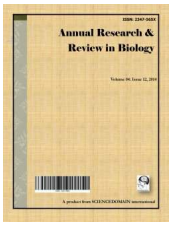

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Dissolving Ability of Commercialized White Tea on Chocolate-stained Fabric: A Potential Stain Remover

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Tea, being the second most consumed beverage in the world, produces huge amount of waste when the used tea bags are readily discarded. This study determined the change in the relative absorbance of commercialized white tea infusions applied to chocolate-stained polyester and cotton fabrics using spectrophotometry. Results showed significantly higher relative stain removal efficiency of unused white tea infusions on chocolate-stained polyester and cotton fabrics possibly due to the solubilizing property of abundant catechins found in tea.

Keywords: Stain removal; tea infusion; chocolate stain; catechins; spectrophotometry.

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1. INTRODUCTION

Fabric stains happen on a normal basis and usually occur around hazardous environments and filthy workplaces. These stains disfigure clothes and other materials and removing them is desirably imperative [1]. Damage created by spots and stains, and the improper removal thereof is one of the most common causes of discarding clothing [2]. To minimize unprecedented replacement of clothes, stain removal should be administered immediately.

Stain removal is the process of eliminating distinguishable discoloration left by a substance on a specific surface, which in the case of this study, specifically on fabric. Factors affecting decisions on which solvents to use in removing stains are the type of stain, the type of material it adheres to, the reactions these two create, and the multitude of steps of eliminating them [3]. These led to the fact that stain removal is highly specific and dependent on the type of substance and the process by which it should be removed. On the other hand, some of the most common fabric stains include lipstick, crayons, blood, mud, grease, chocolate, and tomato products which present the consumers with a wide array of procedures of removing these on various types of fabric [4]. In addition, stain removal is sequential and repetitive, because each application only removes a percentage of the stain, and to completely remove the stain, 5 to 7 reapplications of the substance may be needed due to the complex chemical bonds between the stain and the fabric [1]. Because of this, often consumers resort to dry cleaning using detergent or ironing directly without solely addressing the stain, but this process could sometimes lead to disastrous circumstances [4]. Cost-effectiveness and cleaning quality are the main concerns on laundry and are often oblivious to the public.

Since cost-effectiveness is a concern, most people would utilize alternative methods to address the stain problems. A formulation of chemicals as an alternative to remove stains is suggested, which include white vinegar, baking soda, oxygen bleach, hydrogen peroxide, lemon juice, and natural soap, accompanied by sun-drying after treatment [5]. Also, a mixture of 3% hydrogen peroxide, cream of tartar, and toothpaste is recommended to remove unknown stains [6]. Aside from these, there are numerous blogs and articles sharing different formulations of do-it-yourself stain removers from common household materials, recycled utilities included. One of which that has untested potential is the used tea bag. Second to water, tea is one of the most consumed beverages in the world. Manufactured in varieties from dried leaves of a shrub, *Camellia sinensis* L., belonging to the *Theaceae* family, native to south and southeastern Asia, different types of tea like black, white, green, and oolong differ in processing, growth factors, and geographical conditions [7]. According to the Tea Council, the British alone consume around 60 billion cups a year, approximately 96% of these were brewed from tea bags, which means 55 billion tea bags contribute to trash by the British alone. According to the British government's agency for waste disposal, Wrap, tea is the largest element of avoidable food waste in disposed waste products in United Kingdom. Wrap estimates that 370,000 tons of tea bags and leaves are disposed of by the British every year, when it could be easily reduced by compost pitting [8].

Considering that the total waste produced by tea bags is truly immense, however, it could be avoided [9]. This study could help reduce waste by recycling used white tea bags at home as it offered a new way of removing stains most specifically chocolate stains, which is one of the most common stains found on laundry clothes. As there has been no previous research conducted similar to this study, this will provide new novel knowledge and baseline information on the stain removal potential of white tea. With these facts at hand, the sophistication of stain removal, and the significance of tea and its contribution to waste are evident. Moreover, the stain removing potential of used tea bags has not been investigated yet. Hence, this present study determined the stain removal efficiency of unused and used white tea against chocolate on cotton and polyester fabrics. In particular, the study measured the relative stain removal efficiency of tea infusions from unused and used Twinings® white tea bags on melted Goya® milk chocolate stains by measuring the relative dissolution of chocolate stains using spectrophotometry, and compared the effectiveness of tea infusions from unused and used white tea bags, detergent formulation, and distilled water in removing chocolate stains on stained 100% cotton fabric and 100% polyester fabric.

2. MATERIALS AND METHODS

2.1 Preparation of Fabric Swatches

Fabric samples were procured from a local commercial outlet. All samples were pre-washed with tap water and Tide® detergent prior to application of staining materials. The large fabric was then cut into 3" x 3" fabric swatches. A total of 40 pieces 3" x 3" fabric swatches were prepared (20 pieces cotton and 20 pieces polyester). The fabrics were separately placed in a sterile plastic container according to type and randomly picked in groups of ten for each treatment as replicates. After assigning treatments, the ten pieces of fabric per group were stored in a Ziplock® plastic bag container until the experiment was performed.

2.2 Staining of Fabric Swatches

Two bars of Goya® chocolate were melted and using a sterile syringe, 1 mL of the melted chocolate was evenly applied at the center of the fabric swatch approximately 2" in diameter using a tongue depressor. In all treatment groups, each stain was replicated on ten fabric samples of each type. Stains were left for an hour to dry prior to soaking to simulate the minimal time required to obtain a difficult-to-remove stain [10].

2.3 Preparation of Treatments

Treatments were then applied after the samples were air-dried for about an hour. The four treatments used were: infusions of used and unused Twinings® white tea, distilled water, and detergent solutions. The detergent solution was prepared by dissolving two tablespoons of Tide® powder in 1 L distilled water, as prescribed by the manufacturer. For unused white tea infusion, one tea bag for every 200 mL of boiling water was left for 3 min. The tea bags were removed and the infusion was allowed to cool to room temperature for about an hour. For the used white tea infusion, the same teabags used in the previous preparation (of the infusions from unused tea bags) underwent the same process.

2.4 Application of Treatments

The stained fabric swatches were soaked in 50 mL of their pre-assigned treatment in a Ziplock® plastic bag container and labeled accordingly. The set-ups were left uninterrupted for 10 h. After the treatment, fabric swatches from each sample were removed from the treatment and transferred to another sterile Ziplock®. Treatment solutions with dissolved chocolate stain were secured in Ziplock® until filtration to remove large colloidal particles.

2.5 Filtration of Residual Solutions

Applied treatment solutions, or residual solutions, were filtered using a filter paper and a funnel. Since chocolate contained significantly higher levels of theobromine as compared with other sources of methylxanthines including tea [8] and these methylxanthines have a maximum absorbance at wavelength 272 nm [11], the resulting solution from each sample was transferred into separate 10-mL vials in preparation for absorbance measurement using a spectrophotometer (Jenway UV-VIS) at 272 nm.

2.6 Measurement of Relative Absorbance

Distilled water was used as a blank solution in calibrating the spectrophotometer before measuring the absorbance of the samples. From each vial, 10 µL of solution was transferred using a micropipette into a 1-mL quartz cuvette. Absorbance and percent transmittance were recorded per sample of each treatment. Absorbance of unapplied treatment solutions was measured first. After measuring the absorbance of all samples, the absorbance of the unapplied treatment solutions was subtracted from the absorbance of the residual solutions from each of their respective treatment groups to measure the relative absorbance of the samples.

2.7 Data and Statistical Analysis

Relative absorbance values were reported as means ± standard deviations. Two-way analysis of variance was employed to compare the relative absorbance of the samples. Bonferroni test identified which pairs of treatment groups were statistically different. All analyses were performed using STATA® V12.0 at 5% level of significance.

3. RESULTS AND DISCUSSION

Among the treatment groups, the residual solutions of samples treated with unused tea infusion showed the highest average relative absorbance of 0.883 followed by the detergent-treated samples with an average relative absorbance of 0.251 (Table 1). The used tea

Table 1. Comparison on the relative absorbance values across different treatment groups and fabric types

Fabric	Treatment, (mean ± standard deviation)			
	Water	Unused teabag	Used teabag	Detergent
Polyester	0.196±0.371[a]	1.215±0.073[b]	0.188±0.171[a]	0.167±0.071[a]
Cotton	0.074±0.082[a]	0.551±0.137[bc]	0.266±0.156[a]	0.335±0.175[ac]
Combined	0.135±0.261[a]	0.883±0.365[b]	0.227±0.160[a]	0.251±0.154[a]

Means with the same superscript letters in a specific row do not differ at 5% level of significance using Bonferroni test

infusion had an average relative absorbance of 0.227 which did not differ with detergent-treated group (P > 0.05), while the residual solution of the negative control (water) showed the least relative absorbance of 0.135 (Table 1).

Visual inspection of the residual solutions showed that unused tea infusion samples (Treatment 2, Fig. 1b, 1f) were lighter in color when compared to the detergent-treated samples (Treatment 4, Fig. 1d, 1h). Moreover, the reference solution (rightmost vial labeled as T4 in Fig. 1h) and the residual solution of the detergent group were markedly different. Treatment 2 (rightmost vial labeled as T2 in Fig. 1f) showed more dissolved chocolate stain particles. The relative absorbances across the different treatment groups (P < 0.001) and between the fabric type (P = 0.02) were significantly different. The polyester group exhibited a higher average relative absorbance when compared to the cotton group in the unused tea infusion treatment (Table 1). Moreover, interaction between the treatment group and fabric type was also found to be significant (P < 0.001). Paired comparisons between the treatment groups using Bonferroni test revealed that unused tea infusion (Treatment 2) was significantly different from the other treatment groups (Table 1) suggesting its high potential for chocolate stain removal. This phenomenon is possibly due to the solubilizing property of catechins, which is abundant in tea [12]. Tea generally contains an array of naturally occurring enzymes and a class of polyphenols called catechins [13], which include (−)-epigallocatechin-3-o-gallate (EGCg) [14]. The significant difference in the relative absorbance between unused and used tea infusions may be due to lesser tea compounds available in the latter.

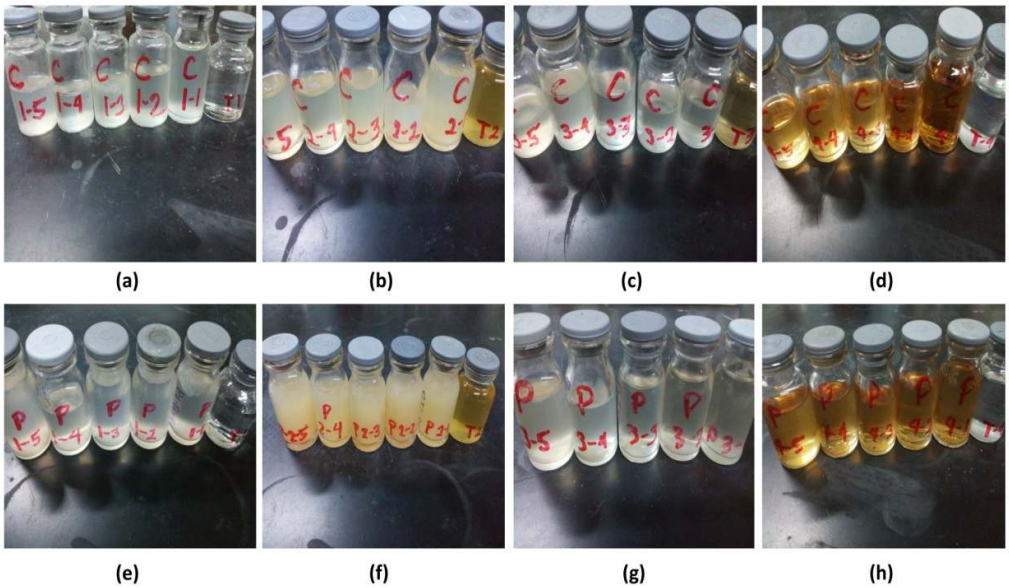

Fig. 1. Appearance of the residual solutions of cotton fabric swatches (1st row, a-d) and polyester fabric swatches (2nd row, e-h) treated with distilled water (a, e), unused tea infusion (b, f), used tea infusion (c, g), and detergent (d, h)

Stains are discolored fabric marks concentrated in an area due to foreign material coming in contact and being trapped in or molecularly bonding in the fibers with the fabric [15]. Stains on this fabric may vary in amount and structure depending on the fiber's maturity and purity [7]. Cotton has been widely used in fabric manufacturing, and the fibers from cotton consist of methyl cellulose, which is structurally similar to cellulose, widely available, and soluble in cold water [16]. Moreover, polyester fabric has similar binding with stain forming compounds compared to cotton fabric [16]. The binding of catechins to cotton fabric, the oxidation of catechins, which results to tea pigments, is confirmed to be suppressed by the catechin-cotton complex formed as the hydrogen bonding between methyl cellulose in cotton is formed and this, in turn, causes the inhibition of catechin oxidation [16].

Stained cotton fabric did not exhibit any significant difference in relative absorbance when treated by unused tea infusions and laundry detergent (Table 1). Laundry detergents operate in a common mechanism, while formulations may vary depending on the company producing the detergents [4]. Commercial laundry detergents are formulated with two major ingredients, surfactant and builder. Surfactants are the active stain-removing agents while builders promote the stain removal efficiency of the surfactant. Builders, such as phosphates and carbonates, react with calcium and magnesium ions in the water which prevent the latter from interfering with the surfactant [4]. In addition, comparative studies about membrane-active molecules such as turmeric extract curcumin and detergent led to a conclusion that EGCg slowly dissolves lipid bilayers, exhibiting a mild detergent-like effect, with its binding effect one order of magnitude smaller than curcumin and its solubilization effect varying with that of detergents [12].

4. CONCLUSION

The relative stain removal efficiency of tea infusions is significantly better in unused Twinings® white tea bags compared to other stain removal methods presented in this study. Tea is full of organic compounds including catechins that have solubilizing properties. However, the chemical analysis of other specific tea compounds that may have contributed to the dissolution of the chocolate stain has not been included in this study but similar studies in the near future might open new ideas and provide alternative stain-removing agents.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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