EXTRACTION OF NATURAL DYES FROM AFRICAN MARIGOLD FLOWER (TAGETES EREECTA L) FOR TEXTILE COLORATION

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Abstract:

African marigold [Tagetes erecta L.], a major source of carotenoids and Lutin, is grown as a cut flower and a garden flower, in addition to being grown for its medicinal values. Marigold flowers [Tagetes], which are yellow to orange red in colour, are a rich source of lutein, a carotenoid pigment. Nowadays, Lutein is becoming an increasingly popular active ingredient used in the Food Industry and Textile coloration [3].This pigment has acquired greater significance because of its excellent colour value. Although marigold flower extract has been used in veterinary feeds, the potential use of marigold as a natural textile colorant has not been exploited to its full extent. This is due to the lack of information on its safety, stability, and compatibility in textile coloration. In this study, an experiment was conducted to study the use of an extract isolated from marigold as a natural dye. The dye potential of the extract was evaluated by dyeing [6], using the flower, in 100 % cotton and silk fabrics under normal dyeing conditions. Studies of the dyeability, wash fastness, light fastness, and colour hue were undertaken [8,9,10]. The, L,a and 'b' of materials dyed using the extract were studied with the use of Computer Colour Matching software [9,10]. The surface colour was not affected by washing, and the quality of the flower was maintained even washing at 60o C for 30 minutes. Studies have indicated that the change of some of the colors have been noticed after washing with soap [8]. Most of the metal salts exhibited the highest K/S values, due to their ability to form coordination complexes with the dye molecules [1,2]. These findings reveal that the extract of Marigold flower can be used for coloration of !00 % cotton, silk, and wool fabrics. This article deals with the chemistry, processing, and stability of the pigment and its applications in textile coloration.

Keywords:

dyeing, cotton, silk, Tagetes erecta L.

Introduction

Dyeing is an ancient art, which predates written records. It was practiced during the Bronze Age in Europe. Primitive dyeing techniques included sticking plants to fabric or rubbing crushed pigments into cloth. The methods became more sophisticated over time and techniques were developed using natural dyes from crushed fruits, berries and other plants, which were boiled into the fabric and gave light and water fastness [resistance]. In many of the world's developing countries, however, natural dyes can offer not only a rich and varied source of dyestuff, but also the possibility of an income through sustainable harvest and sale of these dye plants. Many dyes are available from tree waste or can be easily grown in market gardens [7]. In areas where synthetic dyes, mordants [fixatives] and other additives are imported and are therefore relatively expensive, natural dyes can offer an attractive alternative [6]. In Ethiopia for example, there is a wealth of marigold flowers available for producing natural dyes, but due to lack of knowledge of the processes involved in harvesting and processing the plants, little use is made of this natural resource. Presently there is an excessive use of synthetic dyes, estimated at around 10,000,000 tons per annum [7], the production and application of which release vast amounts of waste and unfixed colorants, causing serious health hazards and disturbing the eco-balance of nature. Currently, ecological considerations are becoming important factors in the selection of consumer goods all over the world. Since the mid-1980s, more interest has been shown in the use of natural dyes and a limited number of commercial dyes, and small businesses have started to look at the possibility of using natural dyes for coloration [11]. At present, large and small-scale industries have begun exploring the use of natural colorants as a possible means of producing an ecologically sound product which would also appeal to the ²Green-minded" consumer. In this study, colour pigments were isolated from the marigold flower [Tagetes erecta] and studied in order to understand the processes taking place during its usage in textile coloration.

Methodology, Materials and Methods

Materials

Flower color chosen

A dark yellow variety of marigold flowers were collected from the Bahir Dar University campus.

Substrates

Desized and scoured cotton, bleached, and silk fabrics were used for dyeing.

Chemicals

Alum, copper sulphate, stannous chloride and ferrous sulphate.

Methods

The dyeing of cotton and silk with marigold flower was carried out in four stages; Pre-Treatment, Extraction of dyes from flower, Mordanting (fixing dye with fiber) and Dyeing

Extraction of colorant

Flowers from the plant source were crushed and dissolved in distilled water and allowed to boil in a beaker kept over water bath for quick extraction for 2 hours. All the color was extracted from flowers by the end of 2 hours. The solution was filtered for immediate use. The flowers were also dried in trays, in thin layers, in a current of warm air immediately after picking.

Scouring of Cotton and Silk

Silk and cotton fabrics and wool yarn were washed in a solution containing 0.5 g/L sodium carbonate and 2 g/L non-ionic detergent solution at 50º C for 25 min, keeping the material to liquor ratio at 1:40. The scoured material was thoroughly washed with tap water and dried at room temperature. The scoured material was soaked in clean water for 30 min prior to dyeing or mordanting.

Mordanting

Accurately weighed cotton, silk and wool samples were treated with different metal salt, only premordanting with metal salts was carried out before dyeing. The mordant 2% (owf) was dissolved in water to make a liquor ratio 1:40. The wetted sample was entered into the mordant solution and then brought to heating. Temperature of the dye bath was raised to 80ºC over a period of half an hour and left at that temperature for another 30 minutes. The mordanted material was then rinsed with water thoroughly, squeezed and dried. Mordanted cotton and wool needed be used immediately for dyeing because some mordants are very sensitive to light.

Table 1. Different pre-mordant, K/S value, fastness properties, and L*, a*, b* values for dyed cotton with Marigold flower at l_{max} = 453nm

Mordant	Wash fastness IS 687-79	Light Fastness IS-2454-85	Rubbing fastness IS-766-88	L*	a*	b*	K/S Value
Alum	3/4	IV	4/5	70.66	10.60	80.8	0.1765
Ferrous sulphate	4-5	IV	4	20.08	4.60	10.1	1.0367
Copper sulphate	4	IV	4	49.41	4.21	42.6	1.1736
Stannous chloride	4	III	4	63.32	36.68	77.7	0.1770

Table 2. Different pre-mordant, K/S value, fastness properties, and L*, a*, b* values for dyed silk with Marigold flower at l_{max} = 453nm

Mordant	Wash fastness IS 687-79	Light Fastness IS-2454-85	Rubbing fastness IS-766-88	L*	a*	b*	K/S Value
Alum	3/4	III	4	58.05	23.44	58.1	0.3719
Ferrous sulphate	4	IV	4	48.81	0.74	24.0	1.2765
Copper sulphate	4	IV	4-5	51.53	9.75	50	0.8594
Stannous chloride	2/3	II/III	4	70.108	16.99	80.33	0.1415

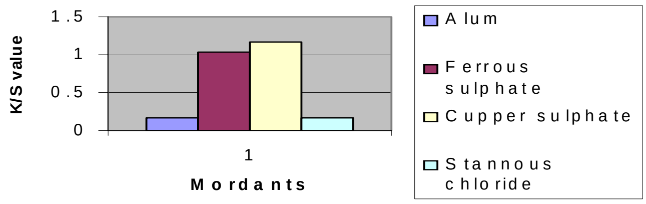

Figure 1. K/S values of cotton dyed with Marigold Flower with different Mordant

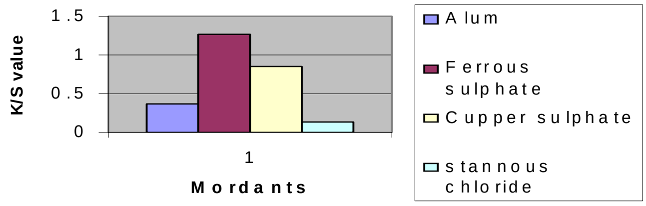

Figure 2. K/S values of silk fabric dyed with Marigold Flower with different Mordants

Dyeing

The cotton and silk samples were dyed with dye extract, keeping M:L ratio as 1:40; however for cotton dyeing it was used directly while in the case of silk dyeing the pH was maintained at 4 by adding a buffer solution (sodium acetate and acetic acid). The dye extract was prepared by adding 4 gm dye powder in 100ml water (M:L: 1: 40). Dyeing was done by the conventional dyeing method. After dyeing, the dyed material was washed with cold water and dried at room temperature. It was then dipped in brine for dye fixing. The color strength was determined calorimetrically using Computer Colour Matching software at the maximum wavelength of the natural colorant.

Results and Discussion

Fastness properties of dyed samples

Light fastness of dyed samples

The resistance of a dye or pigment to chemical or photochemical attack is an inherent property of the dye chromophore, but at the same time the auxochrome may also substantially alter the fastness either way (1,2). The substitution pattern of dyes seems to play an important role in determining their light fastness. A particular substituent may increase the electron density around the reaction site of the molecule facilitating oxidation, or it may reduce the electron density with a resultant increase in case of reduction. It can be seen that the structure of Marigold flower (Fig-3) having two hydroxyl groups, gives good fastness (12).

Samples dyed with marigold extract by using iron and copper sulphate as a mordant have a good light fastness.This is due to the formation of a complex with transition metal which protects the chromophore from photolytic degradation, and the photons sorbed by the chromophoric group dissipate their energy by resonating within the six member ring thus formed, and hence protecting the dye.

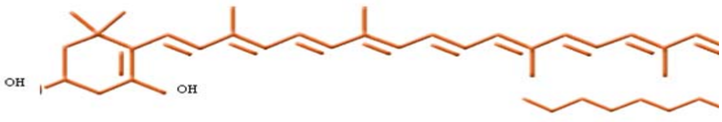

Figure 3. Chemical structure of carotenoid

Wash fastness of dyed samples

Wash fastness of dye is influenced by the rate of diffusion of dye and state of dye inside the fiber. The dye extracted from marigold exhibits good to excellent wash fastness. This is an unusual occurrence in the Ethiopian natural resource product, considering the fact that they are characterized by very low molecular weight as compared to synthetic dyes. Another reason is that they have a tendency to aggregate inside the fiber (thereby increasing the molecular size) and hence exhibit good wash fastness. Complexing with mordant also has the effect of insolubilizing the dye, making it color fast.

<u>Effect of washing on color consistency of treated samples</u>

Figures 4-9 present change in color after soap wash using different pre-mordants.

Our studies indicated that a change of some of the colors could be noticed in the dyed samples (Figures 4,5,6,7,8,9) after washing with soap [13]. This is may be due to several factors, such as:

- The dye itself decomposes, thus converting to colorless or a differentially colored compound.
- The dye detaches from the substrate due to the wear dye-fiber bond between the natural dye and the fiber.
- Ionization of the natural dye during alkaline washing. Since most of the natural dyes have hydroxyl groups, which ionize under alkaline conditions, some of the samples dyed in acidic conditions faded when washed with alkaline soaps. The use of mild non-ionic soaps are recommended for use with these dyes.

Natural dyes mostly require a mordant to be fixed onto the fiber. Common mordants like alum, copper sulphate, potassium dichromate, iron salts and stannous chloride have an affinity for the dye and the fiber then forms an insoluble precipitate with the dye in the fiber. Wash fastness and light fastness is given in Tables1 &2, and it can be seen that those of iron sulphate are good. During washing the sample with alkaline powder there is a complete change in the color of the sample, instead of fading (13). So the wash fastness rating measurement using the grey scale was somewhat difficult as the samples before wash and after wash look completely

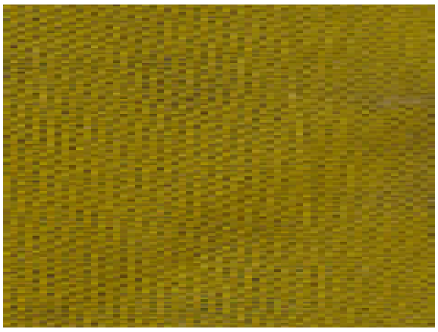

Figure 4. Pre-mordant with Alum before wash

Figure 6. Pre mordant with ferrous sulphate before wash

Figure 8. Pre mordant with copper sulphate before wash

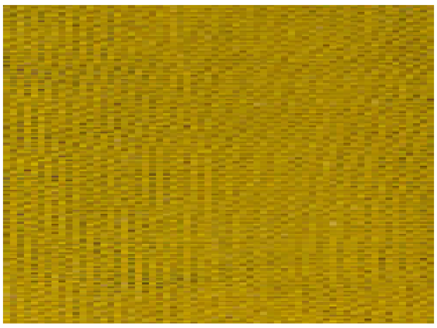

Figure 5. Pre-mordant with Alum after wash

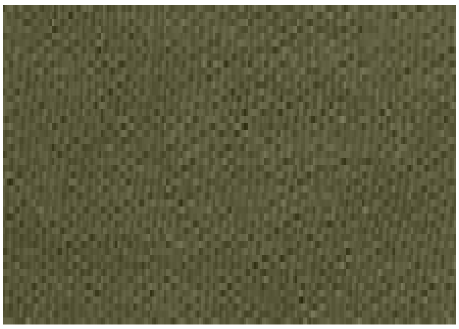

Figure 7. Pre mordant with ferrous sulphate after wash

Figure 9. Pre mordant with copper sulphate after wash

different in color. Light fastness of stannous chloride is 2/3. It fades slightly on exposure to sunlight for more than two hours.

<u>Optimization of mordants with K/S and Color hue changes</u>

Figures 10-13 present 100 % cotton samples dyed with African Marigold Flower using different mordants

Figures 14-17 present silk dyed with marigold flower using different mordants

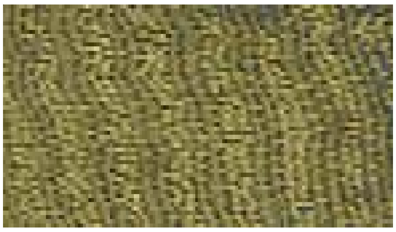

Figure 10. Mordant with Ferrous sulphate

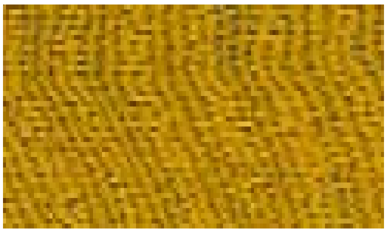

Figure 12. Mordant with Alum

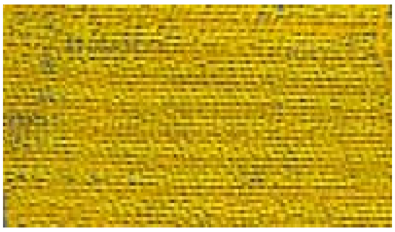

Figure 11. Mordant with Stannous chloride

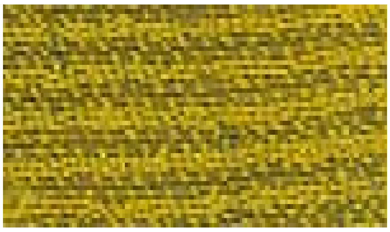

Figure 13. Mordant with Alum

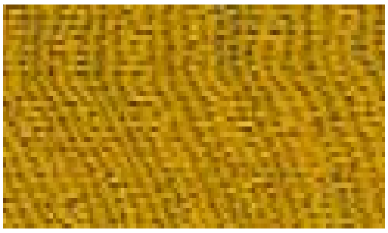

Figure 14. Mordant with Alum

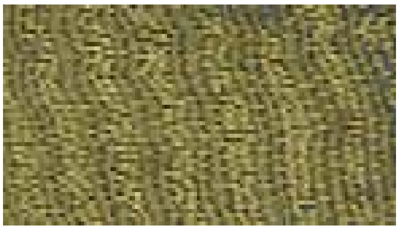

Figure 16. Mordant with Ferrous sulphate

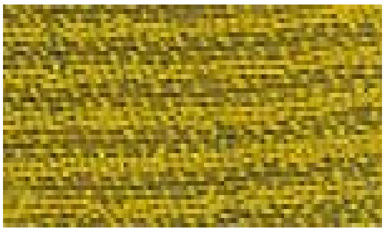

Figure 15. Mordant with Copper

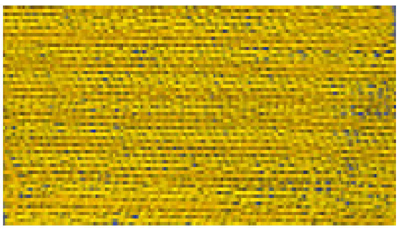

Figure 17. Mordant with Stannous chloride

The color yields of both dyed and mordant samples were evaluated by light reflectance measurements using Computer Color Matching software (CCM) (9,10).The color strength (K/S value) was assessed using the Kubelka-Munk equation [4,5]:K/S= (1-R)2/2R, where R is the decimal fraction of the reflectance of dyed yarn

Different mordants are used in 2-4%, keeping in mind the toxicity factor of some mordants. Varied hues of color can be obtained (Figures 10,11,12,13,14,15,16,17) from premordanting the cotton and silk fabrics and wool yarn with $FeSO_4$, $SnCl_2$, $CuSO_4$, and alum were dyed by aqueous extract of marigold. As shown in the Table-1 the different mordants not only cause differences in hue color and significant changes in K/S values but also L* values and brightness index values. Most of the metal salts exhibited the highest K/S values due to their ability to form coordination complexes with the dye molecules. This strong coordination tendency of Fe enhances the interaction between the fiber and the dye, resulting in high dye uptake, while all other metals show similar coordination. This is clearly shown in Figures 1&2.

CONCLUSIONS

In this century, a global awareness is already in place favoring the use of natural resources for protecting the environment and earth from pollution and ecological imbalances. The present scenario is focused more towards the utilization of the vast diversity of natural resources of color pigments for their use in food materials, pharmaceuticals and textiles, in place of their synthetic counterparts. This trend is aimed at safeguarding human health as well as protecting and prolonging life on earth. Detailed scientific studies with natural dyes have established that in most cases their properties are comparable to those of synthetic dyes. Therefore, if natural dyes have to be commercialized, they need to conform to the same stringent standards of performance that are applied to synthetic dyes. It thus follows that much more research and developmental effort needs to go in this area. The traditional practices may have to be substituted by modern, more scientific practices in order to overcome some of the so-called disadvantages of this dye. The above findings strongly suggest and reveal that Ethiopian natural resources could be successfully used for textile coloration. The above test results strongly indicate that Ethiopian natural resources could have a great value in textile coloration and in the export market.

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