

Effect of Natural Dyeing Using *Flos Sophora Japonica L.* on the UV Protection of Cotton Fabric

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Introduction

Ultraviolet (UV) light is essential to human body since it kills bacteria on the surface and pores of skin and plays a critical role in synthesizing Vitamin D necessary for human bones (Lim et al., 2013). However, as the amount of UV rays reaching the earth increases due to the destruction of ozone layer, excess exposure to UV light may cause skin pigmentation, sunburn, ageing, and serious diseases such as skin cancer. In order to prevent or delay skin ageing, the fundamental remedy is to protect skin from UV rays. The amount of sunlight that is transmitted, absorbed, or reflected through the fiber and yarn when it contacts the fabric surface depends on the type of fiber, areal density, thickness, color, or the type of finishing of the fabric (Majumdar et al., 2015). UV protection finish on textiles can be obtained by mixing UV blocking agent or UV absorbent in the spinning solution to produce UV-cut fiber, or by coating the surface of fabric with similar agents during fabric manufacture (Kim et al., 1994). Quercetin ($C_{15}H_{10}O_7$) and its glycoside rutin ($C_{27}H_{30}O_{16}$) are phenolic compounds that have natural antioxidant property. Casagrande et al. (2006) reported that quercetin can protect skin from accelerated skin damage such as ageing and skin cancer. Maramaldi et al. (2016) confirmed that it can reduce redness, itching and inflammation of skin damaged from UV rays. Rutin, the glycoside of quercetin, is the main component (8-28%) of *Flos Sophora japonica L.* (Wang et al., 2009).

Purpose of research

The purpose of this research was to investigate the effect of UV protection function of cotton fabric dyed with *Flos Sophora japonica L.* The study also aimed to out whether the amount of rutin or quercetin fixed on the fiber through dyeing with *Flos Sophora japonica L.* has effect on the degree of UV protection of the dyed cotton fabric.

Experimental

Dried *Flos Sophora japonica L.* was washed well to remove foreign matters. The material was dried at room temperature for 3 days, and pulverized into powder. 2 g of *Flos Sophora japonica L.* powder and 200 ml of distilled water were placed in a beaker and extracted at 90°C for 1 hour using a Soxhlet's water bath. After filtration, the total amount of *Flos Sophora japonica L.* extract collected was 190 mL. Dyebaths of extraction:water ratio 1:4 and 1:2 were used for dyeing cotton at 70°C or 90°C for 30 minutes or 60 minutes. Dyeing was also carried out using quercetin standard using 5% o.w.f. or 10% o.w.f. concentrations. In all dyeing, alum premordanting was carried out using 5g/L of aluminum potassium sulfate and 100 mL water.

UV protection of dyed samples was measured using the Ultraviolet transmittance analyzer (UV-2000F, Labsphere) based on the American Society for Testing and Materials (ASTM) Test method 183. Four measurements were taken from each sample. High performance liquid

chromatography-diode array detector (HPLC-DAD, Ultimate-3000, Dionex, USA) was used to confirm rutin and quercetin fixed on the dyed cotton. The dye from cotton fabric was extracted with a mixed solution of HCl:Methanol:Distilled water (2:1:1, v/v/v). Quantitative analysis of the amount of rutin and quercetin in the extraction from the dyed cotton was carried out by using the standard calibration curve prepared from rutin and quercetin standards.

Results and Discussion

UPF (Ultraviolet protection factor) is a rating system which indicates the sun protection of fabric. By the ASTM standard D6603, a fabric blocks 93.3-95.8% UV radiation if its UPF rating is 15-24 and the fabric can be labeled as ‘Good UV Protection’ (Sun-Protection-Products-Guide.com, 2009-2010). Mean Lab values of cotton dyed with *Flos Sophora japonica* L. was L value 85.72, a value -0.99, b value 26.04. Mean Lab values of cotton dyed with quercetin was L value 74.46, a value 3.81, and b value 63.85. UPF ratings and the percent transmittance of UVA and UVB through the dyed cotton samples are shown in Table 1.

Table 1. Results of UPF measurements of the dyed cotton samples

| Dye | Conc | °C/Min | UPF | UVA(%) | UVB(%) | Dye | Conc. | °C/Min | UPF | UVA(%) | UVB(%) |
|------------------------------|----------|--------|-------|--------|--------|---------------|------------|--------|------|--------|--------|
| Undyed cotton | | | 6.30 | 22.45 | 12.68 | Undyed cotton | | | 6.30 | 22.45 | 12.68 |
| <i>Flos Sophora japonica</i> | Dye: DTW | 70/30 | 8.47 | 17.42 | 10.28 | Quercetin | 5% o.w.f. | 70/30 | 7.75 | 16.28 | 9.23 |
| | | 70/60 | 10.52 | 14.36 | 8.85 | | | 70/60 | 8.92 | 14.36 | 7.82 |
| | | 90/30 | 11.86 | 12.50 | 7.94 | | | 90/30 | 9.27 | 12.45 | 6.42 |
| | | 90/60 | 12.49 | 11.53 | 7.47 | | | 90/60 | 9.57 | 11.47 | 5.08 |
| | Dye: DTW | 70/30 | 13.65 | 10.63 | 6.98 | | 10% o.w.f. | 70/30 | 9.72 | 10.51 | 4.68 |
| | | 70/60 | 15.09 | 9.76 | 6.49 | | | 70/60 | 9.80 | 9.26 | 4.14 |
| | | 90/30 | 17.19 | 6.86 | 5.05 | | | 90/30 | 9.89 | 8.11 | 3.82 |
| | | 90/60 | 16.12 | 5.27 | 4.23 | | | 90/60 | 9.86 | 6.99 | 3.27 |

Following ASTM D6603, Cotton samples dyed using the dye bath containing *Flos Sophora japonica* L. extract and water 1:2 ratio at 70°C for 60 minutes or 90°C for 30~60 minutes, and all quercetin dyed cotton samples showed ‘Good UV Protection’ rating indicating that the samples block approximately 93.3~95.8% UV radiation from the sun. The UVA and UVB transmittance of these cotton samples were lower than 9.76% and 6.49% consecutively.

Conclusion

The results indicate that cotton dyed with *Flos Sophora japonica* L. does have UV protective function and that the protection increases as higher dye concentration is applied. UV protection of cotton dyed with *Flos Sophora japonica* L. is due to the presence of quercetin in *Flos Sophora japonica* L. extract and its fixation on cotton fabric.

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