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Comparing various dyeing techniques using plant extracts on cotton fabrics

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ABSTRACT

Natural dyes were extracted from marigold flowers, onion outer skins, fenugreek seeds, and green coffee, and were used to color 100% Giza 86 cotton fabric using alum as a mordant. The dyeing process was conducted using three techniques: conventional, microwave, and infrared radiation. The surface properties of the cotton fabric were evaluated using FTIR spectroscopy. Additionally, the dyed fabrics were assessed for color strength (K/S) and fastness properties including washing, light, rubbing, and perspiration fastness. The results indicated a moderate affinity between cotton fabric and the extracted dye. The use of metal mordant improved dye exhaustion in alum-dyed cotton fabrics. There was a significant variation in color shade depth among the different natural dyes. Specifically, marigold extract resulted in a significantly darker yellow shade, while green coffee extract yielded a lighter yellow hue. The dye derived from marigold flowers demonstrated exceptional efficiency in color fastness tests, with the microwave dyeing process yielding the best results for (K/S). However, the use of green coffee and fenugreek in dyeing resulted in superior fastness compared to other methods.

Keywords: Natural Dyes ,Dyeing techniques, Eco-Friendly, Color Properties.

INTRODUCTION

In recent years, natural dyes have become an increasingly popular alternative to synthetic dyes. Natural dye refers to any dye that is derived from natural sources, such as plants. These dyes are non-toxic and non-allergenic, making them a safe choice (young, 2009; Shahid *et al.,* 2013). The textile industry should focus on creating eco-friendly and healthy technologies, such as using natural dyes from renewable sources(Dawson, 2009). Natural colorants are thought to be environmentally friendly because they are renewable, biodegradable, skin-friendly, and may even be beneficial to the wearer's health (Hany, 2020). Extracting natural dyes is essential for reducing environmental pollution. Plant-derived dyes can be used as an alternative to synthetic dyes for natural cotton fiber dyeing. This methodology helps identify plants that produce dyes and test their properties to introduce them to textile fabrics more efficiently. The extracted dyes are tested for color fastness using IR spectrophotometry and various mordants to fix the color onto fabrics (Geetha, 2013).

Previous studies and research have identified several vegetable sources that can provide yellow dye suitable for textile substrates. These sources include French marigold, green coffee, safflower, kamala, onion skin, hemp, turmeric, bearberry, fenugreek, and henna (Samanta, 2011). To find a better yellow dye for textiles like cotton, the researchers have tested numerous plant sources. One of these sources is fenugreek, specifically its seeds. Fenugreek belongs to the legume family and its seeds are commonly used for nutritional purposes (Wani *et al.,* 2018). Fenugreek seeds contain various components, including flavonoids known for their yellow color Flavonoids from *Reseda luteola* and *Allium cepa* are used to dye fabrics. These plants also have more lightfast coloring principles than others (Srinivasan, 2006).

Marigold flowers contain carotenoids, which include a natural dye called lutein ($C_{40}H_{56}O_2$). This dye can be used to color cotton, along with mordents to create long-lasting hues. To achieve shades, cotton fabrics are first treated with tannic acid/tannin-containing mordants and then metallic mordents before dying, among all natural plants marigold flowers have the highest concentration in the lutein.so, lutein concentration in marigold flower measures the strength of the natural dye. (Saxena, 2014; Rashidi *et al*., 2019). African marigolds (*Tagetes erecta* L.) are a great source of carotenoids and Lutein, which give them their bright yellow to orange red color (Chandan, 2015). Onions (*Allium cepa*) belong to the Lilliaceae family and are grown all over the world. Quercetin, a natural dye extracted from onion skins, presents an eco-friendly solution for coloring textiles. By repurposing the most discarded household and commercial food waste, we can reduce waste and create beautiful, sustainably dyed textiles. (RazaMiah et al., 2017; Kumar et al., 2022). Studies show that an onion's outer skin makes up around 2.25% of the onion's weight, and it's not meant for consumption and contains a pigment called Pelargonidin (Chandravanshi, 2013; Nurunnesa *et al.*, 2018). Numerous reviews on the chemical composition of coffee beans have been given by (Streuli, 1970; Clifford, 1975; Farah, 2012; Pujol *et al.,* 2013). Cotton fabrics were dyed with coffee to produce shades of greenish, brown, and dark brown. The dyeing time and temperature were essential factors in enhancing the color intensity. The stability of the dye was higher in dry rubbing than in wet rubbing. Although the FTIR analysis was not able to identify the specific chemical groups involved in the interaction with cellulose, further research is necessary to optimize the dyeing conditions and overall performance (Amel, 2021). Mordants can improve the physical properties such as colour fastness, dye brightness, and rubbing fastness. The use of mordant in dyeing not only increases dye take-up and colour fastness, but the use of various mordants on a natural dye can result in diverse colours and hues. (Menna *et al.,* 2022).

Infrared radiation (IR) is a type of electromagnetic radiation, with longer wavelengths than visible light that is not visible to the human eye. (Liew, 2006), the use of infrared heating technique in dyeing processes is an eco-friendly method that reduces pollution by minimizing waste dyes and electrolytes in the effluent. Compared to traditional dyeing methods, infrared heating technique achieves superior fixation, resulting in a more efficient process. This method has been studied in detail and has been found to be effective in reducing the number of pollutants in wastewater from reactive dyeing (Broadbent *et al.*, 2005; Debasree *et al.,* 2017). In textile processing, infrared quickly and evenly heats materials. This reduces energy consumption and increases production speeds, ultimately resulting in lower production costs. (DragoKatović, 2011; Heraeus 2019). Textile finishing involves the use of infrared heating, particularly in textile coating applications. There are three types of heat transfer used for heating textiles- convection, conduction, and radiation. Infrared heat transfer works differently from convection and conduction. Instead of gradually heating the fibers, it rapidly transfers a significant amount of heat energy to the fibers, acting as a heat source (Braybury, 2018; Van Denen, 1993). Microwave dyeing is a method of heating using microwaves. It can be used not only for drying textiles but also for dyeing and fixing printed and dyed materials. With the gradual application of microwave technology, the performance of microwave components has improved, and the cost has sharply decreased. This high-tech approach is prevalent in the dyeing industry (Huang De-chao, 2015). This study explored the potential of using natural plant dyes for cotton fabric dyeing. Four types of yellow dyes, extracted from marigold flower petals, onion outer skin, fenugreek seeds, and green coffee, were applied using various dyeing methods with alum as a mordanting agent. The color strength of the dyed cotton fabrics was analyzed to evaluate the surface properties of the fabrics. Additionally, the durability characteristics of the dyed fabric were evaluated and compared with various plant-based dyes and dyeing techniques to achieve a range of shades.

MATERIALS AND METHODS

Dyestuffs:

Four natural dyes were purified extracted from:

1- Petals of Marigold flower as shown in Fig. (1) The chemical structure of lutein was represented in Fig. (2) (Chandan, 2015).

Fig. 1. Powder and extraction dye of Marigold Flower.

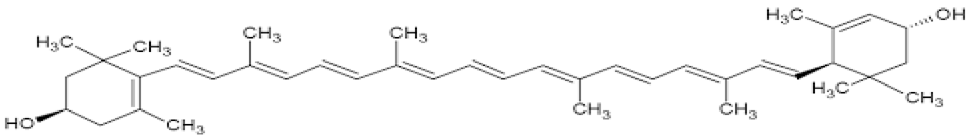


Fig. 2. Chemical structure of (Lutein)

2- Outer skin of onion represented as shown in Fig. (3), the chemical structure of quercetin was represented in Fig. (4).(Uddin, 2014; Mishra , 2011).

Fig. 3. Dried and crushed ocrushedion Skins.

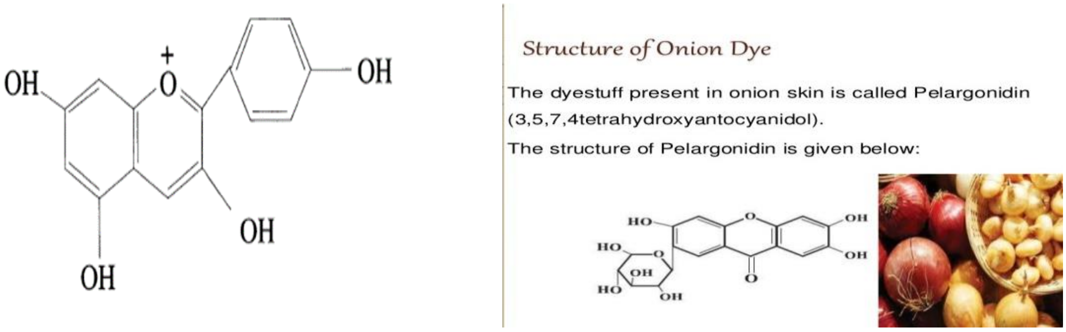
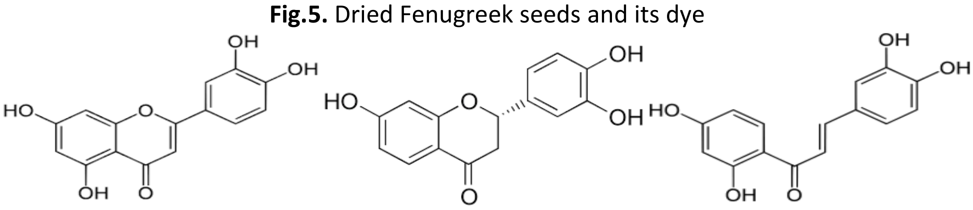


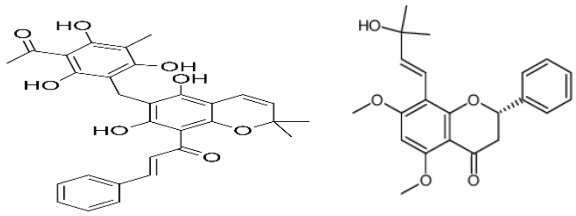
Fig. 4. Chemical structure of Pelargonidin (Quercetin), a dye stuff in onion skin

3- Fenugreek seeds in Figure (5) contain yellow flavonoids used for dyeing textiles. Various sources have been used, such as *Reseda luteola*, *Arthraxon hispidus*, and *Miscanthus tinctorius*, which produce dyes with better light-fastness. See Figure (6) for the principle (Srinivasan, 2006).

Fig.5. Dried Fenugreek seeds and its dye



Luteolin Butin Butein



Rottlerin Quercetol

Fig. 6. Chemical structure of flavonoids constituents of Fenugreek

4- Green coffee was used and represented as shown in Fig. (7), was represented in Fig. (8), the chemical structure flavonoids are known to be yellow in color (Young-Hee, 2007).

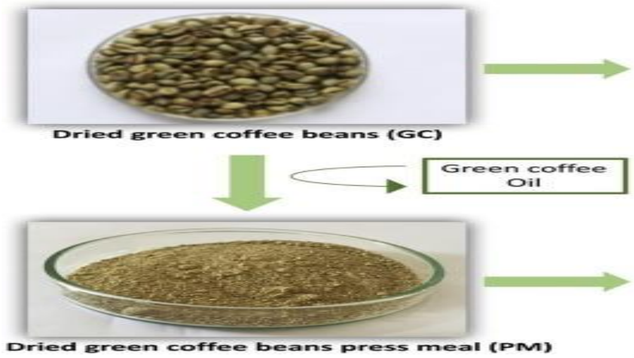


Fig. 7. Dried and crushed of Green Coffee

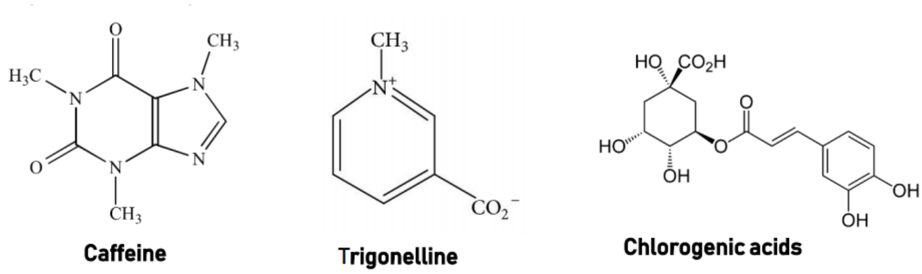


Fig. 8. Chemical structure of Green Coffee

Chemicals:
Aqueous solutions containing 5 g/l Alum ($KAl(SO_4)_2.12H_2O$)was used as mordants. Other chemicals were unpurified.

Cotton fabric:
Scoured and bleached plain weave 100 % Egyptian cotton fabric (Giza 86) was used. With the following specifications: 90 g/m2, yarn count, Ne. (80/2), cut into rectangular pieces of (10 x 14) cm, weighing 2 g.

METHODS

Dye Extraction:
Natural dyes plants material was washed and dried. Then, 100g of each one was powdered and boiled in 1: l of distilled water for 1 h concentrated to 500ml and filtered. The extracted liquor was used as the foundation of the dye. The concentration of the resultant stock solution is 1% w/v.

Mordanting:

Simultaneous mordant treatment whereas dyes and 5.0% (owf) alum solution mordant added at the same bathin the same time to produces a unity between the fabric and dye (Ibrahim et al., 2010; Gawish, et al., 2016; Landi, 1985; Kamel et al., 2012).

Dyeing Procedure:

Three different dyeing processes were carried out using dye extract keeping M: L ratio as 1:30.

1- Conventional dyeing:

The dyeing process was carried out using the dyeing curve as shown in Fig. (9). After dyeing, the sample was treated with detergent at 90°C for 10 minutes, followed by drying according to Debasree *et al.*, (2017).

A – Dye + Fabric

B – Rinse

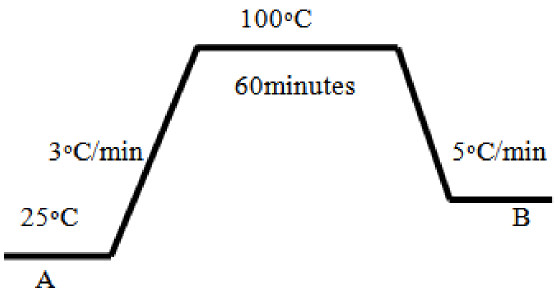


Fig. 9. Schematic chart of dyeing processes

2- Infrared dyeing technique:

Infrared ideal laboratory dyeing machine Model YaboInc, Jiangsu, China, using as a source of heating in the same dyeing curve as shown in Fig. (9). After dyeing, the samples were washed with 2 g/L detergent at 90ºC for 10 minutes, and dried.

3- Microwave dyeing technique:

The microwave heater was also used as a source of heating. The cotton fabrics were dyed in the bath, which contained 10 g/l of each dyestuff, with a liquor ratio of 1:30. The dyeing process was carried out using microwave heating for a duration of 3 minutes. After dyeing, the samples were washed using 2 g/L detergent at a temperature of 90°C for 10 minutes, and then dried.

All cotton samples were conditioned for 48 hours at a temperature of 20°C (±2°C) and a relative humidity of 65% (±5%). This was done in accordance with the ISO: 6359-1971 standard method.

Evaluation tests:

Fourier transformer (FTIR) analysis:

To analyze the peak of infrared radiation, Fourier Transform Infrared Spectroscopy (FTIR) experiments were conducted on four different dyed samples of cotton fabric. The measurements were taken using an attenuated total reflectance (ATR) technique, with the help of a FTIR 6300 instrument from Jasco Inc., Japan. The spectra were recorded in the range of 4000-400 cm^{-1}, and averaged over multiple scans at a resolution of 4 cm^{-1}. Finally, the recorded data was processed using the Spectra Manager II software from Jasco Inc., Japan.

Color strength (K/S):

The K/S of the dyed cotton fabrics were measured using a UV–VIS– Spectrophotometer using the double beam spectrophotometer (Perkin-Elmer Company–USA, of model Lambda 35, Using CIE color system coordinates, the range of visible light (400-700 nm) was analyzed according to ASTM E313-96 (Kubelka Munk, 1931; Broadbent 2001).

Color Fastness Properties:

The color fastness properties of all dyed fabrics were determined by the following methods:

- Wash-fastness was measured according to ISO 105-C01 1998(E), and the resulting stains were assessed using the gray scale.
- Light-fastness was measured according to ISO 105-B01:1994 Textiles-Tests for color fastness, Part B01: Color fastness to light: Daylight.
- Perspiration fastness was evaluated using ISO-E04: 1994.
- Rubbing fastness was conducted in accordance with the test method provided by ISO 105-X12:2016 (both dry and wet), which is part of the Standard Tests for color fastness, Part X12: Color fastness to rubbing.

Statistical Procedures:

The study used a randomized design with three replicates. Data was analyzed using SPSS and significant differences between treatments were compared using the L.S.D method at a 5% probability level. Analysis followed methods by (Snedecor and Cochran, 1981).

The ideal fabric under study was chosen as a result from the following Radar M/S Excel equation

= 0.5*sin (3.14*(360/ (^{n}*180)*(x1*x2) + (x2*x3) + (x3*x1)

^{n} = 16 fabrics, x= properties

RESULTS

FTIR spectroscopic analysis:

FTIR spectroscopic analysis yield important information about the new functional groups present in dyed cotton fabric compared with the un-dyed cotton fabric**.** FTIR spectroscopy identifies functional groups via characteristic peaks in the infrared spectrum (4,000:400 cm^{-1}) region measured by transmission mode because this is the spectrum where most of the chemical changes took place during the dyeing of cellulose fabrics.

The (FTIR) spectra of the plain un-dyed cotton fabric, and fabrics dyed with the four extracted natural dyes (Marigold flowers, Onion outer skins, Fenugreek seeds, and green coffee) were presented in Figure (10, 11).

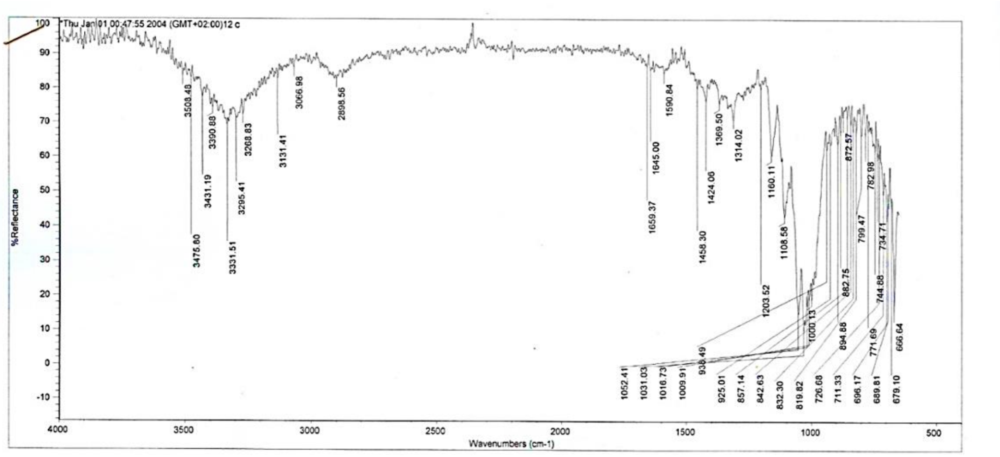


Fig. 10. FTIR spectrogram of the plain undyed cotton fabric (Giza 86)

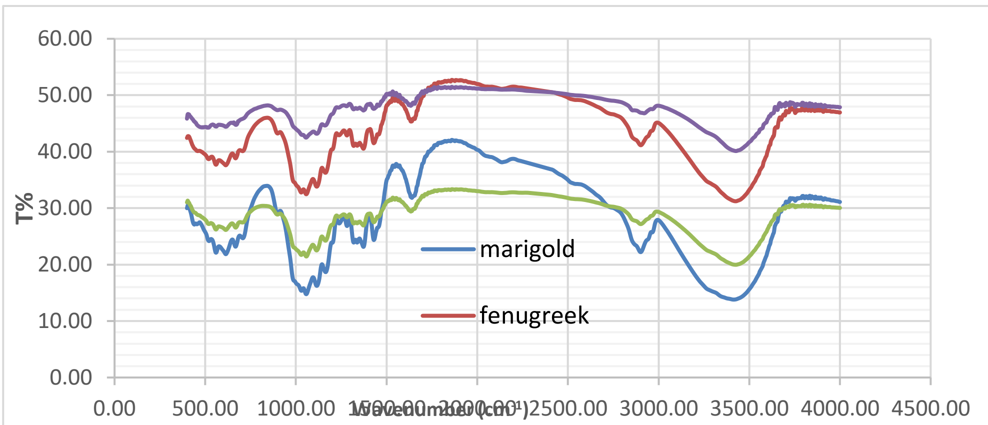


Fig. 11. FTIR spectrogram of 4 samples dyed with (Marigold flowers, Onion outer skins, Fenugreek seeds, and green coffee)

Dye absorption and color measurement:

Analysis of variance in terms of L.S.D for four natural dyestuffs using three dyeing techniques have significant effects on K/S and Color Fastness Properties (Perspiration fastness "Acidic and alkaline", Wash fastness and Rubbing fastness "dry and wet"), and non-significant effects on Light fastness as indicated in Table (1).

Table 1. Effect of dyestuffs on fastness and K/S

Dyestuffs	Mean sum of squares						
	Light fastness	Perspiration fastness		Wash fastness	Rubbing Fastness		K/S
		acidic	alkaline		dry	Wet	
Fenugreek	3-4	3	3-4	3-4	3	3-4	1.14
Onion	4	2	3	3	4	4	1.08
Marigold	4	3	3	3	4	4	2.69
Green Coffee	4	4-5	4-5	4	4-5	3-4	0.84
LSD at 0.05	**NS**	**0.486**	**0.538**	**0.458**	**0.486**	**0.513**	**0.069**

The color strength (K/S):

Results are presented in Fig. (12), values of K/S were used to determine color shade and dye absorption of dyed cotton fabrics. Represented the effect of four natural dyestuffs on the values of K/S using three dyeing techniques. Shades of dark yellow dye were obtained from marigold flowers, and onion dye which gave a relatively dark yellow color, with mordant playing a crucial role in imparting color to the fabric. The use of mordant Alum results in a yellow hue that remains on cotton fabrics.

Table 2. Cotton samples dyed with natural dyestuffs by different processes

Dyeing Processing → **Dyestuffs ↓**	**Conventional**	**Microwave**	**Infrared Rays (IR)**
Marigold flower			
Onion skins			
Fenugreek seeds			
Green coffee			

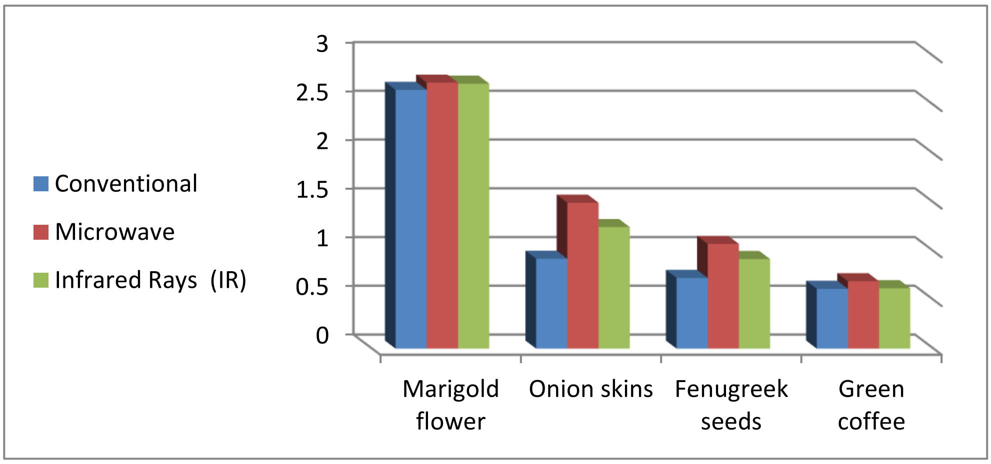


Fig. 12. Effect of dyeing processes with 4 dyestuffs on fabrics Color Strength (K/S)

Evaluation of color fastness properties:

Color fastness to light:

Light fastness is the measure of a dyed fiber's ability to resist fading when exposed to light. Initially, oxidation reaction occurs rapidly when the fiber is exposed to light, causing a sudden change in its color. According to Table (1), neither the four natural dyestuffs nor the three different dyeing techniques had any significant impact on light fastness. Table (3) showcases the light fastness of fabric samples, indicating only slight variations between dyestuffs. While the light fastness of several natural dyes, particularly those extracted from flower petals, ranges from moderate to good, some produce outstanding results.

Table 3. Light fastness values of the cotton samples dyed with different processes

Dyeing Processing → **Dyestuffs ↓**	**Conventional**	**Microwave**	**Infrared Rays (IR)**
Marigold flower	4	4 - 5	4
Onion skins	4	4	4
Fenugreek seeds	4 - 5	4 - 5	4 - 5
Green coffee	4 - 5	4 - 5	4 - 5

Gray scale rating is based on 5-step scale where (1) is bad and 5 is very good.

Color fastness to wash:

The tables (1, 4) show that the cotton fabric dyed with Green Coffee had the highest wash fastness values (4-5) with Conventional and Microwave dyeing processing. The analysis of variance in terms of L.S.D for the (4) types of dyestuffs with (3) methods of dyeing processing had significant effects on wash fastness. The wash fastness of dye in fabric depends on the speed of dye diffusion and the state of the dye within the fibers. According to Jothi (2008), the dye extracted from Green Coffee shows excellent wash fastness because it tends to aggregate inside the fibers. However, Jothi also noticed a change in color in some dyed samples after washing with soap. This change may be due to the dye decomposing into a colorless or differently colored compound, the weak bond between the natural dye and the fibers causing the dye to detach from the fabric, or the ionization of the natural dye during alkaline washing. To prevent this, Jothi recommends using mild, non-ionic soap when working with these types of dyes (Jothi, 2008).

The ability of a fabric to withstand washing depends on its physical and chemical properties, as well as the type of dye used, its interaction with the fabric, and how it reacts with soap (David, 2014).

Table 4. wash fastness values of the cotton samples dyed with different processes

Dyeing Processing → / Dyestuffs ↓	Conventional	Microwave	Infrared (IR)
Marigold flower	3	4	3 - 4
Onion skins	4	3	3
Fenugreek seeds	3	4	3
Green coffee	4 - 5	4 - 5	4

Gray scale rating is based on 5-step scale where (1) is bad and 5 is very good.

Color fastness to rubbing:

Color fastness to rubbing is an important parameter to consider when evaluating colored fabrics. It measures the amount of color that may transfer from a colored fabric to an uncolored bleached test cloth during rubbing. According to Table 5, the cotton fabric dyed with Fenugreek seeds using the Microwave process had the highest rubbing fastness values (4-5 for dry and wet conditions).

Table 5. Rubbing fastness values of the cotton samples dyed with different processes

Dyeing Processing → / Dyestuffs ↓	**Conventional**		**Microwave**		**Infrared (IR)**	
	dry	**wet**	**dry**	**wet**	**dry**	**wet**
Marigold flower	4 - 5	4	4	4	4 - 5	4
Onion skins	4	3 - 4	3 - 4	3 - 4	4	4
Fenugreek seeds	4 - 5	4	4 - 5	4 - 5	4	4
Green coffee	4 - 5	4	4 - 5	4	4	4

Gray scale rating is based on 5-step scale where (1) is bad and 5 is very good.

Color fastness to perspiration:

Perspiration is slightly acidic. When dilute acids act on fabric, they produce hydrocellulose by breaking the chains through hydrolysis. This process weakens the fabric's tensile strength and breaks down the covalent bonds between the fabric and natural dyes. Based on the data presented in Table 6, we can see that cotton fabric dyed with Green coffee had the highest perspiration fastness values (acidic 4-5, alkaline 4-5).

Table 6. Perspiration fastness values of the cotton samples dyed with different processes

Dyeing Processing → / Dyestuffs ↓	**Conventional**		**Microwave**		**Infrared Rays (IR)**	
	acidic	**alkaline**	**acidic**	**alkaline**	**acidic**	**alkaline**
Marigold flower	3	3	3 - 4	3 - 4	3	3
Onion skins	3	3	3 - 4	3 - 4	3	3
Fenugreek seeds	2	2	2	2	2	2
Green coffee	4 - 5	4 - 5	4 - 5	4 - 5	4 - 5	4 - 5

Gray scale rating is based on 5-step scale where (1) is bad and 5 is very good.

DISCUSSIONS

FTIR spectroscopic analysis:

Untreated cotton fabric has specific characteristics that can be identified through certain peak vibrations. For instance, the O-H bond stretching mode is represented by a broad peak at 3337 cm^{-1}, while the C-H bond stretching mode is identified by a peak at 2917 cm^{-1}. Additionally, the peaks at 1428 $cm^{-1}$and 1315 cm^{-1} correspond respectively to the C-O stretching mode and the C-O-H bending mode. All these peaks are related to chemical structure of cellulosic pure cotton fabric. Chunga et al., (2004) noted that despite the presence of –CH_2– groups in cellulose, the peaks corresponding to symmetric and asymmetric stretching modes are not distinctly separated as sharp peaks. The IR spectrum of lutein shows characteristic absorption peaks at 3425 and 1631 cm^{-1}, which are due to the stretching vibration of the intermolecular hydroxyl group and the conjugated double bond. Additionally, the symmetrical and asymmetrical vibrations of hydroxyl groups and -

COO- groups are represented by bands at 3425, 1631 and 1411 cm^{-1}. The peak at 1035 cm^{-1}indicates the vibration of the C-O-C group.

The FTIR spectra of the cotton fabrics dyed with the onion skin extract displayed strong flavonoids functional group C=O at 1624.05 cm^{-1}. Untreated cotton fabric doesn't show any absorption peak in this area. This explains why onion skin grafting cotton fabric expresses the yellowish color. The cotton fabrics dyed with green coffee extract displayed similar absorption bands at 3500-3900 cm^{-1}, corresponding to the OH stretch, as observed in the undyed cotton fabrics. However, new peaks at 1100 $cm^{-1}$and 1500-1800 cm^{-1}were observed in the spectra of the dyed cotton fabrics, which is a unique feature not found in plain, un-dyed cotton fabrics. Additionally, the peak at 2358 cm^{-1}on the undyed cotton fabric had a weaker intensity after the dyeing process and disappeared completely after dyeing the cotton fabrics. Fenugreek seeds contain numerous flavonoids and quercetol, which are already used for dyeing textiles. The FTIR spectra of cotton fabrics dyed with Fenugreek seed extract showed strong bands at 1657 cm^{-1} (C=O, amide I) frequency, which is unique and not present in plain, un-dyed cotton fabrics. The spectrum provides strong evidence that the dye and cellulose have undergone chemical functional bonding, forming a permanent and durable bond that will withstand the test of time.

Evaluation of color fastness properties:

The color strength (K/S):

The results revealed that the highest K/S (2.7286) values were obtained for Marigold using microwave dyeing process followed by onion (1.4968), while the K/S value for Fenugreek was (1.0743), using IR dyeing process, by a small margin, where the lowest K/S (0.6141) values were obtained for Green coffee with Conventional process. Analysis of variance in terms of L.S.D at 0.05 has significant effects on K/S (0.069) for the four natural dyestuffs with three-dyeing processing, as indicated in Table (1) and the dyeability of Cotton fabrics were shown in Table (2).

Color fastness to light:

To enhance the light-fastness properties of various naturally dyed textiles, extensive research has been undertaken (Samanta and Agarwal, 2009) it is crucial to dye mordanted cotton fabrics immediately, as some mordants are susceptible to light. Although the dye's chromatophore makes it resistant to photochemical attack, the auxochrome from the dye might affect the color's fastness (Jothi, 2008).

Color fastness to wash:

According to Jothi (2008), the dye extracted from Green Coffee shows excellent wash fastness because it tends to aggregate inside the fibers. However, Jothi also noticed a change in color in some dyed samples after washing with soap. This change may be due to the dye decomposing into a colorless or differently colored compound, the weak bond between the natural dye and the fibers causing the dye to detach from the fabric, or the ionization of the natural dye during alkaline washing. To prevent this, Jothi recommends using mild, non-ionic soap when working with these types of dyes (Jothi, 2008). The ability of a fabric to withstand washing depends on its physical and chemical properties, as well as the type of dye used, its interaction with the fabric, and how it reacts with soap (David, 2014).

Color fastness to rubbing:

Although the differences between the rubbing fastness values were minimal, the L.S.D for the four types of dyestuffs with three methods of dyeing processing had significant effects, as indicated in Table 1. Overall, most natural dyes have good to excellent rub fastness. The results of the rubbing fastness test showed good penetration and fixation of the dyes.

Color fastness to perspiration

Due to its higher affinity to cotton fabric. Conversely, cotton fabric dyed with Fenugreek seeds had the lowest perspiration fastness values (acidic 2, alkaline 2). It is observed from the results that the color fastness of dyed cotton fabric to perspiration is fair. L.S.D for the (4) types of dyestuffs with (3) methods of dyeing processing had significant effects as indicated in Table (1). It's important to keep in mind that the color fastness of natural dyes isn't solely determined by the chemical nature and type of colorant. It also depends on the chemical nature and types of mordant used. To achieve the best color fastness, a dyer should have a good understanding of how to properly combine fiber and mordant. Further research is needed to identify natural agents that improve the wash and light fastness of natural dyes (Yahaya ado, 2014).

CONCLUSION

This research demonstrates that textiles can be colored using readily available plants like marigold flowers, onion outer skins, fenugreek seeds, and green coffee. The colors obtained vary based on the type of mordant used. Additionally, cotton fabric can be naturally dyed using microwave heating technology, with the shade of color changing depending on the duration and power of the microwave irradiation. Microwave dyeing is a feasible and eco-friendly method with low energy consumption, making it suitable for industrial production. Microwave energy is more efficient than traditional methods for the textile industry, saving time and energy while reducing production costs. Its use is growing, and promoting awareness can attract investment. Further studies are necessary to optimize the dyeing process and improve dye performance by investigating the nature of dyes and their interaction with cellulose.

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مقارنة تقنيات الصباغة المختلفة باستخدام المستخلصات النباتية على الأقمشة المنسوجات القطنية

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الأصباغ الطبيعية ذات أهمية كبيرة لأنها غير سامة، وغير ضارة بالمنسوجات، وصديقة للبيئة, ولزيادة الوعي البيئي من أجل تجنب بعض الأصباغ الاصطناعية الخطرة والمسرطنة، تم اجراء هذه الدراسة لتقييم طرق الصباغة المختلفة في صباغة الاقمشة القطنية بأصباغ طبيعية.

فى هذة الدراسة تم استخدام بعض الاصباغ الطبيعية التى تعطى درجات من اللون الاصفر بعد استخلاصها وهى (ازهار القطيفة – قشر البصل الخارجية – بذور الحلبة – القهوة الخضراء) على قماش 100% قطن(جيزة 86) وصباغتها بثلاث طرق مختلفة للصباغة وهى (صباغة تقليدية – الميكرويف – والاشعة تحت الحمراءIR).

وبدراسة خصائص اللون والسطح للأقمشة القطنية المصبوغة باستخدام مقياس الطيف الضوئي Spectrophotometryلقياس عمق اللون (K / S)، وكذلك اختبارالعينات المصبوغة والغير مصبوغة باستخدام(FTIR) لمعرفة أداء وخصائص هذه الأصباغ الطبيعية, كانت النتائج كالتالي:

- وجد أن الأقمشة المصبوغة بمستخلص زهرة القطيفة أعطت اللون الاصفر الغامق، بينما اظهرت النتائج اللون الاصفر الفاتح للعينات المصبوغة بالقهوة الخضراء ، اما باقى الصبغتين اعطت درجة متوسطة من اللون الاصفر .

- كما تم قياس ثبات اللون للعينات(الغسيل – الاحتكاك – الضوء – العرق) اعطت فى المدى من جيد الى ممتاز اعلاها مع القهوة الخضراء,واقلهم ثباتا مع قشر البصل الخارجية.

- اظهرت النتائج ان استخدام تقنية الميكرويف حققت احسن نتائج فى عمق اللون ودرجة ثبات جيدة وأيضا ليس لها تأثير ضار على الاقمشة القطنية.

-لذلك توصى الدراسة بتطبيق استخدام الميكرويف كمصدر حرارى لصباغة وتجهيز المنسوجات لتحقيق البعد البيئى والاقتصادى من حيث الوقت والطاقة المستخدمة.

الكلمات المفتاحية: تقنيات الصباغة، صديقة للبيئة، خصائص اللون.