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ORIGINAL RESEARCH

Investigation of sustainable dyeing on cotton fabrics obtained from extraction of popular avocado seeds in Vietnam

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Avocado seeds in Viet Nam have more polyphenol content and high antioxidant activity. Avocado seeds have a large amount of common waste every day, and they are not used much for other purposes. This investigation is aimed to set up the proper dyeing methods for cotton fabric 100% based on extracting colorants from avocado seeds. Dyeing solutions were created by dissolving minced avocado seeds with the right moisture in distilled water at 60°C for 60 min. The liquor ratio used in the investigation is 1:10 for the extraction process and 1:30 for the dyeing condition. The most suitable dyeing parameters were achieved at a dyeing temperature of 60°C, a dyeing time of 60 min with a dyeing solution concentration of 75% v/v, and pH = 7. Moreover, the common mordanting chemicals such as Tannin, $CuSO_4.5H_2O$, and $FeSO_4.7H_2O$ were mordanted on cotton fabrics, which aimed to check how the color bonding level is strong or weak through values in the color system including ΔE, L*a*b*, K/S. It can realize that mordanting chemicals had a strong impact on color fastness and color hue changes of cotton when dyed with solutions from avocado seeds that can create a diverse and attractive natural color collection.

Keywords: avocado seeds, extract, natural dyes, cotton fabrics, mordant

Introduction

Natural dyes can be defined as colorants or pigments produced by living organisms such as plants, animals, fungi, or bacteria. Plant sources can produce a variety of colors depending on the part of the plant used. Natural dyes are found in dyeing paper, leather, and especially in ancient textiles. Since the ancient centuries, humans have used natural dyes from plants and animals such as specimens at the pyramids of Egypt, China, and India (1, 2). The dyes extracted from natural materials such as leaves, roots, bark, insect secretions, and minerals are dyes available to humans to color the fabric until the discovery of the first synthetic dye (3). Natural dyes are mainly used to dye protein fibers and cellulose. These fibers have a high affinity for natural dyes and result in relatively good color fastness. Rapid research advances in synthetic chemistry created the industrialization of fabric production which led not only to the development of alternatives of synthetic dyes to popularize natural dyes but also some synthetic dyes that are diverse in color, and these colors gradually push natural dyes into oblivion. However, environmental problems in the production and application of synthetic dyes once again rekindled the consumer's preference for natural dyes during the last decades. Natural dyes are preferred by environmentally conscious consumers, and today, there is a developing market for these fabrics. Natural colorants are friendly to the skin, renewable, and biodegradable. They do not contain harmful chemicals and carcinogens, so they have little effect on the health of users and are safe for workers and consumers. Some natural dyes have anti-bacterial and pharmacological effects that bring positive effects on the wearer and have very good UV protection (4, 5). Avocado's scientific name is Persea Americana, which belongs to the Lauraceae family. Avocado is a perennial woody plant, leaves have oval blades, young branches have fine hairs under the leaves, petioles are 1.5–2 cm long, flowers are light yellow, hermaphrodites, six flower plates, and anthers light red. Avocado seeds make up

16% of the avocado's weight. Avocado seeds contain tannins, phytosterols, triterpenes, fatty acids, proanthocyanidins, and polyphenols (6, 7). The content of these compounds depends on the avocado growing conditions and maturity. The colors of colorant solutions depend on those compounds' ingredients (8). In Viet Nam, avocado seeds are all waste in large quantities and can be collected from coffee shops and local markets. Therefore, we utilized the avocado seeds in this study for dye extraction.

Research elaborations

Dyeing materials

The pretreated cotton fabrics were 100%, provided by Viet Thang Corporation Limited Company in Vietnam, plain woven fabric texture, fabric type was 185 g/m^2, warp yarn count was 16 tex, and weft yarn count was 35 tex. Fabric specimens were cut so that each size reached 2 g.

Dye extraction from avocado seeds

Avocado seeds were collected from local markets and coffee shops in Ho Chi Minh City, Vietnam. Moisture from avocado seeds was removed by exposing them to sunlight over 24 h and milled by a dedicated milling machine to get avocado seed minced powder. That was the input material for dye extraction. The crushed avocado seeds (20 g) were extracted with 0.2 litter of deionized water with different bath ratios of 1:10, 1:15, and 1:20 at a temperature of 60°C and time for 1 h. The next step is clarified and refined twice by the normal filtering method to achieve a colorant solution.

Coloring process

The coloring methods were performed using the IR dyeing equipment (Mesdan, Italy), and a drying oven (Gavazzi, Italy) was utilized to remove moisture from the dyeing materials. To investigate the impact of dye concentration on the coloring progress, various concentrations of avocado seed dyeing solution were given as follows: 25, 50, 75, and 100 v/v%. A level similar to 75% of the colorant solution was selected to examine the impact of various mordants and various temperature scales (60, 70, 80, and 90°C), heating times (30, 60, 90, and 120 min), and pH (4, 7, and 8) on the coloring progress. The volume of water in the bath when coloring was 1:30. After the coloring process, the colored specimens were rinsed with distilled water to eliminate any unbonded colorants and separate water and moisture in the drying oven at 60°C.

TABLE 1 | Influence of extraction levels on the color of dyeing materials.

Extraction ratio	L*	a*	b*	C	ΔE	K/S	Extraction efficiency
Raw fabric	93.7	0.08	2.82	2.82	–	**0.03**	
1:10	10.2	4.46	9.12	9.88	13.0	**0.71**	74%
1:15	7.73	3.73	8.21	8.80	11.4	**0.61**	81%
1:20	7.79	3.84	8.63	9.24	11.9	**0.54**	84%

Mordant chemicals

In this investigation, three various types of specific mordant chemicals were used. The method was performed in a meta-mordanting way on cotton fabrics. The following chemicals were chosen: copper sulfate pentahydrate.

($CuSO_4$ $5H_2O$), ferrous sulfate ($FeSO_4$ $7H_2O$), and tannin. Chemicals' concentration is 5% w/v.

TABLE 2 | Influence of concentrations on the color of dyeing materials.

Concentrations	L*	a*	b*	C	ΔE	K/S
Raw fabric	93.85	0.13	2.77	2.77	–	0.030
100%	10.39	4.56	10.12	10.24	13.45	0.387
75%	9.10	4.49	10.05	10.62	13.32	0.362
50%	9.11	2.98	9.23	9.80	11.68	0.343
25%	8.85	2.01	8.98	9.63	11.43	0.298

TABLE 3 | Influence of temperatures on the color of dyeing materials.

Temperatures	L*	a*	b*	C	ΔE	K/S
Raw fabric	93.90	−0.15	2.79	2.79	–	0.031
60°C	10.06		8.20	9.10	12.24	0.382
70°C	7.89	3.32	7.96	8.41	11.03	0.342
80°C	8.75	4.22	8.61	9.30	12.27	0.320
90°C	11.05	3.70	7.47	8.06	11.02	0.301

TABLE 4 | Influence of time on the color of dyeing materials.

Time	L*	a*	b*	C	ΔE	K/S
Raw fabric	93.55	-0.04	2.91	2.91	–	00.034
30 min	7.98	4.68	9.29	10.14	13.08	0.365
60 min	9.84	7.03	9.34	11.19	14.81	0.385
90 min	8.48	4.77	9.14	10.03	13.01	0.370
120 min	8.80	5.08	10.00	10.95	14.12	0.355

Color measuring and durability assessing

The color system is chosen as follows: L*a*b* CIE. Results were examined using a spectrophotometer (Xrite Color i5, USA). The level of coloration of the colored cotton fabric specimens was assessed using the K/S parameter.

K/S, a parameter of coloring depth degree, is discovered using the above Kubelka-Munk formula as follows:

$$K/S = (1 - R)^2/2R$$

where R is the reflection value, and K and S are absorption and backscattering values, respectively.

The color durability to washing and rubbing criteria of the colored cotton fabric specimens were tested on the reliable international standards: ISO 105-X12: 200 and ISO 105-C06 A1S: 1994.

Results

Evaluating the influences of extracting levels from avocado seed in the dyeing process

By following varying extraction rates for dyeing, samples were cleaned, allowed to dry their color values (CIE L* a * b *), and were noted when they were at room temperature. The color intensity K/S of the measurement results shown in **Table 1** is fabric dropped after being colored with various extraction solutions as the extraction rate decreased. Specifically, the greatest color intensity was reached using K/S data at a 1:10 extraction rate.

The greatest extraction efficiency was achieved at 84 % with a ratio of 1:10, and the shortest value was 70% with a ratio of 1:20.

Evaluating the influences of coloring specific parameters in the dyeing process

To evaluate the influences of coloring-specific parameters that impacted making color on dyeing materials, we have based on basic values in K/S value for the CIE L*a*b*color scheme. The measured values are in turn shown in **Tables 2–4**.

Table 2 exhibits a decline in the K/S value with the greatest value being roughly 0.387 at 100% v/v and ranging from 100% v/v to 25% v/v. However, using 100% v/v concentration did not significantly vary from using 75% concentration; therefore, 75% concentration was used to both attain color value and conserve materials. According to the data in **Table 3**, dyeing was most effective at 60°C. Since this temperature might damage the fastness and changes of colorants in natural dye, we did not elevate the temperature to 100°C. Additionally, if the temperature rises as well high to time, the desorption of colorants on fabrics can happen, which makes the value K/S decrease.

Observing the influence of time on the color of dyeing materials in **Table 4**, it can realize that colorants bonded quite well with cotton material's structure when making color from 30 to 120 min. However, the short time could little affect the coloring of the materials because the colors that are easy to dissolve in water will be influenced at determined temperatures and times. So, 60 min are the most suitable time for the dyeing process.

To assess the effect of the dyeing environment (pH) on the ability to color the cotton cloth, the dyeing method is conducted using the following parameters: 60°C temperature, a 1:10 extraction rate, a 1:30 dyeing ratio, a 75% v/v concentration, and a dyeing period of 60 min, which are common dyeing conditions Environments with pH values of 4, 7, and 8 for basalt are all acidic. The outcomes are displayed in **Figure 1**.

Figure 1 illustrates that the ability of dyeing materials' color absorption is quite sensitive to the pH value, and pH changes will lead to an increase or decrease in the K/S value. The greater the pH, the shorter the K/S value.

The biggest color strength (K/S = 0.47) is in the acid condition, and the shortest color strength is in the basic condition at pH 8 (K/S = 0.37). However, in an acidic environment, dyeing cotton fabrics did not have the same color, and cotton fabrics can lightly decrease fastness. So pH = 7 is chosen for the dyeing process.

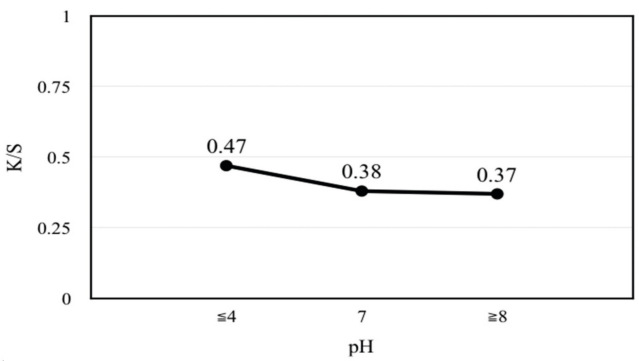

FIGURE 1 | Influence of pH on the color of dyeing materials.

TABLE 5 | Influence of mordants on the color of dyeing materials.

Time	L*	a*	b*	C	ΔE	K/S
Raw fabric	93.66	−0.06	2.74	2.74	–	00.035
Non-mordant	9.10	4.49	10.05	10.62	13.32	0.383
CuSO4·5H2O	14.55	5.80	15.44	16.33	21.09	0.674
FeSO4·7H2O	22.66	1.26	5.79	5.87	10.74	0.611
CuSO4 FeSO4	16.40	0.37	7.57	7.57	10.98	0.599
Tannin	22.09	2.70	17.79	17.95	23.58	2.343

TABLE 6 | Color durability to washing and rubbing to the color of cotton fabrics.

Testing methods	Applied parameters	Mordanting		
		Non-mordanted	$CuSO_4 \cdot 7H_2O$	Tannin
Color durability to washing ISO 105 C06: 2010 Soap: 0.4% ECE (B): 0.1%	40°C, 30 min, 10 steel balls	2–3	3–4	4
		Color staining on multifiber		
Color durability to rubbing ISO 105 X16:2016	Diacetate	2–3	3–4	4
	Cotton	2–3	3–4	4
	Polyamide	2–3	3–4	4
	Polyester	2–3	3–4	4
	Acrylic	2–3	3–4	4
	Wool	2–3	3–4	4
	Dry	5	5	5
	Wet	4–5	4–5	4–5

Evaluating the influence of mordanting chemicals to color the dyeing materials

Evaluation of affecting the used mordanting chemicals to the ability to absorb dyes on cotton fabric was fixed as follows: 75% v/v, 60∘C, 60 min, and pH 7 with simple mordanting method from various chemicals such as $FeSO_4.7H_2O$, $CuSO_4$ $5H_2O$, $CuSO_4$ $FeSO_4$, and tannin, which aim to improve better color strength on fabric.

According to **Table 5**, the greatest K/S value for tannin mordant is approximately 2.343, whereas the K/S of cloth colored without a mordant is 0.383. When employing $CuSO_4$ $5H_2O$, E reaches its highest value of 21.09 between the reference sample and the colored sample. The chemical catechin, which is present in distilled water, tends to change the color of the dyes, especially the color of the blue dye for instance, and when iron and salt are removed from avocado seeds, $FeSO_4$ $7H_2O$ will have colors ranging from gray to black. $Fe2^+$ ions reacted with catechin to form iron (III), which has a dark green color and becomes black when exposed to air. $CuSO_4$ $5H_2O$ gave out a brighter, more uniformly pigmented yellow-brown color after mordanting, as they created insoluble complexes with the dyes that made the color seem lighter and more yellowish direction.

Evaluating color durability to washing and rubbing on dyeing materials

Color durability is tested specifically by reliable standard. The rating scale level is from 1 to 5. With the strength level gradually increasing from 1 to 5, the permissible standard is at level 2–3 for dark colors and at least level 3 for light and medium colors. **Table 6** shows the color durability of the specific influences on cotton fabric: washing and rubbing. Results clearly determined that mordanted cotton fabric achieved levels 3–4, which has very important meanings when using them in wide industrial applications. In contrast, the particular protection must be more careful with dyed products from natural colorants because they are so easily varied in color due to outside impaction.

Conclusion

This research has found that the suitable parameters for making color on cotton fabric 100% with a soluble extracting solution of avocado seeds are as follows: extracting level 1:10 (kg/l), used liquor ratio 1:30, dyeing temperature of 60°C, 60 min, 75% v/v, and mordanted by $CuSO_4$ $5H_2O$ or tannin using the simple performing method. When the cotton fabric is dyed using a non-mordant technique, the dyeing solution that is made from distilled water color of dyed products is a medium pink. Mordants will improve color fastness and create color diversities in dyeing technology. Color durability is so necessary to textile products, for example, washing durability, and rubbing durability got a good level of 3–4, which found that they can be applied in our textile industry. Nevertheless, natural-colored materials do not have a long life duration like dyed materials from synthetic dyes.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be thought of as a conflict of interest.

Author contributions

HK has written all contents which have been presented in this manuscript. HB has reviewed the manuscripts content and format. Both authors contributed to the article and approved the submitted version.

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References

1. Shahid M, Shahid-ul-Islam, Mohammad F. Recent advancements in natural dye applications: a review. *J Clean Prod.* (2013) 53:310–33.
2. Shegog R. *Characterization of perseoranjin, a natural orange pigment from avocado (Persea americana) seed, and its uses as a natural food colorant*. State College, PA: The Pennsylvania State University (2015).
3. Samanta K, Agarwal P. Application of natural dyes on textiles. *Indian J Fiber Textile Res.* (2009) 34:384–99.
4. Ariesya. The study of the dye extraction of avocado seed using ultrasonic. *Chem J.** (2015) 334–40.
5. Thomas B, Rita M. Chapter 2. *Handbook of natural colorants*. Hoboken, NJ: John Wiley & Sons Ltd (2009).
6. Deepti D. A colour avocado seeds extract as a potential natural colorants. *Indian J Food Sic.* (2011) 34:384–99.
7. Ozan A, Ali C, Gorkem G, Arzu Y. Natural dye extraction from waste barks of turkish red pine (*Pinus brutia* Ten.) timber and eco-friendly natural dyeing of various textile fibers. *Fibers Polymers.* (2013) 14:866–73.
8. Rehman F, Naveed T, Nadeem M, Wei W. Study on Tencel fabric dyeing with pomegranate peel natural dyes. *Asian J Chem.* (2017) 29:2279–84.