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Characterisation and Colour Response of Smart Sago Starch-Based Packaging Films Incorporated with *Brassica oleracea* Anthocyanin

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Abstract: To meet the need for food products to be safe and fresh, smart food packaging that can monitor and give information about the quality of packaged food has been developed. In this study, pH-sensitive films with sago starch and various anthocyanin concentrations of *Brassica oleracea* also known as red cabbage anthocyanin (RCA) at 8, 10, 12, and 14% (*w*/*v*) were manufactured using the solvent casting process. Investigation of the physicochemical, mechanical, thermal, and morphological characteristics of the films was performed and analysed. The response of these materials against pH changes was evaluated with buffers of different pH. When the films were exposed to a series of pH buffers (pH 3, 5, 9, 11, and 13), the RCA-associated films displayed a spectacular colour response. In addition, the ability of the starch matrix to overcome the leaching and release of anthocyanins was investigated. Higher concentrations of RCA can maintain the colour difference of films after being immersed in a series of buffer solutions ranging from acidic to basic conditions. Other than that, incorporating RCA extracts into the starch formulation increased the thickness whereas the water content, swelling degree, tensile strength, and elongation at break decreased as compared to films without RCA. The immobilisation of anthocyanin into the film was confirmed by the FTIR measurements. The surface patterns of films were heterogeneous and irregular due to the presence of RCA extract aggregates, which increased as the extract concentration enhanced. However, this would not affect the properties of films. An increase in thermal stability was noted for the anthocyanin-containing films at the final stage of degradation in TGA analysis. It is concluded that RCA and sago starch formulation has great potential to be explored for food packaging purposes.

Keywords: smart food packaging; pH-responsive; colour indicator; *Brassica oleracea*; sago starch; biopolymer film

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1. Introduction

Food preservation is greatly aided by packaging, which protects food against conditions that cause chemical, physical, and microbiological deterioration while also ensuring food safety and quality [1]. Food packaging should also be appropriate to minimise negative environmental effects. The use of plastic packaging imposes a potential danger to human health which might arise from the uptake of food items that have come into touch with plastic or contain microplastic [2]. A deficit in petroleum resources also limits the growth of the plastics