

Panel Name
Pounded Plants on Cotton: Colorfastness of Post-Treatments

Haar, Sherry: haar@ksu.edu
Doty, Kelsie: knd36@cornell.edu

Kansas State University, Manhattan, Kansas, 66506, USA

Sweet potato leaf, cosmos, hammering, steam, fixing agents

Abstract

English: Plant pounding is the transfer of plant pigment onto textiles through the mechanical force of hammering. The resulting image can mimic the original petal or leaf. A challenge can be poor colorfastness. Even though this is a popular technique with several writings on the process, we could find no research examining colorfastness properties. Thus, we examined orange cosmos petals and purple sweet potato leaf pounded onto cotton print cloth for colorfastness to laundering and light exposure following AATCC procedures. Fabric was scoured and mordanted with aluminum acetate. Following pounding, three post-treatments were applied, including steam, a sodium silicate fixative, and a cationic dye fixative. CIELab color coordinates were taken with a spectrophotometer. Cosmos exposed to laundering and light had considerable color change with steam having the most similar color ratings and appearance to its standard. Purple sweet potato leaves had noticeable color change following laundering, with steam retaining original color and imagery best. Conversely, colorfastness to light was poor for all treatments. Overall, a steam treatment is recommended to assist with color and image retention for pounded plants onto cotton fabric that is scoured and mordanted with aluminum acetate.

Spanish: La planta está golpeando la transferencia de pigmento vegetal en los textiles a través de la fuerza mecánica de martilleo. La imagen resultante puede imitar el original u hoja del pétalo. Un desafío puede ser pobre de solidez de color. Aunque esta es una técnica muy popular con varios escritos sobre el proceso, podríamos encontrar ninguna investigación examina las propiedades de solidez de color. Por lo tanto, examinamos los pétalos y cosmos Morado Naranja hoja de patata dulce golpean en algodón de tela para impresión de solidez de color para el blanqueo y la exposición a la luz siguiente AATCC procedimientos. Tejidos rayados y mordanted con acetato de aluminio. Tras golpear, tres post-tratamiento fueron aplicadas, que incluye sala de vapor, un silicato de sodio, fijador y un colorante catiónico fijador. Las coordenadas de color CIELab fueron tomadas con un espectrofotómetro. Cosmos expuesta a la luz y lavado tenían un considerable cambio de color con el vapor tiene la mayoría de las clasificaciones y de color similar apariencia a su estándar. Púrpura hojas de patata dulce tenía color notable cambio a raíz de blanqueo, con retención de vapor color original y mejores imágenes. Por el contrario, la durabilidad de los colores a la luz era pobre para todos los tratamientos. En general, se recomienda el tratamiento de vapor para ayudar con el color y la retención de la imagen para que golpean las plantas en tejido de algodón que se recorrieron y mordanted con acetato de aluminio.

1. Introduction

Hammering or pounding plant pigments onto fabric can transfer color and vein patterns so detailed it appears the actual plant has been painted on the fabric. Plants known for their dye properties often respond well to pounding; however, plants that lose their color in a dye bath, such as most green foliage, red to violet petals, and some yellow petals, often retain their naturally occurring pigments when pounded onto cloth. This process of transferring plant color to fiber through direct and forceful contact has been called flower pounding (Frischkorn & Sandrin, 2000; Martín, 2001; and Rudkin, 2011), leaf hammering (Aycock, 1996), Cherokee leaf pounding (Stephens, 2014), and hapa-zome (Flint, 2008). The basic procedure is to encase fresh plant parts between dry fabric and hammer until the print emerges. A challenge of this method is poor colorfastness which has been addressed by use of pre-mordants, chemical post-treatments, and heat-setting. However, we could find no research that compared treatments or measured color change from treatments. Thus, we examined pre- and post-treatments for colorfastness to

laundering and light on cotton print cloth. The plants tested were petals of orange cosmos (*Cosmos sulfureus*) and the purple leaves of Ace of Spades ornamental sweet potato (*Ipomoea batatas* L.). Pre-treatment was aluminum acetate mordant, and post-treatments were steam, Afterfix (sodium silicate), and Retayne an industrial dye fixative.

1.1 Plants

The instantaneous appearance of color and pattern from hammering encourages exploration of flowers, leaves, stems, and grasses. However, there are characteristics that make the process more successful. Select dark, saturated, and thin, yet stable petals. For example, hollyhock and tulips are considered thick and may leave uneven and splattered impressions, while petals and leaves of coreopsis, cosmos, and impatiens work well for clearly defined imprints. Avoid plant parts that are waxy, glossy, and brittle, as well as thick and full of liquid (such as some coleus varieties). While most plants are best freshly picked, those that are wet or thick with liquid can be placed between towels to wick moisture.

Conversely, a dry leaf may be rejuvenated by placing between wet towels.

Cosmos (*Cosmos sulfureus*) is an annual with yellow, orange, and red flowers, green foliage and seed that readily propagates. Cosmos originates from Mexico and northern South America where it was a source of yellow and orange dye among pre-Columbian civilizations (Jansen, 2005). The orange flowers contain flavonoid pigments of the chalcone and aurone groups which are responsible for the bright orange color (Cardon, 2007; Jansen, 2005). Research examining orange cosmos dyed cotton with sonicator and microwave reported noticeable to slight color change from exposure to laundering and light (Vankar, 2016; Vankar, Tiwari, & Ghorpade, 2001).

The ornamental sweet potato (*Ipomoea batatas* L.) leaf evaluated was Ace of Spades, which is red-violet and heart-shaped. Even though the potato is inedible, ornamental sweet potato plants are desirable in the landscape and ornamental industries as their foliage comes in a wide variety of colors and shapes. The purple color of the leaf suggests high contents of anthocyanins with the major composition cyanidin (Islam, Yoshimoto, Terahara, & Yamakawa, 2002). Chlorophyll and carotenoids are also present in the leaves even though the green pigment is not always reflected (Huang et al., 2015). Anthocyanins readily form complexes with several metallic mordants, including aluminum, however they are pH sensitive (Cardon, 2007; Dayal, 2015). Carotenoids are susceptible to oxidative degradation and can be destroyed by light and heat (Cardon, 2007).



Figure 1. Orange cosmos (*Cosmos sulfureus*) and Ace of Spades sweet potato (*Ipomoea batatas* L.) foliage. Note the bright red-violet underside of the leaf in the upper right corner. Photos by Sherry Haar.

1.2 Fabric, Hammer, Base & Pounding

A variety of fabric structures and natural fibers have been the recipient of plant pounding, with cotton plain weaves used most frequently. The fabric structure should be stable enough to handle the pounding force, smooth enough to produce an image, and porous enough to hold the plant pigment. Heavy-weight watercolor, mulberry, and hand-made papers can also be plant pounded (Martin, 2011). We often use watercolor paper when conducting workshops with youth.

The key to hammer selection is a smooth face surface that won't leave a rim or circle imprint. The authors most often use a soft-face hammer that has a rubber and a plastic face

that are slightly domed with rounded edges. For large areas, we start with a wider face and transition to smaller face hammers for finishing. Other hammer types are ball-peen (machinist or metal-working hammer) which has a rounded face, and light-weight pin hammers typically used for knocking in small nails, pins, and tacks.

The base surface to hammer on should be flat and durable. Often recommended is a wood chopping board placed on a table or an individual's lap (Martin, 2011; Rudkin, 2011; Stephens, 2014). We use thick paperboard from the base of used paper pads and notebooks that is about 1.6 mm thick. We work on stable surfaces that have poured cement such as porches, sidewalks, and ledges, or other stable surfaces in the environment such as cut tree trunks and benches. The layers surrounding the plant and fabric, can be fabric, paper, paper towels, waxed paper, or plastic wrap, bag, or sheeting (Bethamann, 2001; Martin, 2011; Flint, 2008). When using watercolor paper and/or fabric as surrounding materials, there are three useable printed surfaces after pounding; however, the outer layers will be less saturated (Haar, 2011). When conducting research, we use unprinted newsprint paper as surrounding material to minimize variance in absorption by surfaces.

When pounding petals, place the face of the petal against the fabric but for leaves place the vein side to the fabric. While it is recommended to secure arrangements to the fabric with removable or masking tape (Aycock, 1996; Frischkorn & Sandrin, 2000; Rudkin, 2011; Stephens, 2014), we simply place them on the fabric, cover, and pound where protected from the wind. Begin by hammering gently and gradually increase force and rate so the plant pigment is absorbed into the fiber without bursting through the plant edge. Sounds easy, but does take experience to get a clean imprint. Flip to the reverse side and hammer to fill-in any missed areas. Roll off the limp petal or leaf as it becomes difficult to remove once dried. Allow to cure for at least a week prior to any wet-treatments (Flint, 2008; Kadolph & Casselman, 2005).

1.3 Treatments

A range of treatments to assist with colorfastness were noted in the literature. Pre-treatments included mordanting with "alum" or alum acetate and assists of cream of tartar and washing soda (Aycock, 1996; Flint, 2008; Frischkorn & Sandrin, 2000; Kadolph & Casselman, 2005; Martin, 2011; Rudkin, 2011). Recommendations following pounding were heat-setting with a dry iron, steam iron, or heat press, and curing for at least one week (Aycock, 1996; Flint, 2008; Frischkorn & Sandrin, 2000; Kadolph & Casselman, 2005). Chemical post-treatments were soaking in a washing soda solution for pounded flower petals or painting Profix (sodium silicate) over leaf prints (Aycock, 1996), as well as aqueous solutions with vinegar, salt, or wood ash (Bethamann, 2001; Stephens, 2014). Final washing included laundering with a pH neutral soap or drycleaning. A few authors whose outcomes are not intended to be worn, stressed avoiding any type of water or steam by using only a dry iron, oven, or clothes dryer to heat set, and never washing (Frischkorn & Sandrin,

2000; Martin, 2001; Rudkin, 2011). However, any plant matter embedded in the fibers will continue to degrade with temperature and moisture fluctuation resulting in a compost type odor. Thus we recommend final washing with a pH neutral soap.

We evaluated aluminum acetate mordanted cotton print cloth alone and with treatments applied following pounding. The treatments were steam, Afterfix, and Retayne. Aluminum acetate has been used as a mordanting agent in dyeing and printing of cotton since the 18th century and more recent work has brought attention to this mordant for cellulose fibers (Liles, 1990; Slow Fibers Studios, 2011). Aluminum ions' strong affinity for cellulose fibers provide a bond between dye molecules and/or between the fiber and dye improving colorfastness properties (Haar, Schrader, & Gatewood, 2013).

Steam is used in the textile industry to fix dye at atmospheric pressure, to improve fastness, and fixation of dyes applied to cellulose and blends (Vigo, 1994). The high temperature, pressure, and water vapor of steam assists bonding of dye molecule to fiber. Rekebya, Salem, & Nassar (2009) found steam had higher K/S values than heat pressing naturally dyed alkanet and rhubarb prints on cotton.

Afterfix is thick liquid alkali solution of sodium silicate (37.5%) and water that is painted over a dyed area. It is used to fix fiber reactive dyes where by the alkali environment aids the bonding of cellulose and dye (Burch, 2011b). We examined Afterfix since raising the pH, such as with sodium carbonate (soda ash), is typical when scouring and dyeing cotton with plant dyes.

Aycock (1996) used Profix, another brand of sodium silicate to set flower petals. Afterfix is not removable once dry, thus the textile needs to be kept moist in plastic and the workspace and dyer protected.

Retayne is a fixing agent used as an after treatment for reactive and direct dyes on cotton fabrics to prevent color bleeding during washing and to improve fastness to washing, seawater, perspiration, and crocking, as well as prevent dye migration during dyeing (Burch, 2011a). Conversely, such fixatives have been found to reduce colorfastness to light (Burch, 2011a; Trotman, 1975). Retayne is a cationic surface-active compound that has a positive charge allowing it to bond with negatively charged dyes producing a more complex

molecule which improves wet-fastness (Burch, 2011a; Trotman, 1975). As most plant dyes are negatively charged using a cationic fixing agent may enhance colorfastness to laundering. The chemicals in Retayne are proprietary however similar products contain 2% methanol and 0.5% formaldehyde in water (Safety Data Sheet, 2015).

2. Methodology

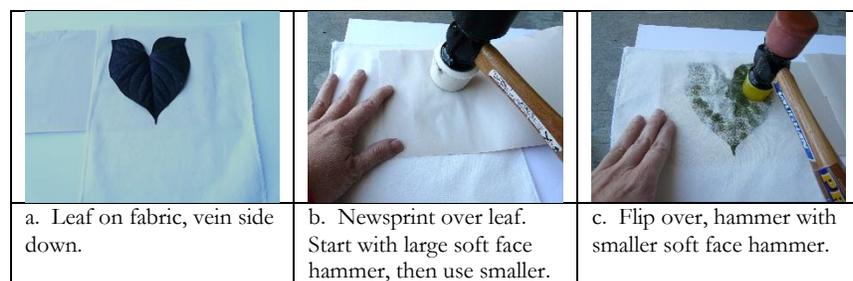
2.1 Materials

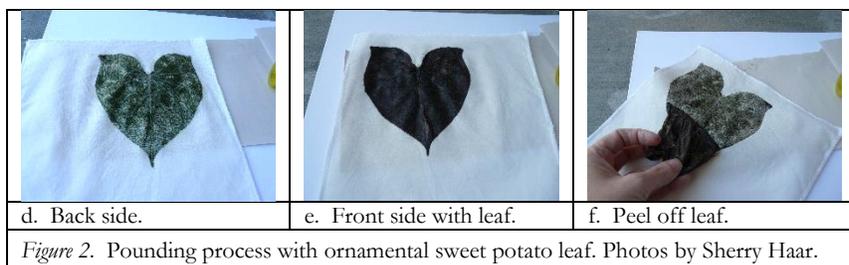
The fabric used in the study was 100% cotton print cloth (107 g/m²), style no. 400 that is bleached, desized, and mercerized from Testfabrics Inc., PA, USA. Orange cosmos (*Cosmos sulphureus*) petals were from Yellow Cosmos - Klondyke Mix (Wildseed Farms, Fredericksburg, TX, USA). The ornamental sweet potato (*Ipomoea batatas*) leaves were Ace of Spades variety that has red-violet, heart-shaped foliage. Both plants were grown in the author's dye garden in Manhattan, KS, USA. All aqueous solutions used reverse osmosis (RO) water. Liquid Scour was obtained from Earth Hues, WA, USA, aluminum acetate from Hillcreek Fiber Studio, MO, USA, and the following from Dharma Trading Co., CA, USA: sodium carbonate, Afterfix, Retayne, and Professional Textile Detergent.

2.2 Procedures

Fabric samples weighing 7.0 g were scoured in an aqueous solution of 5.5% owf Liquid Scour and 2% owf sodium carbonate for 60 min at 80 °C. Samples were pre-mordanted with aluminum acetate at 5% owf in RO water for 60 min at 38 °C. Scouring and mordanting had an 80:1 liquor-to-goods ratio and was conducted using an Atlas Launder-ometer to maintain temperature and agitation. Samples were prepared for three replications of each plant and treatment.

Cosmos petals were placed face down on a) scoured, and b) scoured and mordanted samples, encased in unprinted newsprint paper, and hammered with a soft face hammer. The fabric was then flipped over and hammering continued until saturation was complete. See Figure 2. The plant matter was removed, the pounded sample air dried, and pressed in a steam press. Ornamental sweet potato followed the same procedures except the leaf was placed vein side down onto the fabric. The pounding base was 1.6 mm thick paperboard placed on a cement foundation.





Steaming was conducted in a double walled vertical steamer (Rupert, Gibbon & Spider, Inc., CA, USA). Samples were basted to and covered with cotton print cloth and suspended in the vertical steamer. Once the water temperature reached 100 °C the samples were steamed for 60 min, cooled down for 20 min with lid removed, and upon removal were air dried. Afterfix (sodium silicate) was applied to pounded samples using a 3 in. wide, high density foam roller saturated with approximately 35 g of Afterfix. The sample was cured damp for 60 min by wrapping in plastic sheeting, then rinsed, and air dried. Retayne fixing agent was applied to pounded samples at 6.5% owf in an aqueous solution at 80:1 liquor-to-goods ratio using an Atlas launder-ometer heated to 60 °C for 30 min. The treated samples were rinsed and air dried.

2.3 Tests for Colorfastness

Pounded specimens were tested for colorfastness to laundering according to AATCC 61-2007, Colorfastness to Laundering: Accelerated, Test No. 1A using Professional Textile Detergent at .37% to 200ml RO water volume (AATCC, 2009). Specimens were agitated in an Atlas Launder-ometer for 45 min at 40 °C with resulting color change similar to that produced by five hand launderings. Colorfastness to light followed AATCC Test Method 16-2004 Colorfastness to Light, Option 3 (AATCC, 2009). Light testing was conducted by Atlas Weathering Company, Mt. Prospect, IL, USA using an Atlas Xenon Weather-Ometer, which determined fading after exposure to 20 AATCC fading units (AFU) or approximately 21.5 hours (AATCC, 2009).

3.4 Color Measurement

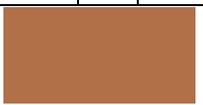
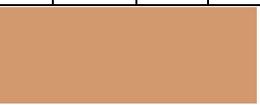
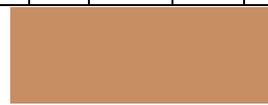
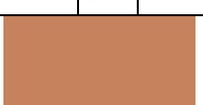
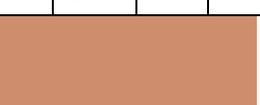
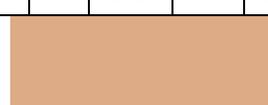
Prior to and following exposure to laundering and light, CIELab ratings were taken to determine color parameters of lightness (L^*), greenness-redness (a^*), and blueness-

yellowness (b^*). A RM200QC Imaging Spectrocolorimeter (X-Rite, MI, USA) was used to obtain CIELab ratings. Ratings indicate for L^* the higher the number the lighter the color, with black at 0 and white at 100. For coordinate a^* , red is $+a^*$ and green is $-a^*$; for coordinate b^* , yellow is indicated by $+b^*$ and blue is indicated by $-b^*$. Overall color change between the control and exposed specimens was calculated as $\Delta E = \sqrt{(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2}$. Gray scale for color change ratings followed AATCC Evaluation Procedure 1-2007 (AATCC, 2009).

3. Results

3.1 Cosmos Petals

Each treatment for cosmos influenced the control with the aluminum acetate mordant being the brightest. Aluminum is known to brighten flavonoids on cotton, while Afterfix and Retayne lost yellow hues ($+b^*$) prior to exposure. See Table 1 and Figure 3. After exposure to laundering the overall color change between the control and exposed specimen indicate Retayne had considerable change ($\Delta E=5.8$; gray scale=2), steam, Afterfix, and mordant much to considerable change ($\Delta E=15.8, 15.7, \text{ and } 26.1$ respectively), and scouring alone was off-shade ($\Delta E=34.7$; gray scale=0). However, when comparing the exposed specimens, steam is slightly darker overall. Cosmos specimens exposed to light and compared to its control indicate steam had considerable change ($\Delta E=8.1$), Afterfix, scour, Retayne, and mordant had much change ($\Delta E=11.7, 16.2, 16.5, \text{ and } 21.5$ respectively). When comparing color values amongst the exposed to light specimens, steam followed by mordant come closer to the unexposed values for light, yellow, and red. Retayne and scour alone had similar ratings for being lightest ($L^* = 73.6 \text{ and } 73.9$), supporting that cationic fixing agents can decrease colorfastness to light.

| Treatment | Control | | | Laundering Exposure | | | | | Light Exposure | | | | | |
|------------|--|------|------|--|------|------|-------------|-----|---|------|------|------|-------------|-----|
| | L* | a* | b* | L* | a* | b* | ΔE | Cc | S | L* | a* | b* | ΔE | Cc |
| Scour | 65.0 | 25.3 | 38.9 | 85.6 | 6.5 | 18.3 | 34.7 | 1 | 3-4 | 73.9 | 15.5 | 29.5 | 16.2 | 2 |
| |  | | |  | | | | |  | | | | | |
| Mordant* | 62 | 31.4 | 49.2 | 70.9 | 18 | 28.7 | 26.1 | 2 | 2 | 69.9 | 19.2 | 33.3 | 21.5 | 2-3 |
| |  | | |  | | | | |  | | | | | |
| Steam** | 64.3 | 23.6 | 45.5 | 63.9 | 21.9 | 29.8 | 15.8 | 3 | 2-3 | 68.1 | 19.3 | 39.8 | 8.1 | 3-4 |
| |  | | |  | | | | |  | | | | | |
| Afterfix** | 54.2 | 23.7 | 32.8 | 68.2 | 16.9 | 30.6 | 15.7 | 2 | 3-4 | 63.9 | 17.2 | 33.4 | 11.7 | 2-3 |
| |  | | |  | | | | |  | | | | | |
| Retayne** | 60.6 | 23.6 | 31.2 | 65.3 | 22.1 | 28.1 | 5.8 | 3-4 | 4 | 73.6 | 14.7 | 27.2 | 16.5 | 1-2 |
| |  | | |  | | | | |  | | | | | |

Note. * = also scoured; ** = scoured and mordanted. Gray Scale ratings for color change (Cc) and Staining (S) are 0=off shade, 1=much, 2=considerable, 3=noticeable, 4=slight, and 5=equal.

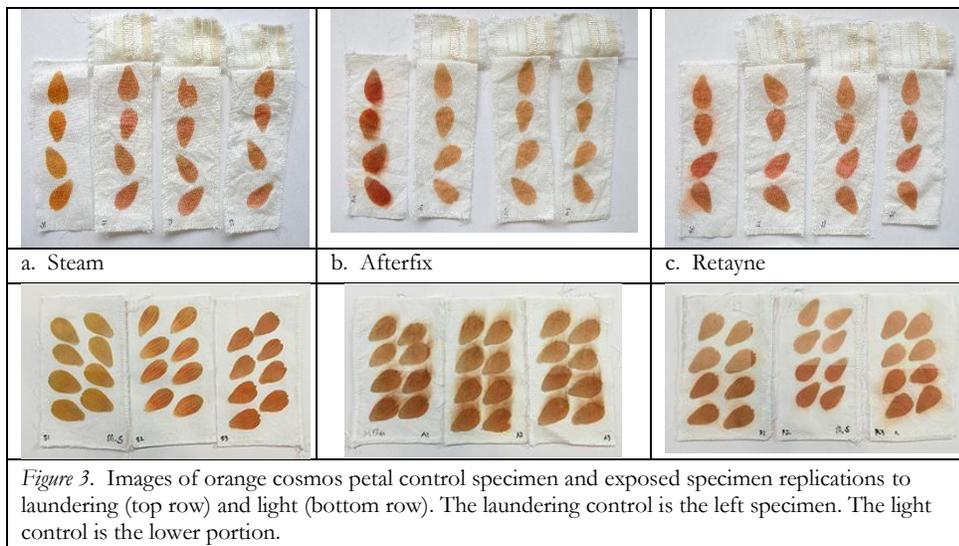


Figure 3. Images of orange cosmos petal control specimen and exposed specimen replications to laundering (top row) and light (bottom row). The laundering control is the left specimen. The light control is the lower portion.

3.2 Sweet Potato Leaf

Even though the ornamental Ace of Spades sweet potato leaf had a red-violet appearance very little of the wavelength was

transferred by pounding onto cotton. Rather, the green chlorophyll was transferred. When comparing each standard to the laundered specimen Afterfix had considerable change ($\Delta E=6.1$; gray scale=2), scour had considerable to noticeable

change ($\Delta E=5.8$; gray scale=2-3), Mordant and Retayne had noticeable change ($\Delta E=3.5$ and 3.1 respectively; gray

scale=3), and steam had noticeable to slight change ($\Delta E=2.0$; gray scale 3-4). Ratings for exposure to light were off-shade and much change between the standard and exposed specimen. These findings indicate that the anthocyanins are not lightfast while their colorfastness to laundering is good.

Table 2
CIELAB L, a*, b* Values of Sweet Potato Leaves Pounded Cotton Print Cloth Treatment and Exposure to Colorfastness to Laundering and Light, and Gray Scale Color Change (Cc) and Staining (S) ratings.*

| Treatment | Control | | | Laundering Exposure | | | | | | Light Exposure | | | | |
|------------|---------|------|------|---------------------|------|------|------------|-----|---|----------------|-----|------|-------------|-----|
| | L* | a* | b* | L* | a* | b* | ΔE | Cc | S | L* | a* | b* | ΔE | Cc |
| Scour | 64.3 | -2.4 | 17 | 68.4 | -0.6 | 13.3 | 5.8 | 3 | 5 | 82.8 | 4.2 | 19 | 19.6 | 1-2 |
| | | | | | | | | | | | | | | |
| Mordant* | 65.5 | -1.8 | 17.9 | 67.9 | 0.2 | 16.4 | 3.5 | 4 | 5 | 83.4 | 3.7 | 19.8 | 18.8 | 1-2 |
| | | | | | | | | | | | | | | |
| Steam** | 63.8 | -0.2 | 19.8 | 64.7 | -2 | 20.1 | 2.0 | 4-5 | 5 | 80.2 | 4.5 | 18.8 | 17.1 | 1-2 |
| | | | | | | | | | | | | | | |
| Afterfix** | 59.8 | -5.6 | 23.4 | 65.9 | -5.6 | 22.8 | 6.1 | 2-3 | 5 | 80.3 | 1.2 | 18.3 | 22.2 | 1 |
| | | | | | | | | | | | | | | |
| Retayne** | 61.0 | -7.0 | 20.8 | 64.2 | -6.6 | 21.2 | 3.2 | 3 | 5 | 85.2 | 1 | 12.4 | 26.8 | 1 |
| | | | | | | | | | | | | | | |

Note. * = also scoured; ** = scoured and mordanted. Gray Scale ratings for color change (Cc) and Staining (S) are 0=off shade, 1=much, 2=considerable, 3=noticeable, 4=slight, and 5=equal.

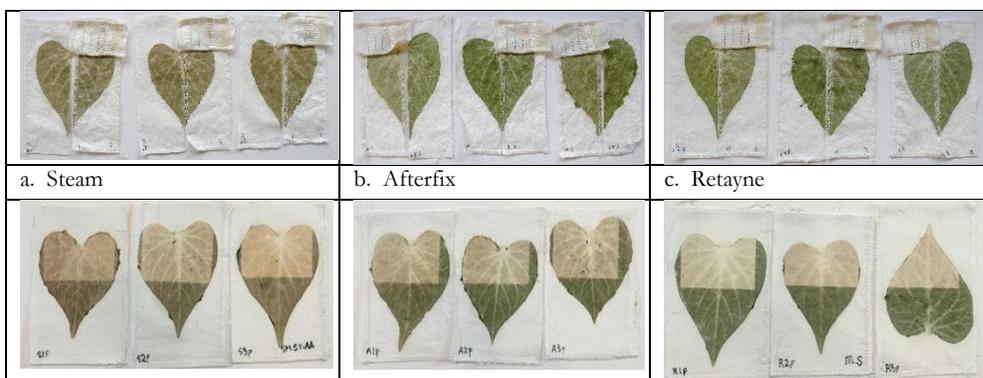


Figure 4. Images of sweet potato leaf control specimen and exposed specimen replications to laundering (top row) and light (bottom row). The laundering control is the specimen without the test strip square. The light control is the lower portion.

4. Conclusion

When pounding cosmos petals onto cotton print cloth there will be considerable color loss from laundering and exposure to light. The flavonoid plant pigment when pounded on cotton, did not have the good color ratings reported from sonicator and microwave dyeing (Vankar, Tiwari, & Ghorpade, 2001). As pounding is done on dry cotton fiber, the lack of moisture and swelled molecules may have contributed to reduced fastness. The weak dye to fiber bond between flavonoids and cotton may have also contributed to the colorfastness results, and the change in hue from a breakdown of the dye to metal complex during washing. Further, we did not examine how the physical pounding impacted the molecular structures. However, when compared to scouring alone, the mordant did improve the bond between fiber and dye. Overall, fixing scoured and aluminum acetate mordanted cotton with steam had color ratings most similar to the original pounded specimens and the highest colorfastness to light rating. The condensation of water vapor on the surface of pounded cosmos may aid the penetration of dye molecules into the cotton fiber (Rekebya, Salem, & Nassar, 2009).

Ornamental sweet potato leaves pounded on cotton print cloth had noticeable to slight color change after exposure to laundering with steam being the most similar overall to its control. Regardless of treatment, the leaves did not retain color following exposure to light. The poor lightfastness is most likely attributed to the inherent propensity of the carotenoid chromophore to photochemical oxidation (Cardon, 2007). Steam had slightly better ratings overall and retained a slight amount of the red pigmentation.

Overall, when pounding cosmos and ornamental sweet potato onto cotton, we recommend scouring, aluminum acetate mordanting, and post-treating with steam for a slight advantage when laundering and when exposed to light. However, ornamental purple sweet potato leaves should not be included on pounded textiles on display where there will be exposure to natural light. The post treatments of Afterfix and Retayne do not provide a color advantage but do introduce chemicals to the effluent. Future research could include a tannin pre-treatment as tannin can aid fastness of cotton fiber.

5. Acknowledgements

Contribution no. 17-111-A from the Kansas Agricultural Experiment Station.

6. References

- American Association of Textile Chemists and Colorists. (2009). 2009 technical manual of the American Association of Textile Chemists and Colorists (Vol. 84). Research Triangle Park, NC: Author.
- Aycock, I. (1996, Spring). Hammered leaves: A dye transfer technique. *American Quilter*, 34-37.
- Bethmann, L. D. (2001). *Nature printing: 30 projects for creating beautiful prints, wearables, and home furnishings*. North Adams, MA: Storey Publishing.
- Burch, P. (2011, November 18a). <http://www.pburch.net/dyeing/FAQ/fixative.shtml>
- Burch, P. (2011, November 18b). http://www.pburch.net/dyeing/FAQ/sodium_silicate.shtml
- Cardon, D. (2007). *Natural dyes: Sources, tradition, technology and science*. London, England: Archetype Publications.
- Dayal, R. (2015). *Natural dyes*. New Delhi, India: I.K. International Publishing House Pvt. Ltd.
- Flint, I. (2008). *Eco color: Botanical dyes for beautiful textiles*. London, England: Murdoch Books UK Limited.
- Frischkorn, A., & Sandrin, A. (2000). *Flower pounding: Quilt projects for all ages*. Lafayette, CA: C&T Publishing Inc.
- Haar, S. J. (2011). From-the-garden garments. *Fiberarts*, 34(4), 18-19.
- Haar, S., Schrader, E., & Gatewood, B. M. (2013). Comparison of aluminum mordants on the colorfastness of natural dyes on cotton. *Clothing and Textiles Research Journal*, 31(2), 97-108.
- Islam, M. S., Yohimoto, M., Terahara, N., & Yamakawa, O. (2002). Anthocyanin composition in sweetpotato (*Ipomoea batatas* L.) leaves. *Bioscience, Biotechnology, and Biochemistry*, 66(11), 2483-2486.
- Huang, W.-D., Lin, K.-H., Hsu, M.-H., Huang, M.-Y., Yang, Z.-W., Chao, P.-Y., & Yan, C.-M. (2014). Eliminating interference by anthocyanin in chlorophyll estimation of sweet potato (*Ipomoea batatas* L.) leaves. *Botanical Studies*, 55(11).
- Jansen, P.C.M., 2005. *Cosmos sulphureus* Cav. [Internet] Record from PROTA4U. Jansen, P.C.M. & Cardon, D. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands. <<http://www.prota4u.org/search.asp>>. Accessed 7 September 2016.
- Kadolph, S. J. & Casselman, K. D. (2004). In the bag: Contact natural dyes. *Clothing and Textiles Research Journal*, 22(1/2), 15-21.
- Liles, J. N. (1990). *The art of craft of natural dyeing*. Knoxville, TN: University of Tennessee Press.
- Martin, L. C. (2001). *The art and craft of pounding flowers*. Mt. Kisco, NY: QVC Publishing, Inc.
- Rekebya, M., Salem, A. A., & Nassar, S. H. (2009). Eco-friendly printing of natural fabrics using natural dyes from alkanet and rhubarb. *The Journal of the Textile Institute*, 100(6), 486-495.
- Retayne: Anti-bleeding rinse. (2011, November 11) Retrieved <http://www.dharmatrading.com/chemicals/retayne.html>
- Rudkin, L. (2011). *Flower pounding*. London, Great Britain: A&C Black Publishers.
- Safety Data Sheet (2015). *Cassofix FRN300 liq bc*. Available http://images.dharmatrading.com/images/public/pdf/msds/DDF_SDS.pdf

- Slow Fiber Studios. (2011). *Natural dye workshop with Michel Garcia: Colors of Provence using sustainable methods* [DVD]. Available from www.slowfiber.wordpress.com
- Stephens, S. G. (2014). Leaf pounding: Guide to Cherokee leaf pounding. Available: <http://www.outofwholecloth.com/leaf-pounding-instructions/>
- Trotman, E. R. (1975). *Dyeing and chemical technology of textile fibres*. London, England: Charles Griffin & Company Ltd.
- Vankar, P. S. (2016) *Handbook on natural dyes for industrial applications: Extraction of dyestuff from flowers, leaves, vegetables*, 2nd Ed. New Delhi, India: NIIR Project Consultancy Services.
- Vankar, P. S., Tiwari, V., & Ghorpade, B. (2001). Microwave dyeing of cotton fabric *Cosmos sulphureus* and comparison with sonicator dyeing. *Canadian Textile Journal*, 118(6), 31-33.
- Vigo, T. L., (1994). *Textile processing and properties: Preparation, dyeing, finishing and performance*. NY: Elsevier Science B.V.

7. Authors



Sherry Haar is Professor of Apparel and Textiles at Kansas State University. Haar earned her PhD at Virginia Tech in 1999; her MS and BS degrees are from University of Nebraska. Haar's scholarship explores the transfer of regional plant color and imagery onto textiles from both aesthetic and scientific perspectives. She creates color, print and pattern using slow methods and regional natural dyestuffs, while also researching colorfastness properties. Photo credit: Michael Henry

Kelsie Doty completed her M.S. degree at Kansas State University in 2015 and is currently enrolled in the Fiber Science and Apparel Design PhD program at Cornell University, USA. Doty's scholarship focuses on color properties and creative outcomes using regional dyewoods and sawmill waste.