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The Impact of Different Concentration of Starch on Starch-based Hydrogels Loaded with *Clitoria ternatea* Extract

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ABSTRACT

Anthocyanins are natural pigments that's available is plant such as *Clitoria ternatea* (Butterfly Pea Flower, BPF) and are widely used as colourants in food industry. Despite their attractive colour and health benefits, anthocyanins are relatively unstable and prone to degradation limiting their application. Starch-based hydrogel (SH) is gaining popularity as a sustainable and cost-effective medium for encapsulating and protecting sensitive compounds like anthocyanins. *Ipomea batatas* (white sweet potato) contains the highest starch content compared to purple and yellow varieties. Starch, a natural polymer that has unique properties that make it suitable for forming hydrogels. This study explores the use of SH derived from white sweet potato starch to encapsulate anthocyanins extracted from BPF. Four formulations of SH ranging from 0% to 6% starch concentration were prepared. This study aims to investigate the physical properties and encapsulation efficiency of these hydrogels. Results showed no significant difference in encapsulation efficiency between hydrogels with the highest starch concentration (96.07 ± 3.1^{A}) and without starch (98.52 ± 0.99^{A}). In conclusion, SH effectively enhances the recovery and stability of anthocyanins and holds promising potential for application in the food industry as natural, functional ingredients.

Keywords: Anthocyanin, *Clitoria ternatea,* encapsulation, *Ipomea batatas*, starch-based hydrogel

INTRODUCTION

Starch-based hydrogel (SH) are three-dimensional networks capable of absorbing water and are widely used in fields such as food and beverages (Cui et al., 2022). Anthocyanins, natural pigments found in flowers, are visually appealing but highly unstable during processing. To enhance their stability and functionality, natural carriers

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like starch have been explored (Schlindweinn et al., 2022). Chen et al. (2022) stated that SH may offer potential for encapsulating anthocyanins, improving their stability and nutritional value by providing a suitable matrix. This study aims to investigate the influence of varying starch concentrations on the physical properties of starch-based hydrogels loaded with *Clitoria ternatea* extract.

MATERIALS AND METHOD

Materials

Dried *Clitoria ternatea* was sourced from Superbee Enterprise, country while the fresh *Ipomea batatas* was obtained from WP Online Groceries, country

Isolation of Starch, Extraction of *Clitoria Ternatea* and Starch-based Hydrogel Production

Starch was isolated using a method by Hazrati et al. (2021) with slight modification. *Clitoria ternatea* was extracted using distilled water at 60°C for 2 h. Starch-based hydrogels were prepared by following a modified method from Apostolidis et al. (2021).

Water Holding Capacity (WHC), Anthocyanin Encapsulation Efficiency (AEE), Colour Profile and Texture Profile Analysis (TPA)

Water holding capacity (WHC) was measured using a modified method from Liu et al. (2018). Anthocyanin encapsulation efficiency (AEE) was evaluated following the method from Liew et al. (2020). The colour profile and t**exture profile analysis** (TPA) of the hydrogel were measured using a modified method from Huang et al. (2024).

Statistical Analysis

The data were analysed using One-way ANOVA (Minitab Version 20).

RESULTS AND DISCUSSION

Water Holding Capacity (WHC) and Anthocyanin Encapsulation Efficiency (AEE)

Table 1 shows the physical properties of starch-based hydrogel (SH). Water holding capacity (WHC) was significantly influenced by starch concentration. Although hydroxyl groups in starch enhance water retention (Yang et al., 2021), the denser gel networks formed at higher starch levels may reduce the availability of free water. There was no significant differences found in anthocyanin encapsulation efficiency among SH with 0%, 4%, and 6% of starch concentration, however, it significantly varied with different starch concentration. This supports the finding of Schlindweinn et al. (2022), who reported that starch-based encapsulation can improve the stability of *Clitoria ternatea* extract.

Table 1
The result of physical properties for starch-based hydrogel

Sample	0% starch	2% starch	4% starch	6% starch
WHC (%)	2.33±1.37^{B}	17.15±7.20^{A}	16.82±1.42^{A}	6.31±4.86^{AB}
AEE (%)	98.52±0.99^{A}	88.62±2.39^{B}	95.00±2.05^{A}	96.07±3.11^{A}
Hardness (g)	4483.10±180.50^{A}	2518.00±238.00^{BC}	2788.20±213.00^{B}	2416.40±149.10^{C}
Gumminess	3883.60±143.90^{A}	2141.90±185.90^{BC}	2345.70±192.20^{C}	2027.80±125.70^{C}
L*	15.56±0.08^{C}	25.56±1.91^{A}	20.23±0.05^{B}	23.80±0.12^{A}
a*	3.87±0.06^{A}	1.28±0.08^{D}	2.02±0.08^{C}	2.60±0.08^{B}
b*	0.86±0.02^{A}	-1.66±0.24^{B}	-6.30±0.08^{C}	-9.72±0.30^{D}

Note. Different superscript letters within row indicate significant difference (P<0.05) between treatments

Texture Profile Analysis and Colour Profile

The hardness of the SH was significantly affected by starch concentration (Table 1). Starch-based hydrogel (SH) with 0% starch had the highest hardness and gumminess. Starch-based hydrogel (SH) with 2% starch showed no significant differences compared to 4% starch. In colour profile, significant differences in b* value indicate variation in blue intensity, with the 0% SH appearing to be the darkest. Decrease in a* and b* values at higher starch concentration (4% and 6%) may indicated opacity in the SH.

CONCLUSION

This study showed that starch-based hydrogels have the potential to enhance the encapsulation and physical stability of anthocyanin extracts from *Clitoria ternatea*. Higher starch concentrations affected the hydrogels water holding capacity, texture, and colour properties. Although WHC decreased with increased starch, encapsulation efficiency remained high. Overall, SH is a promising natural carrier for anthocyanins, supporting its application in functional food systems.

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