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Impact and analysis of the bael (*Aegle marmelos*) pulp pectin coating on sapodilla fruit for shelf life extension

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Abstract
The study was conducted for the pectin extraction from unripe bael and further prepared the pectin based edible coating solution and applied it on sapodilla fruit. Estimation of control and coated sample was done using physico chemical parameters. The solution was prepared with pectin (2%), glycerol (2.5%), polyvinyl alcohol (1.25%), and citric acid. The study was done from day one to day eleven to estimate the parameters. Study reveals that at day 11, 35.40±0.014 and 19.46±0.015% weight loss in control and coated sample, 27 and 24 TSS (°Brix) in control and coated sample, 5.98 and 5.94 pH in control and coated sample, 0.12 and 0.17 Titratable acidity (%) in control and coated sample, 4.80 and 5.30 Ascorbic acid (%) in control and coated sample. According to the research findings after the estimation of physicochemical parameters on control and coated sample, it can be stated that it is conceivable to coat the commodity for shelf life extension using bael pulp pectin coating solution.

Keywords: Sapodilla, pectin, coating, bael, shelf life, coating solution

Introduction
Pectin, a natural polysaccharide used to make palatable films and coatings, extends the longevity of foods that are perishable by covering them from the outside environment, delaying nutritional loss, and supporting the preservation of physical and chemical qualities for an extended period of time (Surolia *et al*. 2022) [1]. Bael fruit contains bioactive substances. The abundance and high pectin content of the bael fruit make it an attractive option for medicinal and food applications. However, researchers have not yet tracked down its physicochemical, electrical, mechanical, and functional properties (Jindal *et al*. 2013) [2]. (Valdes *et al*. 2015) [3] stated that edible films provide a clean and attractive alternative for waste management in packaging materials.

Food will be protected with regard to organoleptic traits by an edible coating. To avoid using formalin for fruit preservation and protection, edible coatings have been chosen as substitutes (Mahardiani *et al*. 2021) [4]. The numerous health benefits of the perishable sapodilla fruit have led to its usage in conventional Indian medicine. The fruit is an excellent provider of chicle gum, which gets used to create chewing gum and has a high content of sugar. Furthermore, sapodilla or sapota fruit comprises minerals, phenolic compounds, and acids. Edible packaging can improve the potential for the preservation of sapota (Menezes *et al*. 2016) [5].

Pectin-based coatings are used to preserve various fruits and vegetables, including avocado, peach, mango, and cucumber. A variety of hydrocolloid component concentrations can be combined to create coating emulsions (Maftoonazad *et al*. 2019) [6]. Spraying, dipping, brushing, and panning are some of the methods used for applying edible coatings to fresh-cut commodities. Different commodities favor pectin-based coatings that are edible, such as pears, which lose less weight and have a higher lightness rating. (Kavak *et al*. 2019) [7], the freshness of minimally processed espada mangoes was preserved during long-term refrigerated storage (Silva *et al*. 2018) [8], blackberries showed a reduction in weight loss (Tumbarski *et al*. 2020) [9], dried red guava improved the nutritional quality of the commodity (Todisco *et al*. 2018) [10], and the coating solution, when mixed with the essential oil of lemongrass, was beneficial in reducing weight loss in strawberries (Da Silva *et al*. 2019) [11]. To ensure the safety and quality of freshly cut apples, a pectin nanoemulsion coating might be used. (Naqash *et al*. 2022) [12].

A pectin-based edible coating containing beeswax, sorbitol, and monoglyceride was found to effectively extend the life expectancy of catalufa mango (Moalemiyan *et al*. 2012) [13]. Food quality is one of the most important aspects, particularly for fresh products, along with its organoleptic qualities, nutritional content, and microbiological safety. Edible coatings are used in conjunction with food products to reduce the usage of plastic packaging and be more environmentally friendly (Rohasmizah *et al*. 2022) [14]. Edible coating compositions can include a variety of chemicals. Coating materials should be soluble in specified solvents. Plasticizers, emulsifiers, and additives can enhance coating integrity, stability, and functioning. Incorporating functional and bioactive chemicals into edible coatings can enhance their effectiveness and promote consumer health. These with active ingredients, such as antimicrobials, antioxidants, antibrowning agents, texture modifiers, and nutrients, are gaining popularity as a way to manage the quality of fresh horticultural produce (Panahirad *et al*. 2021) [15].

2. Materials and Methods

2.1 Collection of Materials

The Unripe Bael of Kaghzi variety was purchased from Chandra Shekhar Agricultural University, Kanpur. The chemicals and reagents were available in the laboratory, food tech department, HBTU Nawabganj, Kanpur.

2.2 Pectin extraction from unripe bael

The pectin from bael pulp was extracted according to (Maskey *et al*. 2018) [16]. The unripe bael was broken with a hammer, and the pulp was scooped and dried at 60°C using a cabinet tray drier (Armfield UOP 8 MKII). The pulp was then ground into powder using a mixer grinder (Prestige Iris Ltd., 750 watt) and kept in an airtight container for further use. For extraction, take a specific volume of water and use a hot plate or water bath to keep the temperature at the appropriate level. After adding bael powder and a certain amount of hydrochloric acid to the water, the pH was adjusted to the required level. The mixture was agitated at a constant temperature for a set period of time and cooled in an ice water bath, followed by centrifugation at 1500 rpm for 10 minutes in a laboratory centrifuge. Following centrifugation, filtration was carried out. The precipitation process continued overnight, with the extraction ratio kept at the volume of alcohol in the filtered solution. Pectin was then separated and dried.

2.3 Pectin edible coating solution preparation

The (Menezes *et al*. 2016) [5] procedure was followed for developing a coating solution. Pectin (2%) was mixed in distilled water at 90 °C. The solution was next mixed with 2.5% glycerol, 1.25 percent polyvinyl alcohol, and 1 percent citric acid. After mixing, the solution was cooled down at room temperature.

2.4 Physico chemical Analysis

2.4.1 Weight loss

Weight loss in both samples (control and coated) is estimated by applying the formula below (Menezes, *et al*. 2016) [5].

$$Weight\ loss = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}}$$

2.4.2 Total Soluble Solids

It can be find out using a hand refractometer. To measure ° Brix, put a fruit juice drop on the refractometer plate surface and take the direct reading (Garza *et al*. 2015) [17].

2.4.3 pH

A digital pH meter is used to determine it. According to Menezes *et al*. (2016) [5], the pH meter must first be calibrated before the probe is inserted into the fruit juice, and the reading is recorded right away.

2.4.4 Titratable Acidity

It is calculated by the method estimated by Ranganna, *et al*. (1977) [18].

$$Acidity\ (\%) = \frac{\text{Titre} \times \text{Normality of alkali} \times \text{Volume made up} \times \text{Equivalent weight} \times 100}{\text{Volume of sample taken for estimation} \times \text{weight or volume of sample taken} \times 100}$$

2.4.5 Ascorbic Acid

Fruits and vegetables are important source of ascorbic acid.

The reagents and required for the estimation:

1. 4% of oxalic acid.
2. Prepare a dye solution by mixing 42 milligrams of sodium bicarbonate with water that has been distilled. Dissolve 52 mg of 2,6-dichlorophenol in it and makeup to 200 mL of distilled water.
3. **Stock Standard Solution:** A 100 ml solution containing 4% oxalic acid (1 mg/mL) was used in order to dissolve 100 mg of ascorbic acid.
4. **Working Standard:** In 100 mL of 4% oxalic acid, 10 mL of stock solution will be diluted. The working standard's concentration is 100 ug/ml.

Procedure

1. Pipette out 5 ml of the working standard solution in a 100 ml conical flask
2. Titrate the dye (V1 ml) against 4% oxalic acid of around 10 ml. The emergence of pink color indicates the endpoint. The quantity of ascorbic acid consumed is equal to the dye quantity.

$$Dye\ Factor = \frac{0.5}{\text{Titre}}$$

3. In 4% oxalic acid, extract the sample (0.5-5 g) to a specified volume (100 ml), then centrifuge.
4. 5 ml of supernatant was pipetted out, then 10 ml of 4% oxalic acid was added and titrated against the dye (V2 ml).

It is calculated using formulae suggested by Ranganna *et al*. (1977) [18].

$$\text{mg of ascorbic acid per 100 ml} = \frac{\text{Titre} \times Dye\ factor \times Volume\ made\ up \times 100}{\text{Aliquot of extract taken for estimation} \times \text{wt or volume of sample taken for estimation}}$$

2.4.6 Statistical Analysis
SPSS Statistics version 27.0.1 was used for the statistical analysis. The mean values, together with the standard deviations, were received, and the experiments were run in triplicate. For all presented data, the homogeneity test was used. The mean values were assessed using a one-way ANOVA to evaluate the mean values, and at a significance level of $p \leq 0.05$, the Duncan test was performed.

3. Results and Discussion
Samples for the pectin-based coating were stored at room temperature after the commodity was coated with the coating solution. For both the control and coated samples at storage, physicochemical parameters were measured.

3.1 Weight Loss: In terms of weight loss, the coated sample's increment turned from 2.09±0.015 to 19.46±0.015, whereas the control sample's increased from 4.23±0.014 on day 1 to 35.40±0.014 at room temperature on day 11. As a result, the lower weight loss in coated samples indicates that the pectin edible coating is more trustworthy for extending shelf life than the control one. Table 1 depicts the values of weight loss.

3.2 Total Soluble Solids: Total soluble solid content of fruit increases during ripening due to polysaccharide degradation and water loss, which concentrates solutes in the tissue. During storage, the control sapodilla fruit had a considerable increase in TSS concentration, while the coated fruit sample remained consistent throughout the period of storage, as illustrates in Table 1.

Table 1: Physicochemical parameter values of weight loss and TSS for control and coated samples.

Days	Weight Loss (%)		Total Soluble Solids (°Brix)	
	Control	Coated	Control	Coated
1	4.23±0.014 [a]	2.09±0.015 [a]	17±0.81 [a]	18±0.47 [a]
3	10.56±0.014 [b]	6.13±0.015 [b]	19±0.81 [b]	19±0.47 [b]
5	17.70±0.014 [c]	10.47±0.015 [c]	22±0.81 [c]	21±0.47 [c]
7	22.22±0.014 [d]	15.10±0.015 [d]	24±0.81 [d]	22±0.47 [d]
9	28.12±0.014 [e]	17.55±0.015 [e]	25±0.81 [e]	23±0.47 [e]
11	35.40±0.014 [f]	19.46±0.015 [f]	27±0.81 [f]	24±0.47 [f]

Source: SPSS Statistics version 27.0.1

3.3 pH and Titratable Acidity
The pH of the coated sample is lower than that of the control sample. The coated fruit sample exhibits minimal pH change after storage. The titratable acidity was lower in the control sample from day 1 to day 11 than in the coated samples. The opposite correlation between pH and titratable acidity has also been found. As the pH rises, the titratable acidity falls due to respiration, resulting in the oxidation of organic acids, and the acid content of fruits diminishes over time. Table 2 shows the physicochemical parameter values of pH and titratable acidity.

Table 2: Physicochemical parameter values of pH and Titratable acidity for control and coated samples.

Days	pH		Titratable Acidity (%)	
	Control	Coated	Control	Coated
1	5.28±0.01 [a]	5.38±0.009 [a]	0.47±0.011 [a]	0.49±0.008 [a]
3	5.41±0.01 [b]	5.52±0.009 [b]	0.35±0.011 [b]	0.36±0.008 [b]
5	5.55±0.01 [c]	5.65±0.009 [c]	0.26±0.011 [c]	0.29±0.008 [c]
7	5.70±0.01 [d]	5.77±0.009 [d]	0.21±0.011 [d]	0.22±0.008 [d]
9	5.91±0.01 [e]	5.84±0.009 [e]	0.15±0.011 [e]	0.19±0.008 [e]
11	5.98±0.01 [f]	5.94±0.009 [f]	0.12±0.011 [f]	0.17±0.008 [f]

Source: SPSS Statistics version 27.0.1

3.4 Ascorbic Acid
Compared to the control sample, the coated sample's ascorbic acid decreased less during storage, from day 1 to day 11. When combined with glycerol, ascorbic acid is regulated as an antioxidant and improves the water-vapor resistance of polysaccharide coatings. Ascorbic acid controls oxygen penetration in edible coatings, protecting oxidative processes. Table 3 displays the ascorbic acid result.

Table 3: Physicochemical parameter values of Ascorbic acid for control and coated samples.

Days	Ascorbic Acid (%)	
	Control	Coated
1	14.61±0.15 [a]	14.40±0.11 [a]
3	12.06±0.15 [b]	12.76±0.11 [b]
5	11.23±0.15 [c]	10.40±0.11 [c]
7	7.96±0.15 [d]	8.76±0.11 [d]
9	5.63±0.15 [e]	6.4±0.11 [e]
11	4.80±0.15 [f]	5.3±0.11 [f]

Source: SPSS Statistics version 27.0.1

3.5 Observation of coated and control samples on different days: The coated and control sapodilla fruit samples were kept at room temperature, and observation was done from day 1 to day 11. Figure 1 represents the appearance of the coated samples.

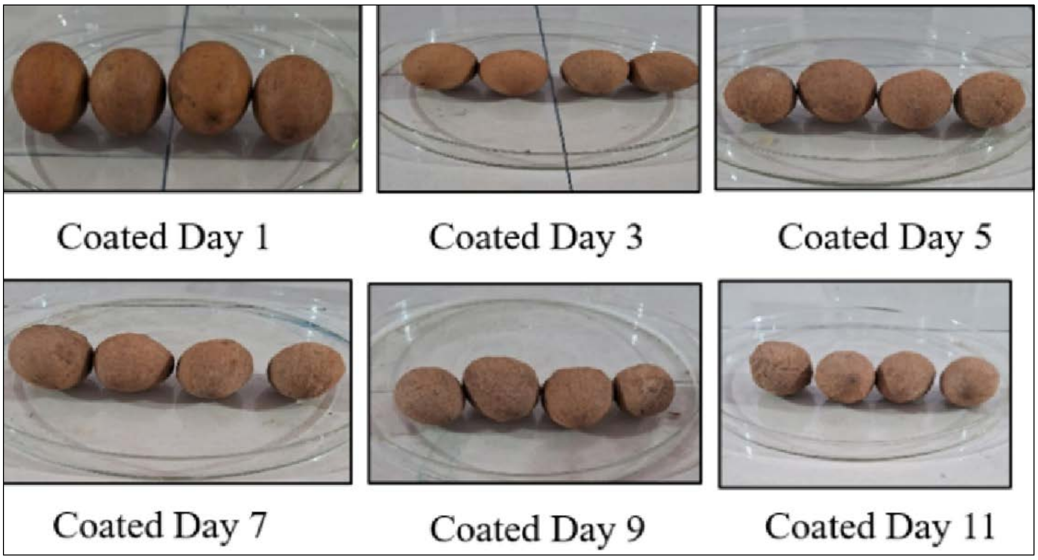

Fig 1: Observation of coated sapodilla samples at different days

Figure 2 depicts the appearance of the control samples at different storage days from day 1st to 11th day.

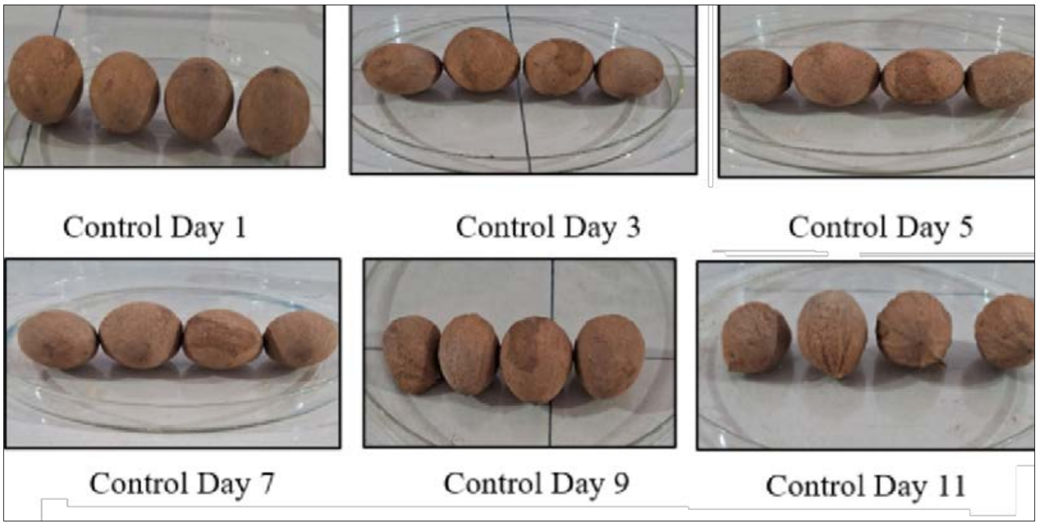

Fig 2: Observation of control sapodilla samples at different days

4. Conclusion

The study reveals that it is feasible to extend the longevity of sapodilla fruit by implementing a pectin coating solution that consists of unripe bael pulp pectin, polyvinyl alcohol, glycerol, which acts as a plasticizer, and citric acid. The result of physicochemical parameters indicates that the lifespan of the commodity can be increased.

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