

OBTAINING COLORED ANTIOXIDANT COTTON AND COTTON/LINEN FABRICS USING GREEN TEA AQUEOUS EXTRACT

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Abstract

Green tea aqueous extract was prepared and characterized regarding total flavonoids and total phenolic contents as well as antioxidant activity (assessed by ABTS method). The characterized aqueous extract was used for dyeing and functionalization of 100% cotton and cotton/linen (47%/53% and 70%/30%) fabrics. Fabric color strength (K/S) values and their antioxidant activities before and after washing were compared. The obtained results revealed that 100% cotton (GTI), 47%/53% cotton/linen (GTII), and 70%/30% cotton/linen (GTIII) fabrics have *K/S* values ranging between 8.33 and 10.85. After one washing cycle, these values decreased significantly. On the other hand, dyed fabrics showed excellent (100 %) ABTS radical scavenging ability which remained excellent (GTII) or decreased to medium (GTI and GTIII) levels after one washing cycle. Based on the obtained results, it can be concluded that 47%/53% cotton/linen fabric is the most suitable for functional clothing capable of trapping the free radical of oxygen species. The current paper represents a step towards a more sustainable textile industry that could undoubtedly contribute to overcoming the environmental problems caused by the textile industry.

Introduction

Nowadays, water pollution represents one of the main environmental issues worldwide, wherein textile industries are known as the main contributors to water pollution. Namely, to produce one tonne of colored textile materials more than 200 tonnes of water were required. After the conventional textile dyeing and functionalization, high quantities of wastewater consisting of residual dyes, hazardous chemicals, heavy metals, microfibers, and mordants are returned to nature [2]. To overcome this mentioned environmental problem and at the same time minimize the textile workers' exposure to harmful chemicals, non-toxic and biodegradable natural dyes and colorants from sustainable sources were used for simultaneous fiber dyeing and functionalization [2-5].

In light of that, in this paper, cellulose fabrics (100% cotton, 47%/53% cotton/linen, and 70%/30% cotton/linen) were simultaneously dyed and functionalized using green tea (*Camellia sinensis*) aqueous extract. The prepared aqueous extract of green tea is intensely colored, and it was reasonable to assume that it will be capable of dyeing textile materials. On the other hand, herbal teas are rich in polyphenolic compounds, mainly phenolic acids and flavonoids that are known for their antioxidant activities [6]. The stability of fabric color strength values and antioxidant activity was examined both before and after one washing cycle and based on the obtained results, the potential utilization of functionalized cellulose fabrics was proposed.

Experimental

Preparation of tea water extracts

The commercially available dried green tea (*Camellia sinensis*) bought from „Tea House“ (Belgrade, Serbia) was ground into a fine powder using a mill. Green tea extract was prepared by immersing 20 g of tea in 1 L of distilled water. The temperature of the mixture was raised to a boiling point and kept at this temperature for 5 min. Thereafter, the mixture was allowed to cool for 2 h, and the solid parts were separated by filtration, while the obtained extract was immediately characterized and used for fabric dyeing and functionalization of cellulose fabrics.

Characterization of the green tea aqueous extract

The total flavonoid and total phenolic contents (*TFC*, and *TPC*) within the tea extract were determined spectrophotometrically according to the methods described by Pavun et al. [7].

The extract antioxidant activity was evaluated using ABTS assay following the procedure given by Lađarević et al. [8].

All spectrophotometric measurements were performed on a Beckman DU-650 spectrophotometer.

Dyeing and functionalization experiments

One hundred grams of 100% cotton (sample I), 47%/53% cotton/linen (sample II) and 70%/30% cotton/linen (sample III) commercially produced fabrics in the plain wave were functionalized with 1 L of prepared extract for one day with constant shaking on a Memmert water bath WNE 14 at 25 °C. After that, the fabrics were rinsed with distilled water, dried at room temperature for 48 h, and characterized. Depending on the chemical composition of undyed fabrics, dyed and functionalized fabrics were denoted as: GTI, GTII, and GTIII.

Characterization of functionalized fabrics

Kubelka-Munk equation[9] was used to calculate the fabrics' color strength (*K/S*) values based on the reflectances recorded on the UV-Vis spectrophotometer (Shimadzu UV-Vis 2600).

The fabrics' antioxidant activity was determined according to the ABTS method described by Glaser et al. [10]. To confirm the differences between the fabrics' *K/S* values before and after washing, the dyed fabrics were washed according to ISO 105-C10 (2010), rinsed, dried at room, and marked as GT0I W, GTII W, and GTIII W.

Results and discussion

Before the utilization for fabric dyeing and functionalization, the prepared green tea aqueous extract was characterized regarding the total flavonoid (*TFC*) and total phenolic (*TPC*) contents, and antioxidant activity (using ABTS assay). *TFC* and *TPC* of the examined extract were found to be 689.7 and 5808 mg L⁻¹, respectively, while it showed 100% antioxidant activity.

Considering the green tea extract's abundance of polyphenolic compounds as well as its excellent antioxidant activity, the prepared extract was used for simultaneous dyeing and functionalization of 100% cotton, 47%/53% cotton/linen, and 70%/30% cotton/linen fabrics. The fabrics' appearances after dyeing and after dyeing and one washing cycle are presented in Figure 1, while the fabrics' *K/S* values are listed in Table I.



Figure 1. Appearance of the fabrics after dyeing (GTI, GTII, and GTIII) and after dyeing and one washing (GTI W, GTII W, and GTIII W)

Table I *K/S* values of studied fabrics before and after one washing

Before washing	<i>K/S</i>	After washing	<i>K/S</i>
GTI	9.07	GTI W	1.33
GTII	10.85	GTII W	1.15
GTIII	8.33	GTIII W	0.88

From the fabrics' *K/S* values, it is evident that prepared green tea aqueous extract can dye cellulose fabrics, both 100% cotton and cotton/linen blends. Fabrics' *K/S* values decreased in the following order: GTII > GTI > GTIII, Table I. The observed different color strength values are attributed to the fabrics' different chemical compositions and extracts' nature that dictate the possibility of diverse binding interactions between colored bioactive compounds' functional groups and fabric surface groups. After washing with standard detergent, *K/S* values of all fabrics significantly decreased and accounted for 1.33, 1.55, and 0.88 for 100% cotton, 47%/53% cotton/linen, and 70%/30% cotton/linen fabrics, respectively.

During the utilization of cellulose fabrics as functional clothing, their antioxidant activity plays an important role since high antioxidant activity leads to the reduced production of free radicals that increase oxidative stress, leading to DNA damage. Moreover, they may also contribute to the anti-inflammatory effect.

After dyeing with green tea aqueous extract, all studied fabrics showed maximum (100%) ABTS radical scavenging ability, Figure 2. Similarly, Ćuk et al. [11] and Islam et al. [12] concluded that cotton fabric functionalized with green tea aqueous extract having 90% antioxidant activity can be used for free radicals' elimination. It is very important to note that after one washing cycle, functionalized fabrics showed excellent (GTII) to medium (GTI and GTIII) ability for trapping the free radical of oxygen species; i.e., inhibition of ABTS radicals present in testing solutions, Figure 2.

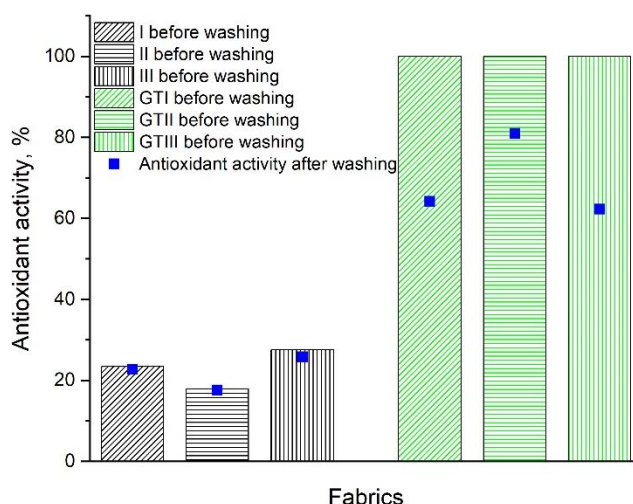


Figure 1. Antioxidant activity of fabrics before and after one washing

Conclusion

Treatment of cotton and cotton/linen fabrics with green tea aqueous extract seems to be very promising for fabric simultaneous dyeing and functionalization or only imparting antioxidant activity, i.e., the ability to trap the free radical of oxygen species, preventing cell deterioration and grow a new cell in the skin. Among all tested fabrics, 47%/53% cotton/linen fabric showed the most stable antioxidant activity after one washing cycle implying that it is the most suitable for functional clothing. The current paper represents a step towards a more sustainable textile industry that could undoubtedly contribute to overcoming the environmental problems caused by the textile industry.

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