

ABSTRACT

Roselle anthocyanins (*Hibiscus sabdariffa* L.) show strong potential as natural textile dyes. However, their low stability against heat, washing, and ultraviolet exposure limits practical application. This study aims to improve anthocyanin stability through encapsulation in calcium alginate–chitosan beads (Ca-Alg-Cts) and to evaluate the effect of different mordant variations on color intensity and fastness in cotton fabric (mori).

The research consisted of four main stages. First, extraction was carried out under three initial material conditions: fresh roselle, commercial dried roselle, and oven-dried roselle at 50°C. Extraction used an ultrasonic-assisted extraction system and the extracts were characterized using UV–Vis and FTIR analysis. Second, encapsulation was performed by forming Ca-Alg-Cts beads with three variations of adsorbate volume. Third, bead stability was evaluated through repeated temperature cycling and thermal stability tests. Fourth, textile application was conducted using a meta-mordanting method with five mordant variations: chitosan, gambier, alum, chitosan–gambier, and chitosan–alum. Color fastness was tested against washing, acidic perspiration, alkaline perspiration, and ultraviolet exposure.

The extraction results showed total anthocyanin content of 127.33 mg/L for fresh roselle, 427.24 mg/L for commercial dried roselle, and 911.40 mg/L for oven-dried roselle at 50°C. The highest encapsulation efficiency of 98.64% was achieved at 4 mL adsorbate volume. In temperature cycling tests, the encapsulated system retained up to 97.33% of anthocyanins, while the non-encapsulated system decreased to 67.66%. At 40°C thermal stability testing, the encapsulated system showed only 2.13% concentration loss, compared to 10.87% in the non-encapsulated system. In textile application, the chitosan–alum mordant combination in the encapsulated system demonstrated the best overall performance. It showed the highest color retention in washing tests at 43.08%, low ΔE values in washing (0.9), acidic perspiration (0.8), alkaline perspiration (1.8), and ultraviolet tests (2.18), and grey scale ratings of 4 to 5, indicating good to very good color fastness. These results confirm that Ca-Alg-Cts encapsulation combined with chitosan–alum mordant effectively enhances the stability and dyeing performance of roselle anthocyanins on cotton fabric.

Keywords: roselle anthocyanin, encapsulation, calcium alginate–chitosan, mordant, color stability, natural textile dye.