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Identification of plant residue with commercial potential as natural dyestuffs

Abstract: The project explored whether plants grown by farmers' market producers could be used successfully as natural dyes for textile making. A variety of plants and dyestuffs were investigated.

Question & Answer

Q: Why would producers be interested in natural dyes?

A: Synthetic dyes are derived from non-renewable coal tar and petroleum. Natural dyes are extracted from plant and animal sources and are renewable resources. While current commercial interest in natural dyes is primarily in the area of natural dyes for food, there is great potential for natural dyes for textiles to be grown in Iowa. This project evaluated 48 plants and found 20 that meet basic criteria for textile applications: produced color that bonds with textile fibers and have acceptable performance for colorfastness to washing and light. Iowa-grown plants from which natural dyes can be extracted would be an alternative crop and income source for Iowa producers.

Background

Natural dyes and plant-based pigments are colorants derived from natural sources such as plants (e.g., indigo), animals (e.g., cochineal beetles), and minerals (e.g., ferrous sulfate, ochre, and clay). Plants and animals that are processed to produce dyes are known as dyestuffs. Dyes are extracted from the original dyestuff, usually in a heated water bath. However, not all colored extract can function as a dye; for example, beet extract is a poor textile dye. Although the beets produce an intense red color, the colorant does not bond with the fiber, and thus, is not considered a viable textile dye.

Natural dyes can be additive or substantive. Additive dyes require the addition of a chemical assistant (such as metal salt) to form bonds between the dyes and the fiber. Substantive dyes are able to bond with fibers without any chemical assistants.

Research and development programs in several countries focus on providing modern dyestuffs for the artisan textile market, fine art practitioners, commercial goods and products, and discerning consumers, as well as contributing to rural development, diversifying the agricultural base, and minimizing environmental impact in the production and use of dyes. While the potential of natural dyes and pigments as alternative, income-producing agricultural crops is largely unexplored, the economic impact of dyestuff production in rural Iowa could be significant.

Approach and methods

The project examined a variety of plants that are or could be grown in Iowa to determine their dye yield, the ability of the dye to bond with silk fiber, the color fastness of the dye, and the consistency of color yield over time or by producer. The specific focus was on plants readily available at farmers markets and plant residues (i.e., weeds, nut hulls and seed pods) removed from gardens, lawns, and woodlots. In many cases, several components of the plant were used, including leaves, stems, roots, flowers, fruit, and hulls. Experimentation included a variety of processing conditions including the number of

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$10,479 for year two

extractions, fermentation of the dyestuff at different pHs, extraction with metal salt, and canning (using heat and pressure to halt biological degradation of plant materials so that extraction of the dye can occur at a later time) of the extract.

The project investigator used traditional immersion dying with aluminum potassium sulfate (alum) as the mordant (a chemical salt used to form a bond between the dye and the fiber) and a triple extraction process to increase dye yield. To identify potential dyestuffs, the investigator visited three farmers markets to determine the variety of available plant materials that were grown in Iowa. Dyestuffs were gathered from neighbors, gardeners, and restaurants to provide sufficient plant materials for use as dyestuffs. Forty-eight plant species were tested.

For those dyestuffs that provided sufficient color, the investigator further evaluated the dyes for fastness or resistance to fading upon exposure to daylight and hand and machine washing using the test methods standardized for the textile industry.

Results and discussion

For many of the 48 plant species evaluated, more than one component was examined. For example, with the apple tree, the bark, wood, and spring twigs/suckers were considered as separate components. The 16 dyestuffs and components that produced only a faint tinge were not evaluated for color fastness since they offered only minimal value as dyes. Some other plants produced noticeable color, but when evaluated for color fastness to light and washing did not meet minimal consumer standards. (Fading is evaluated by using a gray scale to quantify color loss between the exposed and covered portions.)

In addition, specimens were tested for color fastness to washing by using a stainless steel container with deionized water and detergent similar to normal home washing conditions. Specimens were washed under two conditions; one similar to hand washing and the other similar to cool machine washing with gentle agitation. (These are common care procedures for silk apparel.) Stainless steel balls were added to the cool machine washing to simulate abrasion that occurs in normal washing. Fading was evaluated using a gray scale to quantify the loss between washed and unwashed dyed fabrics.

Bleeding (color transfer to other materials via the wash water) was evaluated using multi-fiber test fabric, which includes stripes of six common apparel fibers. Dyes that bleed are likely to stain at least one of the fibers in the test fabric. Five-point rating scales for color change and for staining are used where five corresponds to no color problems and one corresponds to severe color change or bleeding. Minimal performance expectations in the textile industry for color fastness to light and washing are 3.0; less than that will meet with customer dissatisfaction.

More than 20 plants produced noticeable color and had good fastness performance indicating potential marketability as dyestuffs. Among them were apple bark, apple wood, apple twigs, asparagus, blue grass seeds, bracken, chamomile, carrots, elderberries, elm bark, geraniums, goldenrod, grapes, henbit, horehound, horseweed, Jacob's ladder, lambs quarter, mint, mums, onions, pears, pear bark, tomatoes, walnuts, watermelon, wild marjoram, and white heath aster. In year two the testing of these plants was repeated to assess color consistency in additional materials. For a few plants, the original source was no longer available.

As indicated by the color descriptions in the table (shown on the facing page), color consistency for a dyestuff was not good. In almost all cases the color was within the same color family but there was a perceivable difference between samples from years one and two or sources one and two. This means that a dyer would not be able to dye fabric and be assured of the ability to meet textile industry standards for a color match. However, this color matching remains a problem for the synthetic dye industry as well.

Conclusions

Natural dyes are able to produce strong, clear color that is fast to consumer use. Of the 48 dyestuffs studied, 25 plants are potentially able to produce marketable natural dyes. These dyes produce good color and met minimal performance standards for color fastness to light and washing. While color consistency from year one to year two or from source one to source two was not acceptable, further research could address this problem. Possible sources of

DYE STUFF	Procedure/Extract	Color	Light	NO Wash IA*	NOTES	STAININ	Wash 2A
apple: bark		taupe	5	1	intensified, browne	5	3.4
apple: bark	acetic acid soak	tan	4	2	intensified, browne	5	3.4
apple: wood		dark champagne - 4th dip	5	2		5	4
apple: twigs (spring suckers)		light tan	5	3		5	5
asparagus: mature plant (*Asparagus L.*)		greenish tints	5	3		5	2.3
asparagus: seed pods				champagne			
basil (*Ocimum L.*)		grey-brown tints	2.3	3		5	4
beans, green				"champagne"			
beans, yellow				"champagne"			
beets (*Beta procumbens L.*)	alum pre-mordant	brown red tints	1	2.3			2.3
beets		1dip:pink, 2dips: adds yellow	4	1		5	2
beets: ferment	ferment			champagne			
beet: skins		light pink tones	3.4	1		5	2
beet: tops		champagne	5	2.3		5	2.3
beets	2% tannic acid — cotton	pink	4	2		5	2.3
blue berries	extract 2	dusty purple	2	2	lost purple tones	5	3
blue grass: seed heads (*Poa L.*)		khaki	5	2.3	darkened, intensifi	5	3.4
bracken (*Pteridium aquilinum (L.)*)		orange brown	5	1.2	more purple tones	5	3
cabbage	iron .63g, cochineal 2.5g, alum 2.5g 28% acetic acid	dusty purple			1.2		
cabbage:	alum (1.96g) & ammonium hydroxide (3ml)	deep tan			1.2		
camomile (*Anthemis L.*)		yellow	3.4	2		5	3
carrot: peels (*Daucus carota L. ssp.*		light orange	3	3		5	4.5
carrot: tops *sativus (Hoffm.) Arcang.)*		light green	4.5	3		5	3
catmint (*Nepeta mussinii Henckel*)	extract canned before dyeing	khaki	2	2		5	4
catmint				taupe			
cedar (*Thuja L.*)	*extract 1*	dark peach	3	2.8‘			3
cedar	extract 2	peach	3	2			5-Feb
chives (*Allium schoenoprasum L.*)		reddish tints	2.3	2		5	4.5
cilantro (*Coriandrum sativum*)		tan	2.3	2		5	3
cucumber: peels (*Cucumis sativus L.*)	1 dip	champagne	5	3		5	4.5
deadly nightshade: berry (*Solanum interius Rydb.*)				champagne			
deadly nightshade: stem, leaf, root				faint green tint			
elderberry (*Sambucus L.*)	*extract 1*	purple brown	2	2		5	3.4
	extract 2	purple brown, lighter	3	2		5	3
	extract 3	purple brown. Lighter	3	1.2	lost all purple	5	4
elm: wood (*Ulmus L.*)				champagne			
elm: bark		faint orange/red tints	4	3		5	3.4
elm: leaf		terra cotta	3.4	1	red tones	5	3.4
elm: leaf, ferment	ferment	terra cotta	4	1	red tones	5	6
geranium: flowers (*Geranium L.*)		red with cold bath?	3.4	3		5	5

variations in dye lots include growing conditions, soil type and condition, mordanting, extraction, and dyeing. Careful study of each source of variation should be conducted.

Research related to standardizing natural dyes is needed. As the dye literature notes, at present dyes are not standardized even though other textile commodities with wide variations in properties and performance have been standardized. For example, cotton fiber varies widely. Yet manufacturers have developed formulas for mixing fiber from many bales of cotton to produce a standard fabric such as broadcloth. A similar blending operation might work to standardize natural dyes.

Other further research needs include:
- Development of large scale, efficient production and harvesting methods,
- Storage issues related to dyestuffs and dye extracts,
- Markets for dyes and finished products, and
- Consumer awareness of the renewable aspects of natural dyes, their wide color palette, and good performance.

Impact of results

The results indicate that many plants currently produced for farmers markets are natural dyes with good fastness performance. In addition, the project showed that many plants not currently used as natural dyes have the potential to serve as dyes, however color consistency with these dyes is not necessarily good.

Unfortunately, this does not mean that there is a current market waiting for these types of natural dyes. Nor does this research mean that producers are in immediate need of a way to dispose of plant residue. They have developed other ways to use residue and non-marketable produce.

Education and outreach

The project investigator made 12 presentations related to the project topic between 2002 and 2004. Among them were college classes, garden and craft workshops, Extension training sessions, and weaver's guild sessions. Two publications were prepared, one of which has appeared in the Proceedings of the Annual Meeting of the International Textiles and Apparel Association.

For more information, contact
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