Development Of Edible Film By The Incorporation Of Blue Butterfly Pea Flower *(Clitoria ternatea).*

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Abstract:

This study focuses on the development of edible pH-indicating films using butterfly pea flower (Clitoria ternatea) extract and gelatin as a biopolymer matrix. The primary objective was to investigate the pH sensitivity of the butterfly pea extract and its potential application as a spoilage indicator in food packaging. The films were prepared by extracting colorants from 2 g of butterfly pea flowers in 80 mL of water, which was reduced to 60 mL by boiling. To this, 12 g of gelatin and 2 mL of glycerin (used as a plasticizer) were added. The resulting films were analyzed over a 7-day period to evaluate their pH sensitivity, water solubility, swelling, thickness and interaction with food products. An application study was conducted by placing the developed film on a fresh strawberry. The film displayed a visible color change from blue to green in response to pH changes caused by food spoilage, demonstrating its effectiveness as a natural pH indicator and potential use in intelligent food packaging systems.

Key words

Blue butterfly flower(BBF), Gelatin control film(GCF), Food grade gelatin(FGG)

Introduction

The **Blue butterfly pea flower** (*Clitoria ternatea*), also known by several other names like Asian pigeonwings, bluebell vine, and blue pea, is a plant in the Fabaceae family that originated in Ternate, an Indonesian island (Don et al., 1831). In Indian Ayurveda, it's widely recognized as Aparajita. This perennial herbaceous plant features elliptic, obtuse leaves and typically grows as a vine or creeper, thriving in moist, neutral soil. Its most notable characteristic is its vibrant deep blue, solitary flowers with light yellow markings. As a legume, the butterfly pea engages in a symbiotic relationship with soil bacteria called rhizobia. This interaction facilitates nitrogen fixation, converting atmospheric nitrogen into a form usable by the plant. Consequently, this plant can also enhance soil quality through the breakdown of its nitrogen-rich matter. Various chemical compounds have been identified within *C. ternatea*, including triterpenoids, flavanol glycosides, anthocyanins, and steroids (Mukherjee PK et al., 2008). Additionally, cyclic peptides known as Cliotides have been extracted from the heat-stable components of *C. ternatea* (Nguyen et al., 2011). The distinctive blue hue of *C. ternatea* is attributed to different anthocyanins, with ternatins being the most significant (Terahara, Norihiko et al.). The uses of butterfly pea is that they can be used in culinary and also in traditional medicines. In culinary they are commonly used as food colours due to their characteristic blue colour and in traditional medicine extract the flowers are used as a medicine as anti stress, anti depressant, anxiolytic(anti anxiety), anticonvulsant (mood stabilizers), and also has sedative properties. These flowers are intensively used as culinary accessories in Thailand and Vietnam. And in other part of the world they are gaining popularity due to their nutritional benefits. This food/substance provides a wide array of health advantages.

It is known to enhance brain function, assist with weight control, and may even improve the health of hair and skin. Rich in antioxidants, particularly anthocyanins, it could help alleviate stress, sharpen memory, and safeguard against cognitive decline. Furthermore, it is thought to possess anti-inflammatory qualities and might contribute to regulating blood sugar levels. It is also shown that the anthocyanin protects liver from liver damage (Wahyu Widowati et al, 2024). This butterfly pea shows the pH indication properties (Nyi Mekar Saptarini et al, 2015) which can be use as a spolage and microbiological activities indicator because spoilage of foods can educe the pH of the food product and eventually microbial growth is noticed.

The pervasive issue of environmental pollution stemming from the extensive use of non-biodegradable, petroleum-based plastic packaging has driven significant research into alternative materials, particularly bioplastics derived from biodegradable polymers (Jha & Kumar, 2019). Petroleum-based polymers like polyethylene, polypropylene, and polyethylene terephthalate have become ubiquitous in food packaging due to their low cost, processability, and light weight (Robertson, 2014). However, their inherent lack of sustainability contributes substantially to the growing problem of packaging waste and its detrimental environmental consequences (Chawla et al., 2021).Increasingly, consumers are expressing a preference for natural, high-quality, environmentally benign, and safer food packaging options that also maintain convenience.

This evolving consumer demand presents a considerable challenge for the food industry, requiring a transition towards sustainable packaging solutions that effectively mitigate environmental pollution. In response, both academic research and industrial innovation are increasingly focusing on the development of biodegradable, edible, and sustainable materials. These novel materials are not only intended to reduce environmental impact but also to potentially enhance food safety and quality (Trajkovska Petkoska et al., 2021). The broader adoption of such sustainable packaging is anticipated to contribute to a reduction in the overall carbon footprint associated with the food supply chain.Among these emerging approaches, edible packaging stands out as an innovative strategy for optimizing food quality and minimizing waste. A key advantage of edible packaging systems lies in their inherent integration with the food product itself, allowing consumers to consume the packaging along with the food, thereby eliminating the need for disposal and further reducing environmental burden.

Gelatin, a water-soluble protein characterized by its tastelessness, transparency with a subtle yellow hue, is derived from the hydrolytic breakdown of the fibrous protein collagen (Mohamed et al., 2020). Collagen sources for gelatin production include fish, porcine, and bovine tissues (Mihalca et al., 2021). Based on the pretreatment of collagen, gelatin is broadly classified into two types: Type A, obtained through acid hydrolysis, and Type B, resulting from alkali hydrolysis (Maurizzi et al., 2021; Ramos et al., 2016). Within the food industry, gelatin serves various functional roles, including gelling, stabilization, texturization, and emulsification in products such as bakery goods, beverages, confectionery, and dairy items. However, its application is limited in certain contexts due to its inherent limitations in mechanical and thermal stability (Ramos et al., 2016). While gelatin-based films exhibit low oxygen permeability and favorable mechanical properties, their significant susceptibility to moisture and high permeability to water vapor, attributed to gelatin's hygroscopic nature, present challenges for their wider use (Maurizzi et al., 2021).

2. Materials and methodologies:

2.1 Raw materials: Dried butterfly pea flowers, Food grade gelatine, food grade glycerin(plasticizer) and water.

2.2 Methodologies:

2.2.1 Formation of butterfly pea flower solution:

2g of dried flower of butterfly pea is boiled in 80ml of distilled water at 100℃ till the volume of water reaches 60ml. This solution is now stored in -8℃ for further use. This storage usually solidifies the solution, heating at 100℃ liquifies the solution.

2.2.2 Formulation of control film:

Food grade gelatin is measured for 12g in room temperature and added to 60ml distilled water. This is let to sit undisturbed and heated at 80℃ in hot plate for 15minutes till the gelatin crystals liquefied and addition of plasticizer which is food grade glycerin is made to enhance the flexible property of the film. This film solution is now poured into the mold which is coated with a layer of food grade glycerin for ease peeling. The gelatin solution is poured without any patches or bubbles uniformly. Incubators used to dry the film made, at temperature 60℃ for 8 hours. After 8 hours the film is peeled and placed in desiccator to prevent any absorption of moisture till the end of the experiment. (FAH Prakoso et al, 2023).

2.2.3 Formulation of Blue Butterfly pea flower extract film:

The BBF extract solution (60ml) is now added with 12g of gelatin. A 1:5 ratio of film solution is made. 5ml of glycerin as plasticizer is added to the solution and now poured as same as the control film in same way. This proportion of the solution was determined from the past experiments on this film and this proportion showed positive preference.

2.2.4 Process used for BBF film

There are two processes for making edible films: wet and dry process.

Process which is used here is wet process

In the wet process, the film-forming components are mixed with water as solvent, followed by drying to obtain a food film. This process is mainly represented by the casting method. The casting process is the common method of producing edible films and coatings on laboratory. This process involves three steps. Dissolving or dispersing the raw materials in water, is typically, the first method used to prepare films. Additives glycerol (plasticizers) are incorporated into the matrix material to boost these materials' flexibility and durability (Trajkovska Petkoska. A. ,et al 2021). Adjusting the pH or heating the solutions could be required to increase the solubility. The film-forming solution is then cast and dried at the proper temperature and relative humidity, which is the second and third step toward producing free-standing films (Cazón. P., et al 2017). In the casting step, the film-forming solution is poured into a predefined mold. The mold we preferred is a polypropylene plastic petri dish coated with food grade glycerin. The drying process allows the evaporation of water (solvent) that makes a polymer film that adheres to the mold. Tray dryer and incubator is used for the casting of films for easy removal of solvents and peeling of the film (Suhag. R., et al 2020).

2.2.5 Flim analysis

2.2.5.1 Water solubility

The film samples were placed in glass petri dishes and left to dry in a vacuum oven at 80 °C for 2hours. The dried films were then kept in 50 mL of distilled water at 25 °C with continuous stirring for 15 minutes. The insoluble content was separated using filter paper and the filtrate is dried in a vacuum oven at 80 °C for 2h before weighting (final weight). Finally, the percent solubility of the films in water was determined by dividing their soluble quantities by the initial dry weights. (Ayse Gul Asikkutlu et al, 2025) The formula used is

$$\text{Percent Solubility} = \frac{Weight\ of\ soluble\ components}{Initial\ dry\ weight\ of\ film} \times 100$$

2.2.5.2 pH sensitivity

To examine the color response of the films containing butterfly blue pea flower extract at different pHs, approximately 2 cm × 2 cm films were cut and soaked in buffer solutions at different pHs. Images of the films were taken with a camera after 10 min. (Ayse Gul Asikkutlu et al, 2025).

2.2.5.3 Thickness

Thickness is measured by placing the film between the clamp of screw gauge and the reading noted including the zero error and the pitch scale reading. The formula used for calculation is

Total Reading = Pitch Scale Reading + (Circular Scale Reading x Least Count)

3.2.2 Water solubility

The water solubility of the film is calculated using the below given formula

Percent Solubility = $\frac{Weight\ of\ soluble\ components}{Initial\ dry\ weight\ of\ film}$ × 100

3. Results and discussions

3.1 Product development

The optimum edible film were chosen using the analysis made on the film such as wtaaer solubility, pHsensitivity, thickness and peeliability of the film. Initially film made with separate butterfly pea flower solution made with 2g of flower and 20ml of distilled water added with 12g odf gelatin and 60ml distilled water. Since the above formulated solution was so diluted the thickness and peelability of the film is not suitable thus this formulation was overcome by new formulation.

The new formulation includes the 2g of dried butterfly pea flower added with 80ml of distilled water which is boiled upto 60ml of solution. Now 12g of food grade gelatine with 5ml of food grade glycerin. This formulation gave optized results in the analysis along with peeling property.

3.2 Physical properties

3.2.1 Thickness

Thickness of the film was tested using screw gauge. The observation are

Least count = 0.01

Zero error = -13

Pitch scale reading = 0mm

Circular scale reading = 36

Now using the formula, Thickness = (Pitch Scale Reading + Circular Scale Reading x Least Count) - Zero Error

Thickness = (0 + (36 x 0.01)) – (– 0.13)) = 0.49 mm

The thickness of the film is 0.49mm.

3.2.2 Water solubility

Percent Solubility = $\frac{Weight\ of\ soluble\ components}{Initial\ dry\ weight\ of\ film}$ × 100

Percent Solubility = $\frac{0.16g}{0.7g}$ × 100 = 22.8%

The water solubility of the film is 22.8% which indicates a stability against the humid environment and withstand a room temperature and more.

3.3 Chemical property

3.3.1 pH sensitivity

The color response of the film is done by analyzing the characteristic change in different pH levels. For different range of pH 3 buffer solutions are used namely buffer solution of 4.0, 7.0 and 9.2. for this the film is cropped into the size of 2x2cm and submerged in the buffer solution. They have shown significant changes in their color which proves the point that they can change their color in the case of pH changes hence this property can be manipulated as a spoilage indicator.

Conclusion

In conclusion, the escalating global population, shifting climate and dietary habits, and the urgent need for environmental stewardship are driving a significant demand for waste-free food production. Durable and sustainable packaging solutions, particularly edible packaging, have become crucial in mitigating food waste and reducing reliance on petroleum-based resources. This review has highlighted the significance, composition, functions, and production methods of edible packaging materials. Ensuring consumer acceptance necessitates careful consideration of appearance, organoleptic properties, and labeling. The expanding market for edible packaging underscores the need for continued research and development to advance sustainable and eco-friendly packaging practices, thereby enhancing both environmental protection and food safety. Furthermore, this research proposes a novel packaging material capable of indicating spoilage and imparting antioxidant properties to food products. Future work will focus on analyzing the interaction between food products and butterfly blue pea-based packaging to further explore its potential

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