Exploring the effect of Arecanut extract in food packaging film

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Abstract:
Arecanut (Areca catechu) is a significant commercial crop cultivated extensively in tropical regions such as India, Indonesia, and Sri Lanka. While traditionally used in betel quid, recent research explores its potential in sustainable applications, particularly in food packaging. Due to its multifarious properties, arecanut extract can be a promising alternative to conventional plastic-based packaging. This study investigates the feasibility of utilizing arecanut extract to develop active packaging film possessing antimicrobial properties. The composition of film was optimized by varying the concentration of natural polymer PVA (polyvinyl alcohol) is 6.25%, CMC (Methyl Cellulose) is 6.25% and glycerine is 0.25%. Further, 2% arecanut extract was added in the optimized film to develop active films. Arecanut extract possesses good antimicrobial analysis of packaging film against gram-positive and gram-negative bacteria. The quality evaluation tests were performed to check the suitability of developed film for food application. The result of physico-chemical analysis bestowed good tearing strength and GSM. This research holds considerable societal benefits, including promoting environmental sustainability by minimizing plastic dependence. Additionally, it creates economic opportunities for arecanut farmers by diversifying the utility of it in the various area. Overall, this study supports the transition to a circular economy, offering a sustainable and functional alternative to conventional food packaging materials.

Keywords: Arecanut, active film, packaging,

Introduction:

Arecanut, also known as betel nut, is a seed of Areca catechu tree, which is native to Southeast Asia, particularly in India, Philippines and Sri Lanka (Niloufer Sultan Ali, Ali Khan Khuwaja, 2011) Arecanut are oval or cylindrical in shape and generally brown in colour (Garg A.et al,2021). They contain hard outer shell and soft inner flesh. Arecanut is cultivated since thousands of years. Arecanut as a seed plays an important role in economic , cultural and social role many regions. Areca nut is typically used for chewing, a few slices of the nut are wrapped in a betel leaf along with calcium hydroxide (slaked lime) and may include spices for extra flavoring (Niloufer Sultan Ali, Ali Khan Khuwaja,2011) Depending on the cultivar, betel leaf can have a range of bitterness in addition to its different flavor like fresh, peppery. Although the effects vary from person to person, areca nuts are chewed for their mild stimulant properties, (Bhat, Ravi, et al.,2024) which include a warming sensation in the body and a minor increase in alertness. Asia and Southeast Asia are primarily where this practice is most prevalent. Because it is frequently taken during social events, festivities, and religious rites, it is a traditional stimulant. Numerous traditional medical systems, including Chinese medicine, Ayurveda, and numerous other folk medicine practices, have made use of arecanut. Additionally, arecanut aids in appetite stimulation and digestion. Following harvest, the nuts are processed into a variety of forms, including powdered arecanut, sliced pieces, and dried nuts. They are used in various cosmetic products due to its mild exfoliating properties. The husk of Arecanut is also used in production of different natural dyes. Arecanut can also be processed into various biodegradable products such as bowls, plates, and various packaging materials and are considered as an ecofriendly alternative to plastics. (Kumar L.et al, 2017) The increasing trends and change in lifestyle has shown an increase in fast-changing consumption patterns. Consequently, the use of different sustainable packaging materials has also increased. Packaging is used in almost every product ensuring that the food is delivered to the customer in an undamaged manner. Recently Arecanut has gained a lot of attention in the packaging field due to its various properties. In this research we will explore the use of Arecanut or its extract in the development of food packaging material. Due to its antimicrobial properties, it could help to increase the shelf life by reducing the chances of microbial contamination. (Jam N.et al 2021) Arecanut in packaging film will give a natural preservative effect to the film. This can be useful in the packaging of easily damaging or easily perishable foods like fruits and vegetables and meat and meat products. (Dissanayake.et al 2021), Arecanut also contain antioxidant property, using Arecanut in packaging film can give some level of antioxidant protection to foods, and can help reduce chances of oxidation if foods maintain the freshness of food and food products. Arecanut is available in large quantities all around us such as India, South east Asia, Sri Lanka etc. thus by using Arecanut in the packaging film can be less expensive and cost effective and can also be produced locally to cut off the transportation and large production costs. (Chaitra G. B. 2024) The use of Arecanut can also provide an income source for the poor farmers.

Materials and methods

In the following section, the methodology of manufacturing a biodegradable, high shelf life, eco friendly packaging material and a complete material characterization is presented.

Materials

Ethanol 70%, Distilled water, Carboxyl Methyl cellulose (CMC), Glycerol, Starch, Polyvinyl Alcohol (PVA). Magnetic stirrer was also used for efficient mixing, Vacuum pump for de airing the solution, glass plates/ Teflon sheets for film casting, Hot air oven for drying of the films, Micrometre / digital thickness gauge to measure film thickness, Analytical Balance for weighing of materials, and general laboratory supplies like spatula, spreader, forceps, glass rods, etc. Dried arecanut, rotary evaporator.

Method

Arecanut bioactive extraction process

Arecanut seed powder were taken and extracted bioactive compounds from the seeds. 70% ethanol is added to the sieved powder, taking a proportion of 1:10 (g/ml) of arecanut powder to solvent in 10 flasks for extraction. They are shaken for two hours to properly mix and extract the bioactive compounds in the arecanut powder. The mixture is then filtered to eliminate solid impurities, leaving a clear extract. Further it was filtered and concentrated using rotavapor to remove the solvent from the extract. The final extract is refrigerated to maintain its bioactive properties, specifically its antimicrobial activity.

Film formation

For the preparation of the base of the film, carboxy methyl cellulose, glycerol, and polyvinyl alcohol (PVA) are mixed together. These are blended to form a polymer matrix that forms the base of the film. After the base is ready, the arecanut extract is added to the film matrix. The blend is then cast into a thin film. Once the film has been created, its characteristics like GSM (grams per square meter), strength, and flexibility are analysed.

Table 1: Formulation of eco-friendly packaging film

Sr. no.	CMC (g)	Glycerol (g)	PVA (g)
1	1	5	2
2	1.5	5	2
3	2	5	2
4	2.5	5	2
5	5	5	2

Physical properties of Film:

1. **GSM:** The GSM of packaging material is calculated according to the American Society of Testing and Materials Standards method reported by (Paine et al., 1992).
2. **Thickness:** Thickness were calculated using Vernier calliper reported in ASTM.
3. **Tearing Strength:** The Elmendorf tearing tester is used to check the strength of packaging material (ASTM, D 689-79 Part 20).
4. **Bursting strength:** To assess the strength and toughness of packaging material bursting strength tester is used (IS 1009-1966 Part I).
5. **Tensile Strength:** It was carried out using universal tensile strength tester according to the ASTM (Paine et al., 1992).

Result & Discussion

This section elaborates on the extraction of bioactive compounds, film formation and its physical and antimicrobial property.

70% ethanolic extract of arecanut showed good antimicrobial activity against S. aureus followed by S.Typhi and E.coli respectively. Three different ingredients like CMC, glycerol and PVA is used and five different formulations taken for the film formation (Table 1). Among all 5g CMC, 5 g glycerol and 2g PVA is optimized based on its appearance and physical properties indicated in table 2.

Table 2: Physical properties of Packaging Film

Property	Value	Implication
GSM (Grams per Square Meter)	4.82 g/m²	A very light packaging film, making it flexible and lightweight while still needing sufficient strength.
Thickness (mm)	0.66 mm	Provides a balance between flexibility and strength, improving barrier properties against moisture, oxygen, and contamination.
Tearing Strength (N/m^2)	10.4 N	Ensures durability against accidental tears, protecting the package from external contaminants.
Bursting Strength (Kg)	2.81 kPa	Helps the film endure internal and external pressures during shipping and storage.
Tensile Strength (kg/cm^2)	0.6 kg/6 cm	Contributes to the film's durability and resistance against stretching forces.

According to the majority of research on food packaging films, films with GSMs between 10 and 40 g/m² are typical for general use, especially when it comes to packing fresh goods (Shin. et al,2016). When the film's GSM is less than 5 g/m2, it can be used to wrap products, such as single-use packaging, rather than for secondary purposes (Table 2). While standard food packaging films are thinner, ranging from 0.02 to 0.1 mm for flexible food packaging, the resultant packaging film has a thickness of 0.66 mm (Gopal, TK Srinivasa, 2025). This could be the result of the solution spreading unevenly during preparation. This film's thickness may aid in its resistance to oxygen and moisture, which is crucial for prolonging its shelf life and preventing spoiling. The obtained film has a tearing strength of 10.4 N. When it comes to food safety, this shows that the film can withstand accidental rips and punctures under normal handling circumstances. Depending on their intended use, most commercial food packaging sheets have ripping strengths between 5 and 20 N. For packaging that will be handled heavily, such as supply networks for larger goods, greater tearing strengths are crucial (Maddala, Pranay Raj Reddy,2017). The amount of force needed to rupture or shatter any packing material is indicated by its burst strength (Bharti. et al, 2023). The designed packaging film has a bursting strength of 2.81 kPa. The greatest tensile (pulling) force that a material can withstand before rupturing is known as its tensile strength. (Mohamed. et al, 2019) Units of force per width are typically used to record it. Packaging film has a tensile strength of 0.6 kg/cm.

Antimicrobial activity of packaging

The use of arecanut extract to the packaging film provide a major benefit in relation to antimicrobial properties. Arecanut extract has a ability to inhibit the growth of harmful microorganism such as Escherichia coli (E. coli), Salmonella, and Staphylococcus aureus (S. aureus). The film has strong inhibitory properties against bacterial growth, especially for Salmonella and S. aureus, according to the antimicrobial activity data. This is essential for increasing food safety and extending the shelf life of short-lived items. In positive samples, for instance, E. Coli and S. aureus displayed growth inhibition of roughly 1.5 to 3.5 cm, demonstrating the film's potent antibacterial action. Its effectiveness against Salmonella is also noteworthy, as seen by some samples showing a reduction of up to 4 cm, further supporting its value in preventing microbiological contamination of packaged foods. These results are consistent with earlier studies showing growing interest in the use of antibacterial agents derived from plants in food packaging. (Bose, et al, 2023) further highlighted the efficacy of natural antimicrobial compounds, such as arecanut extract, towards food safety improvement and shelf-life enhancement. Antimicrobial activity of packaging film is seen from the fig. 1 and diameter from the Table 3.

Fig. 1. Antimicrobial activity of extract and film against bacterial strain

Antimicrobial activity of extract and film can be visualize from fig 1.

Table 3: Zone of inhibition of arecanut extract & development film

Culture	Film diameter (cm)	Positive (cm)	Extract (cm)
E. *Coli*	2	3.5	2
Salmonella.Typhi	2	3.5	2.5
S.*aureus*	2	2.5	3

Significance for Food Packaging

Synergism of this packaging film's mechanical and antimicrobial activities lends itself favorably to foods that need to be physically safeguarded as well as for greater shelf life. The relatively low weight of the film, given its low GSM, allows for minimal contribution to the overall product weight, which is beneficial as a cost-reducing practice in packaging. Its strong mechanical properties with reference to its tear resistance strength and bursting strength, also positions it ideally for commercial supply chain handling, where products endure physical stresses in transport and storage in addition to this arecanut extract ensures about the protection of product from microorganism. This is particularly useful for fresh produce such as fruits, vegetables, meats, and dairy products, which are more susceptible to microbial spoilage. The film's capacity to add shelf life by inhibiting the development of microorganisms and pathogens without chemical preservatives fits with the consumer demand for more natural, healthier products.

Conclusion

In conclusion, this study highlights the potential of arecanut extract as a valuable component for the production of environmentally friendly, sustainable, and antimicrobial food packaging films. The findings demonstrate some promising advantages of adding arecanut extract to a polymer-based film composed of cellulose, polyvinyl alcohol (PVA), and glycerol. The resulting film has excellent mechanical qualities, including enough tensile, bursting, and tear resistance to be used to safeguard food products during handling and transit. Arecanut extract's antibacterial properties are especially noteworthy since they help to prolong the shelf life of food by preventing the growth of harmful bacteria including Salmonella, Staphylococcus aureus, and Escherichia coli. Short-lived foods are further protected by the antibacterial action, which reduces the risk of both foodborne illness and microbial contamination. In general, this study proves that arecanut-based packaging films have significant potential as a functional, eco-friendly substitute for traditional plastic-based food packaging.

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