prevents localized spoilage

Table No.07 Physical Evaluation Edible Coating solution.

A physical evaluation is required to determine how successfully edible coating treatments preserve the quality and extend the shelf life of fruits and vegetables. To track changes in the qualitative characteristics of product while it is being stored, a number of parameters are evaluated. Colour change is one such characteristic that can be assessed visually or using a colorimeter. Minimal colour changes are preferred since they show less oxidation and enzymatic browning, which helps to preserve the freshness and aesthetic appeal of the product. Other important sensory characteristics that are evaluated by panellists with training include flavour, texture, and odour. Any unpleasant taste or smell could be a sign of microbial spoiling or chemical interactions, both of which lower the product's quality.

In order to evaluate the coated produce's chemical stability, its pH and acidity levels are also tracked throughout time. Consistent acidity and a constant pH indicate good preservation and decreased microbial activity. A viscometer is used to measure the coating solution's viscosityin addition to sensory and chemical assessments. An ideal viscosity guarantees uniform application and good adhesion to the produce's surface, both of which are essential for creating a strong protective layer. Finally, to guarantee even coverage, the homogeneity of the coating is evaluated by eye examination or microscopic imaging. Localized spoiling is avoided and consistent protection is provided by a uniform coating. All things considered, these factors taken together offer a comprehensive picture of how well edible coatings work and how well they preserve the quality of fresh produce while being stored.

Observation Table:

No of days	Images of coated fruits	Images of fresh coated vegetables
Day 01	 Fresh apple, cutted fresh apples, oranges,mangos,grapes.	 Tomato, potato, fresh cutted potato, capsicum.
Day 02	 Cutted apple and fresh apple.  Grapes, apples, oranges, mangos.	 cutted potato  Capsicum, tomato, potato.

Day 07	 Oranges, apples, grapes, mango.	 Potato, tomato, capsicum.
Day 14	 Apple, mangos, oranges, grapes	 Tomato, potato, capsicum.
Day 21	 Apples, oranges, mangos, grapes.	 Potato, tomato, capsicum.
Day 30	 Apple, mango, orange.	 Tomato, potato.

Table No.08 Observation of Coated Fruits & Vegetables.

Through a 21-day period, the quality and appearance changes of coated and uncoated fruits and vegetables are visually seen in the provided photograph. Apples, cut apples, oranges, mangoes, grapes, potatoes, cut potatoes, tomatoes, and capsicums are among the examples. All fruits and vegetables are brightly coloured, fresh, and show no symptoms of rotting on Day 1. On Day 2, some initial variations start to show up, particularly in cut samples like apples and potatoes, where a faint discoloration is seen, signifying the start of browning in uncoated samples. On the other hand, the coated samples mostly keep their original look.

Uncoated fruits and vegetables start to exhibit more obvious deterioration symptoms by Day 7, such as softening and a dulling of colour. Coated samples, on the other hand, appear to be relatively fresh, indicating that the edible coating has begun to successfully postpone the spoiling process. The difference becomes more obvious on Day 14. In contrast to their uncoated counterparts, which exhibit more noticeable aging and spoiling symptoms including wrinkling and browning, coated apples, mangoes, and grapes remain whole and aesthetically pleasing. While covered samples seem structurally stable, uncoated vegetables, such as potatoes and tomatoes, lose hardness.

On Days 21 and 28, both coated and uncoated fruits and vegetables were observed. Apples, oranges, mangos, grapes, potatoes, tomatoes, and capsicums are on display on Day 21. Coated samples exhibit comparatively better preservation than uncoated ones, which show symptoms of browning and spoiling. By Day 28, the distinctions become more noticeable: covered tomatoes and potatoes retain their firmness and appearance better, while coated apples, mangos, and oranges seem fresher with less deterioration. This implies that the deterioration process was successfully slowed down over time by the coating treatment.

The freshness and shelf life of fruits and vegetables can be effectively extended by edible coatings, such as those made with alum and aloe Vera. The coating appears to significantly reduce rotting indicators and preserve quality over a 28-day storage period.

Evaluation Parameters:

Parameters	Observation	Inference
Visual Appearance	Colour retention (freshness, brightness, uniformity)	Coated samples maintained a more appealing and fresher look.
Texture and Firmness	Firm and intact surface texture	Coating helped preserve firmness and delayed softening.
Weight Loss	Minimal shrinkage and dehydration	Reduced moisture loss in coated fruits and vegetables.
Shelf-life Extension	Longer preservation with minimal spoilage	Coated produce remained acceptable Beyond the usual spoilage period.
Colour Changes	Natural colour preserved with less browning	Coating reduced enzymatic browning and pigment degradation.
Microbial Growth	Limited or no visible mold or decay	Coating acted as a barrier to microbial contamination and growth.

Table No.09 Evaluation Parameters for Coated & Fruits & Vegetables.

When compared to uncoated samples, the evaluation of coated fruits and vegetables showed that edible coatings greatly improved quality parameters. By preserving freshness and consistency, improved colour retention enhanced the visual attractiveness. By reducing moisture loss, coatings delayed softening, maintained texture and stiffness, and decreased weight loss. Because spoiling was postponed and natural colour was preserved with less browning, shelf life was increased. Furthermore, Microbiological growth was minimal, indicating that coatings served as a robust barrier to keep contaminants at bay. Fruits and vegetables were generally safer, looked better, and were better preserved thanks to coatings.

VI. CONCLUSION

Edible coatings are one potential way to enhance the fresh fruits and vegetables' quality, safety, and shelf life. Among the other natural materials studied, alum and aloe Vera are unique due to their ability to form films, antibacterial properties, and biocompatibility. Aloe Vera functions as a barrier to stop moisture loss and microbial deterioration because of its abundance of polysaccharides and phenolic compounds. Aloe Vera is enhanced with alum, which has antibacterial properties and further suppresses the growth of pathogens. When combined, these materials can create a sustainable and efficient substitute for artificial preservatives. Commercial uptake and consumer acceptance will depend on further research into their synergistic effects, application techniques, and effects on sensory qualities. Because the solution has a shelf life of up to three months and may be stored for as long as we need it for coating, refrigerated coatings provide for the longest possible storage time. In the end, edible coatings made from alum and aloe Vera provide a sustainable and natural way to address postharvest issues in the fresh fruit sector.

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