DEVELOPMENT OF GREEN PACKAGING MATERIALS FOR FOOD INDUSTRY FROM PROPOLIS, A BYPRODUCT FROM BEEKEEPING

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Introduction:

The global food packaging industry is heavily reliant on petroleum-based synthetic plastics, which contribute significantly to environmental pollution and pose long-term ecological risks. The need for sustainable, biodegradable, and functionally effective alternatives has never been more urgent. This project addresses that need by developing a green packaging material using propolis - a natural resinous substance collected by honeybees from plant sources - as a bioactive additive in chitosan-based biodegradable films.

Propolis is a well-documented byproduct of beekeeping that is rich in flavonoids, phenolic acids, and terpenoids, giving it potent antimicrobial and antioxidant properties. Chitosan, derived from crustacean shells, is a naturally occurring biopolymer known for its film-forming ability, biodegradability, and inherent antimicrobial characteristics. The combination of these two natural materials presents a promising platform for developing packaging films that are both eco-friendly and functional for real-world food preservation.

This work is particularly relevant to the fresh produce and food retail sector, where rapid spoilage of fruits such as strawberries and grapes leads to significant post-harvest losses. Replacing conventional plastic wraps with propolis-chitosan biofilms could offer a commercially viable, sustainable, and health-safe alternative.

Objectives:

1. To study the chemical composition and functional properties of raw propolis relevant to food packaging applications.
2. To evaluate the antimicrobial and antioxidant characteristics of propolis ethanolic extract.
3. To design and fabricate biodegradable packaging films into a chitosan-plasticizer matrix.

4. To assess the mechanical strength, thickness, flexibility, water vapor barrier, and optical properties of the prepared films.
5. To test the antimicrobial efficacy and food-safety performance of the developed films using real food samples, including shelf life and microbial load analysis.

Methodology:

Raw propolis was collected from actively maintained honeybee colonies, cleaned to remove wax and debris, and crushed to facilitate extraction. An ethanolic extraction method was employed to obtain propolis extract, which was then characterized for presence of phenolic content, flavonoid content. A biodegradable film matrix was prepared by dissolving chitosan in dilute acetic acid with glycerol as a plasticizer. Propolis extract was incorporated, into the solution and were cast onto glass plates, dried at controlled temperature, and peeled to obtain uniform films.
The films were subjected to a comprehensive battery of characterization tests: tensile strength, elongation at break, thickness measurement, light transmittance, and visual flexibility assessment. The films were then applied to fruit packaging and spoilage, microbial load, and sensory quality were monitored over a defined storage period. Biodegradability was confirmed through the soil burial method over 30 days.

Result and Conclusion:

1. Propolis ethanolic extract was confirmed to be rich in phenolic compounds and flavonoids, which contributed to the bioactive and functional character of the developed packaging film.
2. SEM analysis revealed a uniform and compact film morphology, confirming that the film was successfully formed with a consistent structure.
3. FTIR analysis confirmed molecular-level interaction between chitosan and propolis, indicating that a stable and cohesive film matrix was formed rather than a simple physical blend.
4. The biofilm was tested for food packaging performance using fresh strawberries and grapes, comparing three conditions - unpackaged control, chitosan-only film, and chitosan–propolis biofilm.
5. The chitosan–propolis biofilm outperformed both controls, showing visibly delayed spoilage and better retention of fruit quality throughout the storage period.
6. Extended shelf life was observed in fruits packed with the chitosan–propolis film, attributed to the combined antimicrobial action of chitosan and the phenolic compounds from propolis.
7. The film effectively slowed down microbial growth on the fruit surface and reduced oxidative deterioration, making it suitable for fresh produce packaging.
8. Overall, the chitosan–propolis biofilm was established as a natural, biodegradable, and eco-friendly alternative to conventional plastic packaging, with strong potential for broader application in the food industry.

Fig 1- Unpackaged strawberries showing severe spoilage with visible Mold, shrivelling, and complete loss of freshness.

Fig 2 - Chitosan-wrapped strawberries showing moderate preservation with mild softening and slight colour change.

Fig 3 - Chitosan–propolis wrapped strawberries retaining firmness, colour, and fresh appearance with minimal spoilage.

Fig 4- Unpackaged grapes showing significant deterioration with shrivelled berries, browning, and visible microbial growth.

Fig 5- Chitosan-wrapped grapes showing partial preservation with slight berry detachment and surface deterioration.

Fig 6- Chitosan–propolis wrapped grapes maintaining firmness, colour, and cluster integrity with least spoilage.

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Future Scope:

The future scope of this project includes:

1. Scale-up of film production using roll-casting or industrial coating techniques for commercial applicability
2. Investigation of the films' performance under varying temperature and humidity conditions to develop packaging specifications for refrigerated and ambient storage.
3. Exploration of propolis sourced from different geographic and floral origins to optimize antimicrobial potency and standardize extract composition.