Environmental friendly dyeing of silk using temple used marigold flower

Abstract:

The disposal of temple floral waste, including marigold (*Tagetes erecta* L.) flowers, into water bodies contributes significantly to river pollution. This study presents a novel and eco-friendly approach for utilizing marigold floral waste as a natural dye for silk fabrics, eliminating the need for chemical solvents in the dyeing process. The aqueous extraction method was employed to obtain the dye, highlighting its sustainability and alignment with green chemistry principles. The dyeing process was conducted on 100% silk fabrics under optimized conditions. The dyed fabrics exhibited vibrant and uniform coloration, which was analyzed using a Colorimeter to determine L, a, and b values. The results demonstrated high color fastness, with the surface color remaining intact even after a 30-minute washing cycle at 60°C. This is the first study to successfully utilize marigold floral waste for silk dyeing without the use of chemical solvents, offering a sustainable alternative to synthetic dyes. By repurposing temple waste and avoiding harmful chemicals, this method addresses environmental concerns associated with both floral waste disposal and textile dye pollution. The findings highlight the potential of this innovative approach for sustainable textile coloration while contributing to waste management and pollution reduction.

Keywords: Lutein, natural dye, marigold, colorimeter

Introduction:

India is among the twelve mega-diverse nations globally and is recognized as one of the eight primary centers for the origination and diversification of domesticated taxa. The country is endowed with over 500 species of plants that yield dyes, a gift from nature (Dayal, R., et al., 2001) (Siva, R., et al., 2007), some notable examples include edible ornamental crops, such as African marigold (*Tagetes erecta* L.), rose, and *Butea monosperma* etc. (Niizu, P. Y., et al., 2005). The textile sector relies heavily on synthetic dyes (Sudha, M., et al.,2014) which are primarily derived from inexpensive petroleum. These sources are harmful to health, detrimental to the environment, and toxic to aquatic life (Pervaiz, S., et al., 2016, Devi, V. N. M., et al., 2013, and Dan'Azumi, S., et al.,2010). Given the present environmental awareness, researchers have redirected their focus towards the utilization of natural dyes for dyeing textiles in recent years.

Currently, there is a global inclination towards employing natural colors in diverse industries because of the environmental risks stemming from the excessive use of synthetic dyes. The continuous increase in the popularity of natural dyes is due to the fact that their production and application don't require strong acids or alkalis (Samanta, K. A., et al.,2009 and Bhuyan, R., et al.,2004). Despite the historical usage of natural dyes spanning 5000 years, synthetic dyes prevail because of their wide availability and cost-effectiveness, which are attributed to their superior reproducibility and favourable application characteristics. Given their specific strengths and constraints, natural dyeing persists predominantly for specialized products, whereas synthetic dyes have been extensively adopted for general textiles owing to their advantages and scalability (Punrattanasin, N., et al., 2013). Pigments can be derived from the roots, barks, leaves, fruits, and flowers of plants. Natural dyes not only offer medicinal benefits but also enhance the product's aesthetic appeal. They are distinctive and environmentally friendly (Rungruangkitkrai, N., et al.,2012). The utilization of plant-based natural dyes dates back to ancient civilizations. The Ajanta, Ellora, and Bagh caves' paintings were created using these dyes, and they remain conserved as significant historical monuments by the Archaeological Survey of India (Devi, V. N. M., et al., 2013).

Marigold, scientifically known as *Tagetes erecta*, is a member of the Asteraceae family. This compact shrub produces abundant yellowish-orange flowers that flourish for over 6-8 months during the flowering season. Native to various regions in India and Sri Lanka with a humid climate, *Tagetes erecta* is recognized for its pigments, primarily composed of carotenoids and flavonoids. These natural compounds have found applications as food colorants and additives in feed, serving diverse purposes (Vasudevan, P., et al.,1997). The marigold flower crop is plentiful in tropical regions, primarily cultivated for decorative, medicinal, and cosmetic purposes. Additionally, the marigold flower serves as a valuable source of natural dye, with lutein being the primary component responsible for its coloration. The blossoms are presented as offerings to the deities in temples, resulting in a substantial quantity of flowers categorized as temple waste. In Kanpur city alone, the total estimated daily waste amounts to 20 tonnes. A significant portion of these flowers is either discarded along the banks of the Ganga River or left to decompose naturally, eventually being employed as compost (Vankar, P. S., et al.,2009). We have harnessed the potential of this discarded material, utilizing its colorant for the purpose of dyeing. The marigold flower is recognized as a valuable natural dye source, with lutein serving as its primary colorant component (Piccaglia, R., et al.,1998 and Sowbhagya, H., et al., (2004). Researchers have found that lutein, a water-soluble pigment, acts akin to a dye. Various studies have documented the dyeing of different textile substrates using marigold flower extracts (Adeel, S., et al.,2017 and Agarwal, R., et al., 2007). The widespread use of synthetic dyes has led to an increase in environmental pollution and health risks. Consequently, environmentally conscious consumers are turning back to natural and biodegradable alternatives (Bechtold, T., et al., 2003). Natural dyes, typically lacking inherent substantivity, require the assistance of mordants, with an affinity for both the coloring matter and the fiber, for application on textiles. Consequently, this study aimed to specifically extract a natural dye from African marigold flower petals without the use of any solvent. The investigation also sought to assess the dyeing effects on silk fabric samples. The study included impact on dye stability and color shade. Color shade differences, L*, a*, b*, and c* values were evaluated using spectrophotometer NS800.

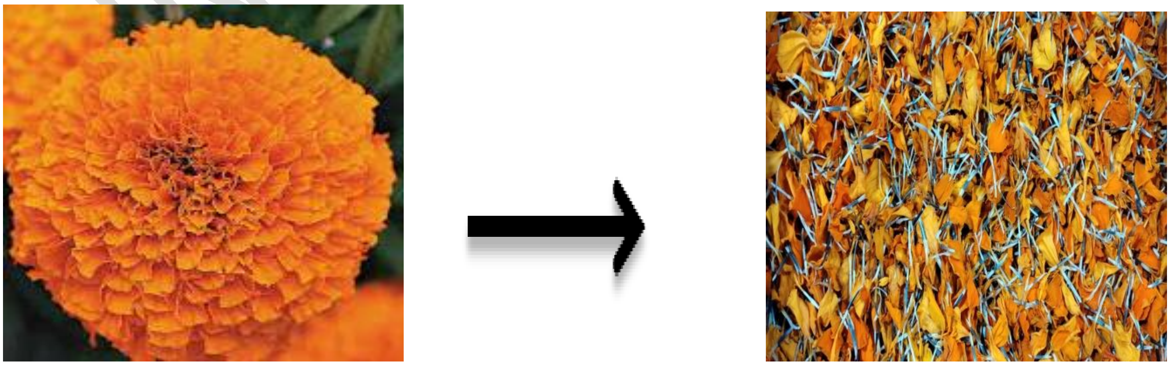

Fig. 1: Marigold flower (*Tagetus erecta*) from temple and it’s petals.

Material and Methods:

Material

Silk material was procured from local market. Temple waste flowers were collected from local areas of Lucknow. Alum was used as natural mordant. The washing method uses sodium carbonate and nonionic detergent. The dyeing method was carried out stepwise i.e., pre-treatment of silk cloth, extraction of dye, mordanting and dyeing of fabric and colour fastness test.

Methods

Preparation of fabric*:*

The samples of silk textiles were washed at 50°C for 25 minutes in a solution containing 0.5g/l sodium carbonate and 2g/l nonionic detergent keeping the material to liquor ratio at 1:50 as a pre-dyeing procedure. The scouring material was carefully cleaned with water before being allowed to air dry.

Extraction Method:

Fresh marigold flowers were collected from local temples of Lucknow, and there petals were separated from flower. The 100 gm petals were then subjected to grinding in mixer grinder with 40ml of distilled water. The slurry of marigold petals was then filtered with help of 60 mesh. The filtrate obtained was then used for dyeing as the method given below.

Dyeing Method:

The dyeing process was executed as follows: The obtained filtrate was diluted with water at a ratio of 1:10. Simultaneous mordanting was carried out using alum, where 20 grams of alum were blended into a solution containing the diluted slurry of the extract. Subsequently, silk fabrics were immersed in this solution. The dyeing procedure lasted for 2 hours at a temperature ranging from 30 to 80°C. After this period, the dyed fabrics were removed and pressed to eliminate excess dye. The dyed materials were then immersed in a saturated brine solution for 15 minutes, serving as a dye fixative, followed by thorough rinsing in tap water. Finally, the dyed fabrics were left to air dry.

The colorimetric data obtained from the dyed fabrics, which had undergone pre-treatment and fixation with a brine solution, revealed a significant enhancement in wash fastness. This improvement was evident in terms of the change in shade of the dyed fabrics and an increase in color strength.

HPLC analysis of extract of marigold flowers

The Shimadzu Prominence system, equipped with an autosampler (SIL-20 AC), LC Solution 1.0 software, and a DAD detector, was employed for the HPLC analysis of the aqueous extract obtained from marigold flowers. The plant extract was examined in triplicate at a concentration of 1 mg/ml, following the procedure outlined by Bhattacharya et al.,(2010). The analysis was conducted under the specified conditions, utilizing a C18 column (dimensions: 250 mm x 4.6 mm, particle size: 5 µm) as the stationary phase. The mobile phase consisted of acetonitrile/methanol/ethyl acetate (9:1:2), with an injection volume and flow rate set at 1.5 ml/min. The wavelength for analysis was fixed at 447 nm. All reagents employed in the chromatographic analysis were of HPLC grade.

Statistical analysis

The color characteristics (L*, a*, b*, ΔE) of the fabric were assessed using a colorimeter through six washing cycles. The fastness properties for each dyeing condition were analyzed using variance analysis, with each treatment being replicated three times, and the standard error of difference (SED) was calculated (±).

Result and Discussion

The provided table illustrates the L*, a*, b*, C*, and h^o values of the silk textile following six washes, as measured by a colorimeter. A maximum L* value of 100 indicates a perfectly reflecting diffuser, while the minimum value of 0 corresponds to black. Positive 'a' signifies red, whereas negative 'a' represents green. Positive 'b' denotes yellow, and negative 'b' indicates blue. The color axis operates on the principle that colors cannot simultaneously be red and green or blue and yellow, as these colors are opposites. Notably, there is minimal variation in the specified parameters after six washes, suggesting color stability.

Table 1. The values of color parameters L* (indicating lightness), a*(redness), b*(yellowness), C*(chroma), hº (hue) measured using colorimeter.

	L*	a*	b*	C*	hº
First wash	1.71	0.89	2.52	2.67	70.61
Second wash	1.89	0.90	2.76	2.90	71.93
Third wash	1.86	0.91	2.74	2.89	71.55
Fourth wash	1.77	0.92	2.60	2.76	70.55
Fifth wash	1.78	0.86	2.62	2.75	71.87
Sixth wash	1.81	0.96	2.68	2.85	70.25

Fig. 2: Silk cloth dyed with Marigold flower (*Tagetus erecta*) from temple.

The analysis, of the dye of Marigold flower using high-performance liquid chromatography coupled to a DAD detector (HPLC–DAD), enabled the identification and quantification of lutein labelled as ‘A’ (3R, 3’R, 6’R-βε-carotene-3,3’-diol) in Figure 2 and is classified as a xanthophyll pigment, belonging to the category of oxycarotenoids at retention time of 2.033 previously reported in marigold flower (19) with an area percentage of 53%.

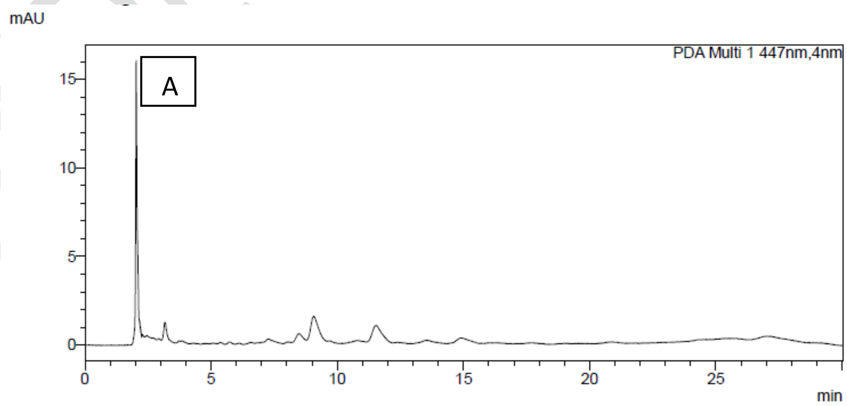

Fig. 3: The chromatographic profile of the marigold dye indicating the identified markers A: Lutein:

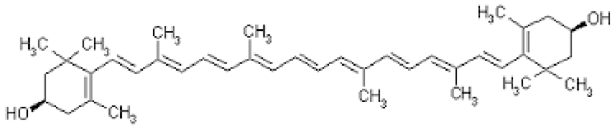

Fig. 4: Structure of Lutein

Conclusion:

The current investigation demonstrates the successful extraction of a natural dye from *Tagetes erecta L.* flowers through an environmentally friendly process, entirely avoiding the use of solvents. Results indicate a significant dyeing potential in marigold flowers, making them a promising source for textile dyeing. The color was produced using an eco-friendly mordant, namely alum. In the contemporary era, there is a growing global awareness advocating for the use of natural resources to protect the environment from pollution and ecological imbalances. The current trend emphasizes the utilization of diverse natural resources for color pigments in food, pharmaceuticals, and textiles, replacing synthetic counterparts to safeguard human health and the longevity of life on Earth.

Scientific studies on natural dyes have revealed that, in many cases, their properties are comparable to synthetic dyes. However, for the commercialization of natural dyes, they must meet the same rigorous performance standards applied to synthetic counterparts. This necessitates further research and development efforts in this field. Modern, scientific practices may need to replace traditional methods to address perceived disadvantages of natural dyes. Achieving good washing and light fastness, particularly when using alum as a mordant, could be a positive factor to consider in contemplating the commercialization of natural dyes for textile applications.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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