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Starch-Based Film Incorporated with *Clitoria ternatea* Flower Extracts as pH Indicator

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Abstract. The present study demonstrated the evaluation of starch-based film formulated with *Clitoria ternatea* flower extracts as a pH indicator. Maceration, sonication, and infusion extraction were employed to determine the percentage yield of the flower extracts. Extract solutions (1 mg/mL) were subjected to UPLC-QTOF/MS to detect and identify the chemical constituents of *C. ternatea*. UV-Vis analysis was done by treating the extracts (4 mg/mL) with prepared buffer solution in various pH values (2.0–11.0), and the absorbance was observed within a broad range of wavelength (400–700 nm). Approximately 100 mL solution of 4 g starch, *C. ternatea* extracts, and glycerol (19 g plasticiser/100 g starch) in distilled water underwent gelatinisation to form the desired thin film. The functional group presented in the film and raw materials were detected and defined by analysis through FTIR spectroscopy. From the results, the maceration technique produced a higher yield of extracts with 41.48% compared to the sonication and infusion methods. Varied colours of *C. ternatea* solution were observed at different pH values. At pH lower than 3, the extract solution was light red to purple, while at a higher pH, i.e., towards increasing basic pH (4, 5, 6, 7, 8, and 9), the colour can be perceived as blue. The gelatinisation process produced a blue smooth thin layer of film. FTIR analysis showed that all samples contain a C-O bond (3300 cm^{-1}). Starch-based film formulated with *C. ternatea* as a pH indicator can be applied to detect the food spoilage in food wrapper and packaging production.

Introduction

Natural plants are well known for their medicinal benefits long before the prehistoric period. Bioactive components in plant extracts play an important role in treating illnesses like diabetes, cancer, mental health, and others. *Clitoria ternatea*, which is good for skin protection and can prevent cancer, is a plant with high antioxidant activity due to its phenolic components that scavenge free radicals [1]. Traditionally, the blue flowers of *C. ternatea* are used as food colourant to make the dishes more attractive. Meanwhile, in India and the Philippines, the flowers are consumed as a vegetable [2]. The extract of the blue flower is said to be high in anthocyanin. Anthocyanins are composed of phenolic components from the flavonoid functional group, synthesised through the phenylpropanoid pathway. Cyanidin, malvidin, delphinidin, pelargonidin, peonidin, and petunidin are the six common anthocyanins composed of hydroxyl groups at 3-, 5-, and 7- positions [3]. The most interesting fact regarding this water-soluble pigment is that it appeared in varied colours based on its surrounding. It may appear red in acidic conditions, whereas in basic condition, it will turn blue. A study was conducted to determine the stability of varied anthocyanin colours in *C. ternatea* flowers. The result showed that the most stable anthocyanin during storage belonged to the red flavylium cation, while 7 °C was chosen as the best condition for storing red, blue, and violet extracts [4].

In analytical chemistry, the pH indicator is very important, especially when performing an acid-base titration technique. It is defined as a compound that displayed visual colour changes in a solution of different pH values. The basic principle behind this phenomenon is the formation of hydronium ion, H_3O^+, or hydrogen cation, H^+ when it reacted with water. Litmus paper, which is synthesised from lichen mixture, is one of the commercial pH indicators that illustrated blue colour