DEVELOPMENT OF BIODEGRADABLE SACS FOR FRUIT RIPENING USING RICE STARCH

Project Reference No.: *47S_BE_3257*

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Keywords:

Bioplastic, Rice starch, Biocompatibility, Ethylene, Ripening

Introduction:

In recent years, as environmental concerns have taken centre stage, the quest for sustainable solutions has become more urgent than ever. One area where this quest has been particularly pronounced is in the realm of packaging, especially for food products. In response to the detrimental effects of traditional plastic packaging on the environment, scientists and researchers have been tirelessly exploring alternative materials that are both effective and eco- friendly. One such innovation is the development of a biodegradable sac for fruit ripening, utilizing the versatile properties of rice starch. At the heart of this endeavour lies the recognition of rice starch as a promising candidate for biodegradable packaging. Rice starch, derived from one of the world's most widely cultivated grains, possesses several characteristics that make it an ideal material for this purpose. Not only is rice starch abundant and renewable, but it also boasts impressive biodegradability, breaking down naturally into harmless byproducts over time. Additionally, its inherent biocompatibility ensures that it poses minimal risk to both human health and the environment.

The journey towards the creation of the biodegradable sac for fruit ripening has been marked by meticulous research and experimentation. On one hand, the sac must provide adequate protection for the fruit, shielding it from external factors that could compromise its quality. On the other hand, it must also facilitate the ripening process, allowing the fruit to mature naturally and develop its characteristic flavour and aroma. Achieving this delicate balance has required a nuanced approach, with researchers fine-tuning the composition and structure of the sac to optimize its performance. The development of the biodegradable sac for fruit ripening holds immense promise for the future of sustainable packaging. Not only does it offer a viable alternative to traditional plastic packaging, but it also represents a significant step towards reducing the environmental impact of food production and distribution. By harnessing the power of rice starch, researchers have unlocked a pathway to greener, more sustainable packaging solutions that benefit both people and the planet. As the journey towards sustainability continues, the development of innovative solutions like the biodegradable sac for fruit ripening serves as a beacon of hope.

Objectives:

1. To extract the starch from rice grains.
2. To prepare a biodegradable sac from the extracted starch.
3. To determine the sustainability of the Biosac.

Methodology:

1. Extraction of starch from white rice grains

100g of white rice grains is collected. These rice grains are washed and boiled with water. These rice grains are subjected to grinding in a mortar with 100ml distilled water. The mixture was filtered and the remaining solid mass was put into the mortar. The procedure is repeated 5 times to obtain more starch. This blend was allowed to settle in the beaker for 5mins, then 100ml of purified water is added and is agitated softly. The water is removed after repeating the above process 3-4times and the starch, white in colour, is obtained.

Fig 1.1: Soaked rice grains

Fig 1.2: Grinded rice grains

Fig 1.3: Filtration

Fig 1.4: Liquid mass

Fig 1.5: Settling of mass

Fig 1.6: Supernatant

Fig 1.7: Sundried

Fig 1.8: Grinded

Fig 1.9: Rice Starch

2. Preparation of sac with extracted rice starch:

The extracted starch is mixed with 100ml of distilled water along with additives. These additives are as follows:

- Glycerol: Act as plasticizer
- Vinegar: Provides smoother and more consistent texture by breaking the starch molecules for a more uniform film
- Gelatin: Improves flexibility, enhances strength, biodegradable in nature and versatile which makes it compatible with starch.

The mixture is stirred at a rate of 180rpm for 10mins, then the mixture is heated on a hot plate at 100°C and manual stirring is done for 70mins continuously. The mixture is casted onto a flat, levelled, non-stick trays to set. Once set, the trays are held over-night in microwave at 55°C for 10hrs undisturbed and then cooled at ambient temperature for 3-4 days before peeling the films off the trays.

SAMPLE	RICE STARCH (in grams)	GLYCEROL (in ml)	VINEGAR (in ml)	GELATIN (in grams)	WATER (in ml)
S1	15	10	10	3	100
S2	20	10	10	3	100
S3	25	10	10	3	100

Table 2: Different ratios of Starch, Glycerol, Gelatine, Vinegar and Water

Preparation of biosac with extracted strach:

Fig 2.1: Heating of mixture

Fig 2.2: Starch Paste

Fig 2.3: Paste spread mold

Fig 2.4: Paste dried into film

Fig 2.5: Starch film

3. Characterization of Starch film:

Elasticity: Prepare a thin biosac strip and secure its ends to a stretching apparatus. By slowly pulling on the material, we can observe the point where it begins to noticeably stretch and the point of breakage.

Fig 3.1: Universal Testing Machine (UTM)

Fig 3.2: Starch film for testing

Water resistance: A small beaker was taken and the top was covered with small piece of prepared film and kept in place with a thread. A small groove was made on the small piece and water was added to it. The apparatus was left for 72 hr and later observed weather the film breaks down or retains its structure.

Fig 3.3: Test for water resistance

Water solubility: The film sample was cut into square sections of 2.0 cm, and the dry film mass was weighed accurately and recorded. The samples remained immersed in 100 mL distilled water and fixed agitation at 180 rpm were carried out for 6 h at 25 ◦C. The lasting portions of the film were filtered after 6 h. They were then dried in a hot air oven at 110 ◦C until an ultimate fixed weight was found.

Fig 3.4 Starch film weight

Fig 3.5: water solubility

Biodegradability test: A potted plant was taken and the soil near the roots were dug. A small piece of biosac was cut for faster degradation. The piece was placed into the soil and left covered. After 10 days, the residual piece was removed and observed for breakdown and fragmentation.

Fig 3.6: Piece of film placed in the soil

Thickness measurement: We use a micrometer, a small instrument with a screw gauge that provides precise measurements. Ensure the bioplastic sample is placed on a flat, stable surface. Gently lower the micrometer's anvil onto the bioplastic sample. Slowly turn the screw gauge until the spindle touches the bioplastic without applying excessive pressure, which could deform the material. The thickness of the bioplastic will be displayed on the micrometer's scale.

Fig 3.7: Micrometer

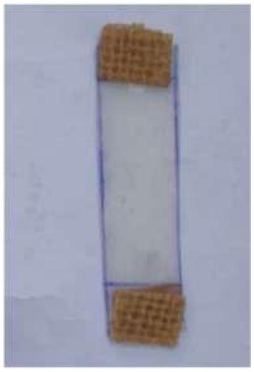

Fig 3.8: Sample used

4. *Test for natural ripening*

After the characterization of film, it will be tested for their fruit ripening property. Check for the time taken by the film to ripen the fruit and compare it with normal time taken by the Fruit to ripen naturally within a normal plastic. The first fruit that we tested for ripening is Banana. Two unripe bananas were taken; one was covered with the starch Biosac and the other was covered with normal plastic. The bananas were left untouched for 24hrs. The same procedure was done for other fruits like custard apple and mango. The results were observed.

Fig 4.1: Test on Banana

Fig 4.2: Test on Custard

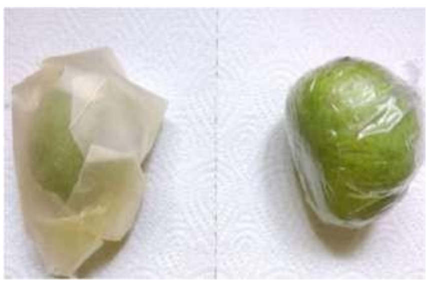

Fig 4.3: Test on Mango

Conclusion:

1. *Rice starch extraction:*

Efficient rice starch extraction yielded high- quality material, perfect for biodegradable bag production, exemplifying sustainable resource utilization and agricultural innovation.

Fig 1.1: Rice starch

2. *Starch film formation:*

Biosacs, crafted from extracted rice starch and eco-friendly additives, boast durability, tamper- proof design, and versatility in accommodating diverse fruits, showcasing sustainable packaging solutions.

Fig: 2.1: Starch film

3. *Characteristics for the film sustainability:*

a. Water resistance test: Results have shown that rice starch films exhibit good water resistance, making them suitable for applications requiring moisture barrier properties, such as food packaging and agricultural films.

Fig 3.a: Dried starch film

b. Water Solubility test: The starch film dissolved into small pieces after 4 hours in water, yielding a final weight of 0.093g and a water solubility percentage of 25.2%, indicating good water solubility.

Fig 3.b: Water solubility test for starch film

c. Elasticity/ tensile strength test: The bioplastic exhibited a tensile strength of 0.73 MPa, with a Young's modulus of 3.636 MPa, indicating moderate stiffness and a ductility of 20.075%, suggesting significant elongation before fracturing.

Fig 3.c: Test results for tensile strength

d. Thickness measurement results: The average thickness of the bioplastics measures 0.25 mm (250 microns), well above the Government of India's regulation of 50 microns for plastic bags, affirming suitability for carry bag preparation.

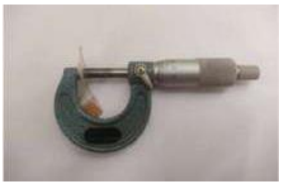

Fig 3.d: Thickness measurement of sample

e. Biodegradability test results: The bioplastic, made with rice starch, displayed significant degradation within 20 days, breaking down into smaller pieces due to microbial activity, affirming its eco-friendly nature and potential for sustainable waste management.

Fig 3.e: results of biodegradable test

4. Test for natural ripening process:

Bananas covered with starch film ripened faster than those in normal plastic bags after 14 hours, highlighting the starch film's efficiency in accelerating ripening. This outcome underscores the potential of starch film as a sustainable alternative for fruit packaging.

Fig 4.1: Unripen Banana

Fig 4.2: Banana Ripened after 14hrs

The similar procedure was done for Custard Apple and Mango. For Custard Apple that was covered with the starch film, we observed that after 36 hrs it turned blackish-yellow compared to the custard covered with normal plastic bag. For mango we observed that after 82hrs it turned yellow when compared to mango covered with normal plastic.

Fig 4.3: Unripen Custard Apple

Fig 4.4: After 36hrs of observation

Fig 4.5: Unripen mango

Fig 4.4: After 82hrs of observation

5. Comparison table for fruits:

A comparative analysis of the ripening process of various fruits, including banana, custard apple, and mango was conducted over durations of 14 hours, 36 hours, and 82 hours, employing both bioplastic and conventional plastic packaging. Results revealed distinct patterns in ripening progression across fruit types and packaging materials. Bioplastic packaging demonstrated a more ripening curve compared to conventional plastic, suggesting a potential role in increasing ripening rate. With banana exhibiting the fastest ripening process, followed by custard apple and mango.These findings underscore the influence of both packaging material and fruit type on the ripening kinetics, offering valuable insights for optimizing storage and transportation practices in the fruit industry towards enhancing shelf life and ripening rate.

Fruits	Fruits covered with starch film			Fruits covered with normal plastic		
	Colour at initial stage	Colour at final stage	Duration (in hrs)	Colour at initial stage	Colour at final stage	Duration (in hrs)
Banana	Green	Yellow	14hrs	Green	Greenish-Yellow	14hrs
Custard Apple	Green	Blackish-Yellow	36hrs	Green	Greenish-Yellow	36hrs
Mango	Green	Yellowish-Green	82hrs	Green	Greenish-Yellow	82hrs

Table 5: Colour and duration comparison table

Scope for future work:

Market Adoption: As consumer awareness of environmental issues continues to grow, there is a significant market potential for biodegradable packaging solutions. The project can explore partnerships with fruit producers, distributors, and retailers to introduce the rice starch-based sacs into the market.

Environmental Impact Assessment: Conducting a comprehensive life cycle assessment (LCA) to evaluate the environmental impact of the rice starch-based sacs compared to conventional packaging materials would provide valuable insights and potentially influence policy decisions.

Global Reach: Expanding the project's reach to other regions and countries where agricultural practices vary could help address specific challenges and opportunities in different contexts.

Educational Initiatives: Developing educational materials and outreach programs to raise awareness about the benefits of biodegradable packaging and sustainable agriculture could foster widespread adoption and support for the project.

Collaborative Partnerships: Collaborating with industry stakeholders, research institutions, and environmental organizations can facilitate knowledge sharing, resource pooling, and collective action towards a more sustainable future.