

The application of Xinjiang safflower extract on Aidelaisi silk fabric

Xu Cao and Lei Wang

Xinjiang Normal University, Urumqi, China

International
Journal of
Clothing Science
and Technology

81

Received 3 May 2024
Revised 26 July 2024
Accepted 28 August 2024

Abstract

Purpose – This study aims to explore the traditional plant dyeing of Xinjiang Atlas silk fabrics, providing references for the comprehensive utilization of plant dyes in intangible cultural heritage.

Design/methodology/approach – The focus of this study is on dyeing experiments of Atlas silk fabrics using safflower extracts, constrained by regional resources. Safflower dry flowers grown in Xinjiang were selected, rinsed with pure water and rubbed. Yellow pigments were removed by adding edible white vinegar. Red pigments from safflower were extracted using an alkaline solution prepared with *Populus euphratica* ash, a special product of Xinjiang. The extraction rate was analyzed under varying material-to-liquor ratios, pH values, times and temperatures. Direct dyeing process experiments were conducted to obtain different colorimetric L, a, b and K/S values for comparison. Samples with good color development were selected to test the impact of dyeing immersions on color development, and their color fastness, UV protection and antibacterial effects were verified.

Findings – The dyeing experiments on silk fabrics confirmed their UV protection capabilities and antibacterial properties, demonstrating effectiveness against *E. coli* and *Staphylococcus aureus*. As a major producer of safflower, Xinjiang underscores the significance of safflower as an essential plant dyes on the Silk Road. This study reveals its market potential and suitability for use in the plant dyeing process of Atlas silk, producing vibrant red and pink colors.

Originality/value – The experiments indicated that after removing yellow pigments, the highest extraction rate of red pigment from safflower was achieved at a pH value of 10–11, a temperature of 30°C and an extraction time of 40 min. The best bright red color effect with strong color fastness was obtained with a material-to-liquor ratio of 1:20, a temperature of 40°C and three immersions. The best light pink color effect with strong color fastness was a material-to-liquor ratio of 1:80, a temperature of 30°C and two immersions.

Keywords Safflower, Plant dye, Silk fabric, Dye application

Paper type Research paper

1. Introduction

Safflower (*Carthamus tinctorius* L.) is a well-known herb in traditional Chinese medicine, celebrated for its antimicrobial, immunomodulatory, anti-inflammatory, analgesic, antioxidant and hypotensive properties. It is primarily cultivated in regions such as Yili and Tacheng in Xinjiang, China (Tomasz *et al.*, 2021). It is known that the main active components in the dried petals of safflower are flavonoids, of which the red pigment content is about 6%, a natural pigment used for thousands of years (Weiyong and Gao, 2019).

© Xu Cao and Lei Wang. Published by Emerald Publishing Limited. This article is published under the Creative Commons Attribution (CC BY 4.0) licence. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this licence may be seen at <http://creativecommons.org/licences/by/4.0/legalcode>

Funding: The Xinjiang Social Science Fund youth project (No. 2023CYS109). Xinjiang scientific research business expenses and scientific research cultivation program (No. XJEDU 2023P083).

Availability of data and materials: This thesis aims to explore the traditional plant dyeing techniques for Xinjiang Aidelaisi silk textiles, providing insights for the comprehensive utilization of plant dyes in the preservation of intangible cultural heritage. However, the dataset is available from the corresponding author upon reasonable request.



International Journal of Clothing
Science and Technology
Vol. 37 No. 1, 2025
pp. 81-92
Emerald Publishing Limited
0955-6222

DOI 10.1108/IJCT-05-2024-0103

According to contemporary pharmacological studies, aqueous extracts of safflower exhibit inherent dyeing properties and antibacterial efficacy. When medicinal safflower is used to dye fabrics, its pharmacologically active components adhere to the fabric, resulting in vibrant colors and providing antibacterial effects simultaneously (Bai *et al.*, 2015)

In Luopu County of Xinjiang, five pile-woven carpets with motifs of human figures were excavated. Authentications established that these carpets date back to the 3rd to 5th centuries AD, representing relics from the early era of the Yutian Kingdom. Notably, the first carpets, identified as No.1, features red-based human figure motifs (colored patterns on a red background) with edges in a striking crimson hue, suggesting the use of plant dye (Xiaoshan, 2010). In a seminal 1987 article published in “*Chinese Agricultural History*”, Zhao Feng explored the spread, cultivation and application of safflower in ancient China, establishing a foundation for further research on the subject. Building upon this, Yang Jianjun and Cui Yan delved deeper into the history of safflower dyeing, dissemination and cultivation along the Silk Road in their study, “*Research on Traditional Chinese Safflower Dye and Safflower Dyeing Techniques: A Case Study of Safflower Spread on the Silk Road.*” The chronicles of safflower’s use as a dye extend back to the 25th century BCE in Egypt. Xu Shu’s “*Bo Wu Zhi*” describes the plant, known for its red and yellow flowers and green, thorny leaves, which bloom in summer and bear spherical fruit beneath, resembling small beans. It notes that the famous explorer Zhang Qian brought safflower seeds from the Western Regions. Further references to safflower are found in the “*Illustrated Pharmacopoeia*,” “*Compendium of Materia Medica*,” and “*Explanation of Medicinal Materials.*” (Qin, 2019) In ancient oral traditions, “Yanzhi” is synonymous with “rouge,” reflecting an alternative name for safflower, which was also known as rouge grass and historically used in the making of rouge and lip balm. This indicates an early cultivation of safflower in the Xinjiang. Today, the primary regions for extensive safflower cultivation in China are Yunnan and Xinjiang provinces.

Aidelaishi silk, celebrated as a “living fossil” of cultural exchange, continues to embody traditional weaving techniques and the intricate art of botanical dyeing. This silk retains its smooth texture and boasts, natural hues (Hong *et al.*, 2007). Originating from Xinjiang, Delaici Silk, a traditional handcrafted fabric, carries a legacy of over 2000 years. Each piece, measuring 45 centimeters in width and 650 centimeters in length, is dyed using botanical dyes sourced from roots, bark, fruit peels and fresh flowers (Chen, 2015). In Aidelaishi silk textiles, red is the dominant shade, with historical records highlighting the use of safflower as a key ingredient in ancient dyeing practices. As documented in “*Tiangong Kaiwu*,” the process involves transforming safflower into cakes and removing the yellow juices to reveal a true red, yielding colors such as “lotus red,” “peach red,” “silver red” and “water red.” “*Qimin Yaoshu*” by Jia Sixie recommends that sun-drying the safflower petals as an optimal method for extracting “haematochrome” dye.

In the realm of natural plant dye extraction, modern techniques such as ultrasonic extraction, wall-breaking extraction and enzymatic extraction are prevalent. This study, however, focuses on utilizing the purest safflower extracts for dyeing under the conditions of traditional folk craftsmanship and regional resources, minimizing the impact of contemporary industrial and chemical processes. It discusses the safety and ethical merits of eschewing mordants, simplifying procedures, reducing chemical use, lowering costs and eco-friendliness.

The contemporary trend of embracing nature and environmental sustainability has brought natural plant dyes to the forefront for their non-toxic, eco-friendly and sustainable characteristics. The development and application of these dyes meet the contemporary demand for environmentally conscious solutions (Ayele *et al.*, 2020). In advancing Aidelaishi silk fabric dyeing techniques, it is essential to explore the potential of indigenous plant dyes, constrained by the need to utilize local geographic resources. This approach is invaluable for the comprehensive use of plant dyes in preservation of intangible cultural heritage

(YanMei, 2010). By utilizing safflower dry flowers from Xinjiang, this study employs a method of rubbing and weak acid soaking to eliminate yellow pigments, followed by extraction of red pigments using an alkaline solution made with *Populus euphratica* ash, a special product of Xinjiang. These red pigments were applied to white Atlas silk fabrics in an experiment (Ohama and Tumpat, 2014) aimed at replicating the “Tang Red” color, optimizing dyeing methods and assessing the dyed fabric’s color fastness, antibacterial properties and UV protection capabilities. The novelty of this study lies in its investigation of safflower extract dyeing on traditional folk fabric, Aidelaisi silk, under regional resource limitations. It explores the innate compatibility of local plant dyes within geographical constraints, offering a reference for the comprehensive use of plant dyes in the context of intangible cultural heritage.

2. Subjects and methods

2.1 Experimental materials and equipment

Fabric: pure white Aidelaisi silk fabric, cut into 10 cm*10 cm samples.

Equipment: Beakers, glass rods, an LQ-A6001 electronic balance (Leqi brand), a temperature-controlled intelligent electromagnetic stove, thermometers, a Lambda 35 UV-visible spectrophotometer, a Datacolor 850 color matching spectrophotometer (manufactured by Datacolor Inc., USA), an SW-20B washing color fastness tester and a UV-2000F textile UV protection factor tester.

Reagents: Safflower dry flowers sourced from Xinjiang, soda ash sourced from Xinjiang (mainly consisting of Na_2CO_3 and NaHCO_3), edible white vinegar from Xinjiang (primarily CH_3COOH), distilled water and sterile gauze.

2.2 Experimental procedure

2.2.1 Pigment extraction.

- (1) Around 50 grams of safflower per sample were weighed and soaked in 2000 ml of pure water for 4 h, then wrapped in sterile gauze and rubbed and squeezed 1–10 times. After soaking in a weak acidic vinegar solution for 24 h, then samples were removed and rinsed with clean water for subsequent use.
- (2) The solvent was prepared with material-to-liquor ratios ranging from 1:5 to 1:80, pH value of the alkaline extraction liquid made with *Populus euphratica* ash between 9 and 12, and extraction times from 10 to 60 min. The solvent was heated from room temperature 20°C–40°C.
- (3) Treated safflower was added to the solvent, stirred and rubbed six times, sealed and soaked for 3 h to ensure full absorption. The dye solution was heated in a water bath at a constant temperature of 20°C–40°C for 10–60 min to obtain.
- (4) The heated dye solution was cooled within a wavelength range of 350–450 nanometers, and the visible light scanning spectrum was recorded.
- (5) The pigment extraction rate was calculated as $(1 - \text{unextracted pigment}/\text{total pigment content}) \times 100\%$

2.2.2 Direct dyeing process.

- (1) The pristine white Aidelaisi silk fabric was moistened with distilled water, wrung out, laid flat and prepared for dye liquor immersion.
- (2) The alkaline dye liquor was neutralized to a pH of 6 using edible white vinegar before application to the fabric.

- (3) The fabric was immersed in the dye liquor for 40 min with gentle agitation. Four groups with optimal color development were selected for three additional soaking cycles with consistent agitation.
- (4) Post-immersion, the fabric was rinsed in distilled water, wrung dry and air-dried in the shade to preserve its original color.

2.3 Analysis and testing

(1) Colorimetric analysis

The L, a and b values of the samples were determined under D65 illuminant using the Datacolor 850 spectrophotometer at a 10° viewing angle. The dyed fabric, folded twice was tested at five points per sample to calculate average values. The K/S value, indicating color strength, was directly measured and recorded using the formula: $K/S = (1-R)^2/2R$.

(2) Color fastness properties

The washing color fastness of dyed silk was assessed according to ISO 105-C10-2006, with items washed at varying material-to-liquor ratios, and compared against the original sample using the SW-20B color fastness tester.

(3) UV protection properties

The dyed silk fabric, folded in two, was tested on a UV-2000F fabric UV protection factor tester (YG(B)912, China), following the standard GB/T 18830-2009, with the UPF value recorded.

(4) Antibacterial performance

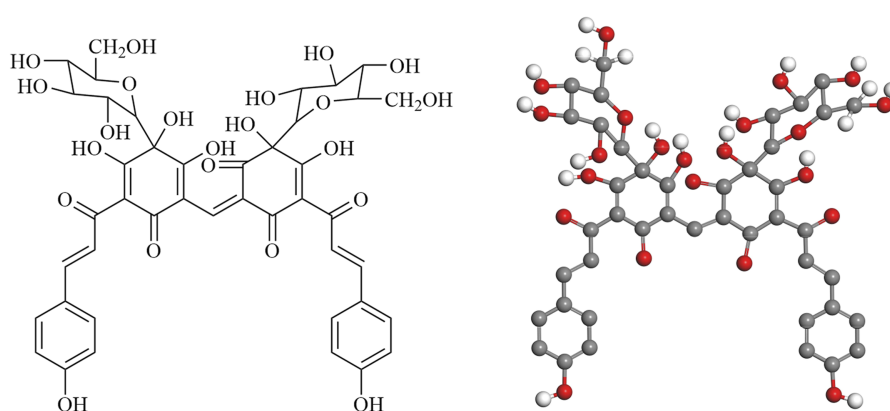
The antibacterial properties of the samples against *S. aureus* (*Staphylococcus aureus*) and *E. coli* (*Escherichia coli*) were evaluated according to the textile antibacterial standard (GB/T 20944.3-2008), with the experimental procedure and bacteriostatic rate calculation following reference (Mayer *et al.*, 2008).

3. Results and discussion

3.1 Extraction of haematochrome from safflower

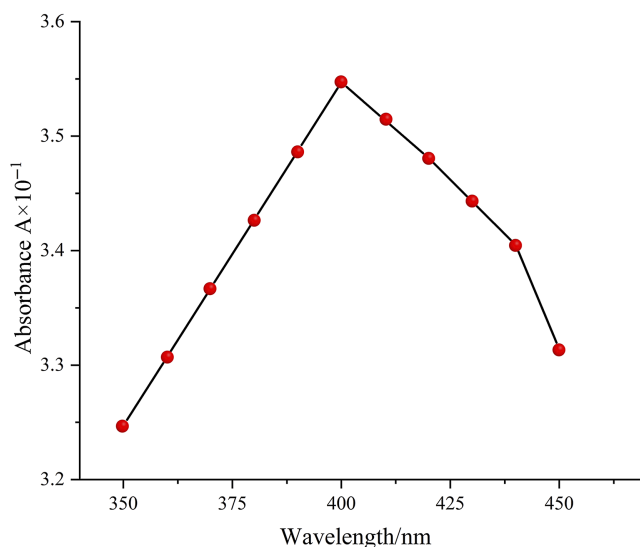
3.1.1 Maximum absorption wavelength. Figure 1 displays the chemical and molecular formulas of haematochrome (carthamin) found in safflower. Figure 2 shows the determination of the maximum absorption wavelength of the safflower extract, identified at 400 nm from the UV absorption spectrum's peak, which was selected for subsequent wavelength measurement.

3.1.2 Pigment extraction efficiency. Figures 3–5 illustrate the optimization of four factors under constant conditions: material-to-liquor ratio, extraction pH value, extraction time and control temperature. A comparative analysis of material-to-liquor ratios from 1:5 to 1:80 indicated an initial steady increase in extraction rate, followed by a plateau. The extraction rate reached a stable peak at a material-to-liquor ratio of 1:20 and a pH value between 10 and 11. Further experiments revealed that the extraction rate was highest at a control time of 40 min with a range of 10–60 min. Controlling the temperature from 20°C to 40°C increased the extraction rate, with a decline above 40°C. The optimal control temperature was determined to be 40°C, with a range of 27.5°C–32.5°C optimal for peak observation at 30°C. This non-toxic and simple process yields a high pigment extraction rate.



Source(s): Authors' own creation

Figure 1.
Chemical and
molecular formula of
haematochrome in
safflower



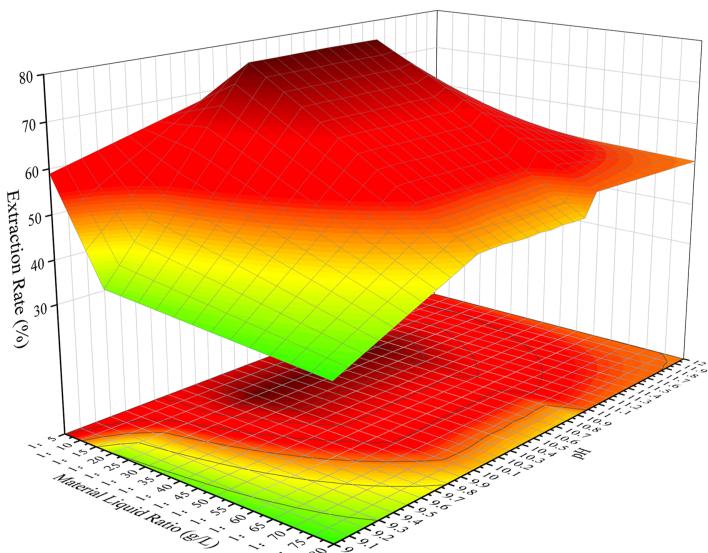
Source(s): Authors' own creation

Figure 2.
Determination of the
maximum absorption
wavelength of
safflower extract

3.2 Dyeing with the dye

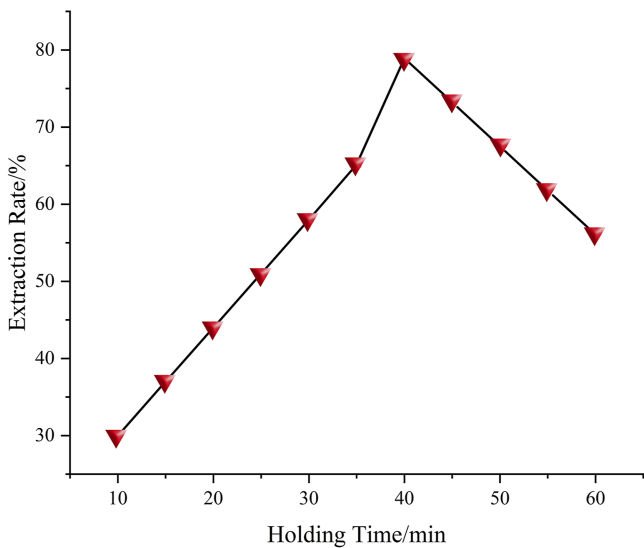
As detailed in Table 1, once the optimal extraction rate was established, a comparative analysis of silk dyed with different liquor ratios was conducted to assess color rendering. Under direct dyeing conditions, observations were made regarding changes in the L, a, b values and the K/S value. At a liquor ratio of 1:5, the silk exhibited enhanced color rendering, yielding a deeper red hue with high purity and low luminosity. At a liquor ratio of 1:20, the silk displayed a bright red color with the most vibrant luminosity and purity. Decreasing the liquor ratio resulted in a lighter color, culminating in a delicate pink at a 1:80 ratio, characterized by the highest luminosity and purity (Ding and Freeman, 2017, Grifoni *et al.*, 2020).

Figure 3.
Three-dimensional
relationship between
extraction rate of
safflower
haematochrome
dyeing solution and
ratio of liquor to
material and pH value



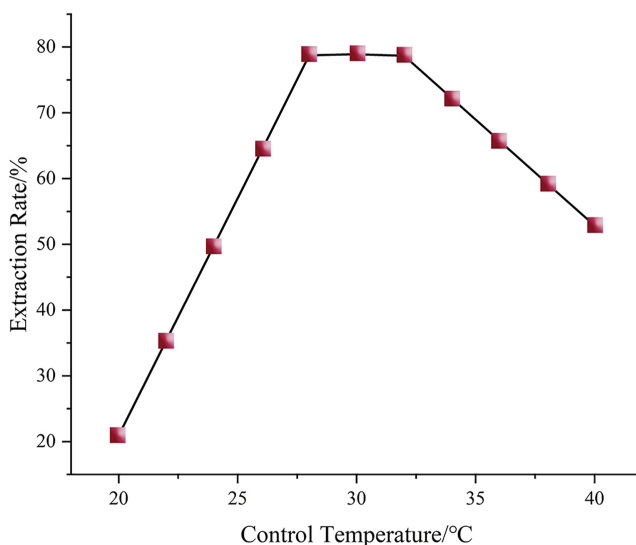
Source(s): Authors' own creation

Figure 4.
Relationship between
safflower
haematochrome dye
extraction rate and
control time



Source(s): Authors' own creation

Table 2 outlines the impact of dyeing frequency on the dyeing effect, particularly for liquor ratios that demonstrated significant color development, such as 1:5, 1:20, 1:60 and 1:80. Experimentation revealed that after three or more dyeing cycles with a 1:20 liquor ratio, the red hue achieved the highest levels of brightness and purity. Similarly, The material-liquid



Source(s): Authors' own creation

Figure 5.
Relationship between
the extraction rate of
safflower
haematochrome dye
liquor and control
temperature

ratio was 1:80 for more than three times to obtain the pink color with the highest brightness and purity at the same time. Other experiments indicated that while purity could remain high, it might be accompanied by a decrease in brightness or minor changes alteration.

3.3 Color fastness properties

According to the data in Table 3, tests were conducted and graded based on reference standards, categorized into five levels, with level 1 representing the lowest performance and level 5 the highest. The Aidelaisi silk fabrics dyed with safflower extract exhibited favorable color fastness properties, with the most optimal performance observed within dye liquor ratios ranging from 1:25 to 1:45.

3.4 UV protection properties

As indicated in Table 4, the ultraviolet (UV) protection value of undyed Aidelaisi silk fabric was 43.13, indicating moderate UV resistance. After dyeing with safflower extract, the fabric exhibited significantly enhanced UV resistance, with minimal fluctuations in data after rinsing and gradually stabilizing (Chen and Qin, 2017). This suggests that Aidelaisi silk fabrics dyed using safflower extract possess UV protection properties, demonstrating potential for wider application.

3.5 Antibacterial performance

The results presented in Table 5 reveal that the undyed silk fabric exhibits some antibacterial properties and that they were not markedly pronounced (Huang *et al.*, 2022). In contrast, silk fabric dyed with safflower extract demonstrated an antibacterial rate of 73.51–83.98% against *E. coli* and 84.07–92.71% against *Staphylococcus aureus*. These effects are attributed to alterations in the permeability of plant cell membranes within the fabric and the antibacterial activity of flavonoid compounds present in the dye solution (Saiwan Sabah and Saleh, 2015; Ji *et al.*, 2013; Ke *et al.*, 2015).

Number	Material Liquid Ratio/g/L	Images of dyed fabric	Colour parameter fabric			
			L	a	b	K/S
1	1: 5		49	52	27	2.312
2	1: 10		50	56	23	2.298
3	1: 15		50	56	20	2.292
4	1: 20		51	59	13	2.284
5	1: 25		52	54	11	2.279
6	1: 30		56	53	11	2.271
7	1: 35		57	46	8	2.268
8	1: 40		59	45	5	2.255
9	1: 45		57	42	5	2.480
10	1: 50		60	40	3	2.236
11	1: 55		64	36	2	2.221
12	1: 60		65	42	14	2.134
13	1: 65		65	41	14	1.824
14	1: 70		66	40	13	1.758
15	1: 75		73	35	12	1.625
16	1: 80		74	33	10	1.483

Source(s): Authors' own creation

Table 1.
Influence of dyeing
concentration on
dyeing effect

Number	Material Liquid Ratio/g/L	Frequency	Images of dyed fabric	Colour parameter fabric			
				L	a	b	K/S
1	1:5	1		49	52	27	2.312
2		2		46	51	27	2.321
3		3		42	52	26	2.337
4		4		39	48	21	2.344
1	1:20	1		51	59	13	2.284
2		2		50	60	14	2.287
3		3		49	61	15	2.289
4		4		48	65	19	2.291
1	1:60	1		65	42	14	2.134
2		2		63	40	14	2.139
3		3		60	38	7	2.146
4		4		58	40	9	2.155
1	1:80	1		74	33	10	1.483
2		2		70	57	11	1.491
3		3		66	39	12	1.499
4		4		63	44	13	1.507

Source(s): Authors' own creation

Table 2.
Influence of dyeing
frequency on dyeing
effect

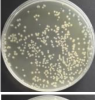
Table 3.
Color fastness test
results

Number	Dyeing process	Material liquid ratio/g/l	Original	Dyed silk fabric
1	Direct dyeing	1:5	1	4.8
2		1:10	1	4.7
3		1:15	1	4.9
4		1:20	1	4.9
5		1:25	1	5
6		1:30	1	5
7		1:35	1	5
8		1:40	1	5
9		1:45	1	5
10		1:50	1	4.8
11		1:55	1	4.8
12		1:60	1	4.8
13		1:65	1	4.7
14		1:70	1	4.7
15		1:75	1	4.7
16		1:80	1	4.6
Source(s): Authors' own creation				

Table 4.
Anti-UV effect of dyed
silk fabrics

Number	Washing frequency	0	5	10	20	25
1	Direct Dyeing	188.653	155.65	155.23	152.656	151.3
2	Undyed Silk Fabric	43.13	—	—	—	—
Source(s): Authors' own creation						

Table 5.
Antibacterial effects

Number	Fabric Treatment Method	Escherichia Coli		Staphylococcus Aureus	
		Experimental Pattern	Bacterial Inhibition Rate/%	Experimental Pattern	Bacterial Inhibition Rate/%
1	Blank Control Group		-		-
2	Undyed Silk Fabric		32.32		27.54
3	Safflower Extract Direct Dyeing 1		73.51		92.71
4	Safflower Extract Direct Dyeing 2		83.98		84.07
Source(s): Authors' own creation					

4. Conclusion

The study introduces a novel method for extracting natural red pigment from safflowers cultivated in Xinjiang, assessing its application on Atlas silk fabrics. Utilizing single-factor experiments, optimal dyeing parameters were identified: a material-to-liquor ratio of 1:20, a pH value of 10–11, an extraction time of 40 min and a constant temperature of 30°C. Notably, a material-to-liquor ratio of 1:20 at 40°C, coupled with three dye baths, yielded the most vibrant red color with exceptional color fastness. Conversely, a ratio of 1:80 at 30°C with two dye baths produced the most desirable light pink color, also with strong color fastness. The resulting dyed silk demonstrated commendable UV protection and antibacterial properties, maintaining a UV protection index above 50 even after 20 washes, and exhibiting antibacterial rates of 73.51–83.98% against *E. coli* and 84.07–92.71% against *Staphylococcus aureus*. These findings offer valuable strategies for enhancing plant-based dyeing techniques for Atlas silk fabrics under the unique resource limitations of Xinjiang.

This research further substantiates the direct dyeing process and the use of safflower, highlighting its non-toxic, absence of heavy metals and the elimination of the need for mordants. It establishes the viability of achieving the historically significant “Tang Red” hue on Atlas silk by employing pigment derived from dried safflower flowers, thus paving the way for innovative utilization of Xinjiang’s agricultural bounty. However, the study acknowledges its limited scope, precluding a broader regional comparison of safflower efficacy and necessitating further investigation into the stability of safflower-derived pigments as an agricultural product. By delving into the effectiveness and applicability of safflower extract dyeing, this research sheds light on the traditional use of safflower extract, weighs its economic benefits against chemical dyes and gauges consumer preference for naturally dyed silk. Additionally, it underscores the environmental merits of safflower as a natural dye and opens dialogue for potential global partnerships in advancing the research and commercialization of safflower extract dyeing technologies.

References

- Ayele, M., Tesfaye, T., Alemu, D., Limeneh, M. and Sithole, B. (2020), *Sustainable Chemistry and Pharmacy*, Vol. 17, 100293, doi: [10.1016/j.scp.2020.100293](https://doi.org/10.1016/j.scp.2020.100293).
- Bai, L., Zou, M., Wang, H. and Tan, Y. (2015), “In vitro bacteriostasis of three safflower[J]”, *Food Technology*, Vol. 40 No. 2, pp. 311-314.
- Chen, Y.Q. (2015), “The technological character and development direction of Xinjiang Aidelaisi silk”, *China Fiber Inspection*, No. 18, pp. 84-85.
- Chen, L. and Qin, D.U. (2017), “Ultraviolet protection properties of several kinds of vegetable dyes”, *Shanghai Textile Science and Technology*, Vol. 45 No. 2, pp. 55-57.
- Ding, Y. and Freeman, H. (2017), “Coloration Technology”, Vol. 133 No 25, pp. 369-375, doi: [10.1111/cote.12288](https://doi.org/10.1111/cote.12288).
- Grifoni, D., Roscigno, G., Falco, E., Vece, A., Camilli, F., Sabatini, F., Fibbi, L. and Zipoli, G. (2020), *Fibers and Polymers*, Vol. 21 No. 8, pp. 1750-1759, doi: [10.1007/s12221-020-1045-8](https://doi.org/10.1007/s12221-020-1045-8).
- Hong, X.U., Xiao-hong, S. and Hong, L.I.U. (2007), “The live fossil multicultural syncretizing on silk road—aidelaisi silk”, *Journal of Xinjiang University (Natural Science Edition)*, No. 3, pp. 365-368.
- Huang, L., Yang, K., Zhao, Q., Li, H., Wang, J. and Wu, Y. (2022), “Bioelectrochemistry”, Vol. 143, 107969, doi: [10.1016/j.bioelechem.2021.107969](https://doi.org/10.1016/j.bioelechem.2021.107969).
- Ji, X., Chang, R., Liang, H. and Feng, Q. (2013), “Preliminary study on pharmacodynamics of carthamus tinctorious containing microemulsion for external use”, *Journal of Shanxi University of Chinese Medicine*, Vol. 14 No. 3, pp. 2-3.

- Ke, C.-L, Ren, M.-S, Wang, D, Xie, H.-W, Huang, B. and Zhao, Y. (2015), "Research progress on the antibacterial mechanism of flavonoids", *Science and Technology of Food Industry*, Vol. 36 No. 2, pp. 388-391.
- Mayer, R., Stecher, G., Wuerzner, R., Silva, R., Sultana, T., Trojer, L., Feuerstein, I., Krieg, C., Abel, G., Popp, M., Bobleter, O. and Bonn, G. (2008), "Proanthocyanidins: Target Compounds as Antibacterial Agents", *Journal of Agricultural and Food Chemistry*, Vol. 56 No. 16, pp. 6959-6966, doi: [10.1021/jf800832r](https://doi.org/10.1021/jf800832r).
- Ohama, P. and Tumpat, N. (2014), "International Scholarly and Scientific Research and Innovation", Vol. 8 No. 5, p. 432, doi: [10.5281/zenodo.1092830](https://doi.org/10.5281/zenodo.1092830).
- Qin, T. (2019), *Chinese Plants Dye Inheritance and innovation*, China Architecture & Building Press, Eastern Connecticut State University, pp. 149-154.
- Saiwan Sabah, F. and Saleh, A.A. (2015), "Evaluation of antibacterial activity of flavonoid and Oil extracts from safflower (*Carthamus tinctorius* L)", *Journal of Natural Sciences Research*, Vol. 5 No. 8, pp. 41-44.
- Tomasz, B., Martyna, Z.D., Aleksandra, Z., Nizioł-Lukaszewska, Z., Wasilewski, T. and Hordyjewicz-Baran, Z. (2021), "Antioxidant and Cytoprotective properties of plant extract from dry flowers as functional dyes for cosmetic products", *Molecules*, Vol. 26 No. 9, pp. 2809-2833, doi: [10.3390/molecules26092809](https://doi.org/10.3390/molecules26092809).
- Weiyong, L. and Gao, G. (2019), "Antimicrobial performance test of natural plant dye-stained textiles", *Chemical fiber and Textile Technology*, Vol. 48 No. 4, pp. 18-21.
- Xiaoshan, Q.I. (2010), "A figure grain planted in a blanket unearthed in Shampulu Township, Luopu County, Xinjiang", *The Western Regions Studies*, Vol. 7, doi: [10.16363/j.cnki.xyyj.2010.03.011](https://doi.org/10.16363/j.cnki.xyyj.2010.03.011).
- YanMei, J.A. (2010), "Synthesis of F locu lant DADM AC YU Tao LIU Dong-xue", *Dyestuffs and Coloration*, No. 1, pp. 14-16.

Corresponding author

Lei Wang can be contacted at: minxi9510@163.com

For instructions on how to order reprints of this article, please visit our website:

www.emeraldgroupublishing.com/licensing/reprints.htm

Or contact us for further details: permissions@emeraldinsight.com