

A Comparative Study of Mordant and Dye Concentrations on the Dyeing Efficiency of Safflower (*Carthamus Tinctorius*) on Silk

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Abstract

The growing environmental and health concerns associated with synthetic dyes have renewed interest in natural dyes derived from plant sources. The present study investigates the dyeing efficiency of safflower (*Carthamus tinctorius*) on mulberry silk fabric using alum as a mordant at varying concentrations. Safflower petals were extracted at three dye concentrations (15%, 25%, and 35%), while alum was applied as a fixative agent at similar concentration levels. The dyeing performance was evaluated in terms of colour intensity, shade variation, wash fastness, and light fastness. Results indicated that both dye and mordant concentration significantly influenced colour depth and fastness properties. Optimum dyeing performance was observed at 25–35% concentrations of both safflower dye and alum. The findings confirm that safflower is an effective eco-friendly dye source for silk and holds promise for sustainable textile applications.

Keywords - Natural Dyes, Safflower, Silk Fabric, Alum Mordant, Dye Concentration

1. Introduction

Safflower (*Carthamus tinctorius* L.), a member of the family Asteraceae, is an important oilseed and multipurpose crop cultivated across a wide range of agro-ecological zones in Asia, particularly in India and China [1].

The dried petals of safflower yield two major pigments: carthamidin, which imparts yellow shades, and carthamin, responsible for red hues. These pigments show strong affinity towards protein fibres such as silk and wool under suitable dyeing conditions.

The pigment composition of safflower petals typically includes approximately 3–6% water-insoluble red pigment, mainly carthamin, and 24–30% water-soluble yellow pigments, primarily carthamidin [2]. These pigments, particularly safflower yellow, have attracted considerable interest due to their bright coloration, safety, and wide applicability. Recent studies have demonstrated that *C. tinctorius* exhibits antioxidant, anti-inflammatory, and antidiabetic activities, further enhancing its therapeutic significance [3].

With increasing concerns regarding the environmental and health impacts of synthetic dyes, biodegradable and eco-friendly colorants derived from natural sources have gained prominence as sustainable alternatives [4]. Safflower pigments have been successfully incorporated into food products, where they enhance both aesthetic appeal and functional value. For instance, the addition of carthamidin extracts has been reported to improve the chemical properties of ice cream and other dairy products [2], as well as

enhance the therapeutic potential of functional foods [5]. Carthamin is widely used as a natural coloring agent in foods such as ice cream, jellies, soups, beverages, and cosmetics [1,2]. China has also developed large-scale production of carthamin for use as a red pigment in cosmetic formulations [6].

Considering the economic, medicinal, and industrial importance of safflower petals, there is substantial potential for their utilization as a source of natural colorants across food, textile, and pharmaceutical industries. Therefore, the present study was undertaken to explore the extraction and identification of major pigments from safflower florets. The objectives included isolation and evaluation of their potential applications. This study contributes to a deeper understanding of safflower pigment biochemistry and supports their development as environmentally sustainable alternatives to synthetic dyes.

2. Materials and Methods -

The research was conducted on plain undyed silk fabric using safflower as the natural dye source and alum as the fixative agent.

Preparation of Fabric – The silk fabric was first scoured to remove natural impurities such as fats, waxes, and finishing agents that hinder dye uptake. Scouring was performed using a material-to-liquor ratio (MLR) of 1:40. The fabric (53 gm) was washed at 50°C for 25 minutes in a solution containing 0.5 gm/L sodium carbonate and 2 gm/L non-ionic detergent. After scouring, the fabric was rinsed thoroughly with tap water and dried at room temperature.



Figure 1 Mulberry Silk

Pre-fixative agenting Process – Alum was used as a fixative agent in three concentrations: 15%, 25%, and 35%. The fabric was first rinsed with cold water and then immersed in 100 ml of fixative agent solution prepared for each concentration (15 gm, 25 gm, and 35 gm of alum respectively). Each sample was heated in a water bath at $80 \pm 1^\circ\text{C}$ for one hour with occasional stirring. After fixative agenting, the fabrics were lightly rinsed and air-dried.



Figure 2 Alum



Figure 3 Water bath

Preparation of Safflower Dye Extract – Dried safflower petals were powdered and used for dye extraction at three concentrations: 15%, 25%, and 35%. For each concentration, 15 gm, 25 gm, and 35 gm of dye powder were soaked in 100 ml distilled water for 15 minutes at room temperature. The mixture was then boiled and extracted at 60°C for one hour. The solution was filtered to obtain the aqueous dye extract. The temperature and time for extraction were based on literature and experimentation.



Figure 4 Dye extraction

Dyeing of the Fabric – Dyeing was done using the pre-fixative agented silk fabrics in three dye concentrations (15%, 25%, and 35%). The dye bath was maintained at 70°C for one hour with continuous stirring and an MLR of 1:40. Each sample used 120 ml of dye solution prepared from 15 gm, 25 gm, and 35 gm of safflower dye respectively. The pH of the dye baths ranged between 5.45 and 5.46, indicating acidic conditions suitable for protein fibers like silk. After dyeing, the fabric was rinsed with cold water and dried in shade.

Fixing and Finishing – To improve resistance to fading, the dyed fabrics were post-treated by rinsing with mild detergent and cold water to remove excess dye. Finally, the samples were dried in shade and ironed to complete the process.

Colour strength assessment – It is the most important parameter to test the quality check of a sample in terms of depth of colour on dyed fabric. K/S value defines the absorption of dye on fabric in the percent.

The colour strength (K/S) of dyed material was determined using Kubelka- Munk equation. K/S of dyed samples was measured using a spectrophotometer (X4000) [7].

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

Where R is the reflectance value of dyed fabric at λ max, K is the absorption co efficient, S is scattering co- efficient. Each fabric was folded once so as to give two thickness and average of three readings were taken each time.



15% Alum +35% dye



25% Alum +35% dye



35% Alum +35% dye



15% Alum + 15 % Dye



25% Alum + 15 % Dye



35% Alum + 15 % Dye



15% Alum +25% dye



25% Alum + 25% dye



35% Alum +25% dye

3. Results and discussion

The study successfully evaluated the dyeing efficiency of safflower (*carthamus tinctorius*) extract on mulberry silk fabric using alum as a mordant in varying concentrations (15%, 25%, and 35%). The dyeing results were analyzed visually and qualitatively in terms of color intensity, shade variation, and fastness properties.

3.1 color intensity and shade variation

Increased dye concentration (from 15% to 35%) led to darker and deeper shades on the silk fabric.

Similarly, higher mordant concentrations also improved the affinity of dye to the silk fibers, resulting in enhanced color depth.

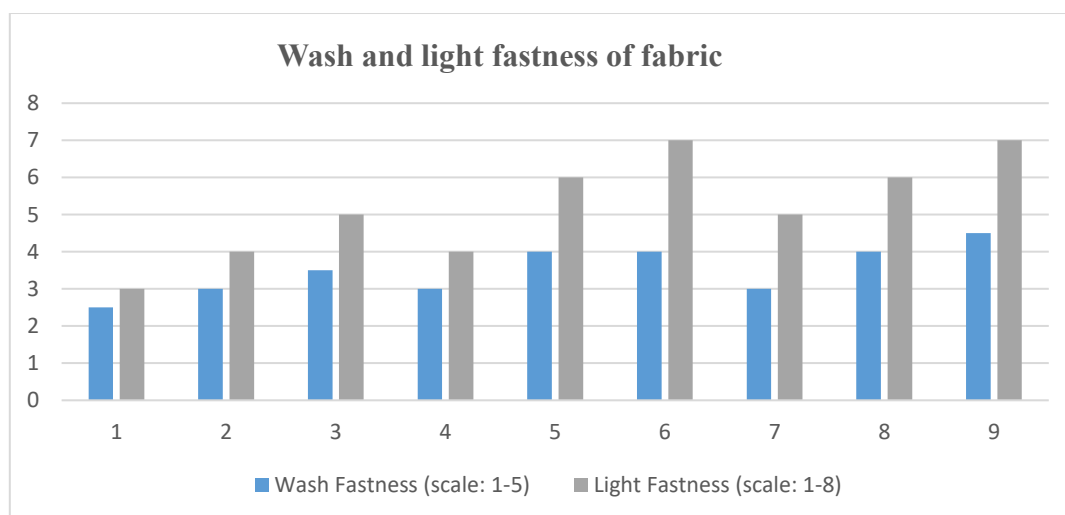
The combinations of 25% dye + 25% alum and 35% dye + 35% alum produced the most vibrant and even coloration, demonstrating optimum interaction between dye molecules and mordant. Fastness properties:

3.2 wash fastness: fabrics dyed with higher mordant concentrations showed better resistance to fading after washing.

3.3 light fastness: samples exposed to natural light retained their color longer when treated with 25% or 35% alum, indicating that alum improved light fastness.

Table 1: Result Showing of color intensity, shade variation, and fastness properties.

S.No.	Alum Concentration	Dye Concentraion	Wash Fastness (scale: 1-5)	Light Fastness (scale: 1-8)	K/S
1.	15%	15%	2.5	3	15.62
2.	25%	15%	3	4	16.20
3.	35%	15%	3.5	5	17.18
4.	15%	25%	3	4	16.90
5.	25%	25%	4	6	18.64
6.	35%	25%	4	7	19.18
7.	15%	35%	3	5	16.70
8.	25%	35%	4	6	18.74
9.	35%	35%	4.5	7	20.50



4. Conclusion

This study highlights the potential of safflower petals as a sustainable and effective natural dye source for silk fabrics. The experimental results demonstrate that:

Both dye and mordant concentration significantly affect the shade depth and colorfastness of the fabric.

Alum, as a fixative, played a crucial role in enhancing dye uptake and improving the wash and light fastness of the silk.

The optimal results were observed at 25–35% dye and alum concentrations, providing the best balance between color intensity, fabric quality, and fastness.

5. References

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