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# The use of Turmeric and Ginger Extracts Mixture as Eco-Friendly Natural Dyes

## Zerdeçal ve Zencefil Özleri Karışımının Çevre Dostu Doğal Boyalar Olarak Kullanımı

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**ABSTRACT**

In this study, the dyeing properties of cotton fabric, wool yarn, wool fabric leather and pine wood were investigated by using Turmeric (Curcuma longa L.) and Ginger (Zingiber officinale L.) extracts mixture. For this purpose, these materials were subjected to pre-, meta- and post mordanting processes. Mordanting processes were carried out in the presence of $FeSO_4$, $CuSO_4$, $AlK(SO_4)_2$ and Resadiye clay mordants. The results were evaluated by color analysis of the dyed samples. Rubbing (dry/wet), washing and light fastness values were determined. Color codes, K/S and CIE-Lab values were measured with Konica Minolta CM-3600d Spectrophotometer. Fastness analyses were evaluated using the gray scale acording to ISO 105-C06 standards and CIS. As a result, it was concluded that turmeric and ginger extracts mixture could be a suitable source of dyestuffs for natural dyeing of cotton, wool, leather and wood samples.

**Keywords:** Ginger, cotton fabric, wool yarn, leather, dyeing, fastness

**ÖZ**

Bu çalışmada, Zerdeçal (*Curcuma longa* L.) ve Zencefil (*Zingiber officinale* L.) ekstraktları karışımı kullanılarak pamuklu kumaş, yün iplik, yün kumaş derisi ve çam ağacının boyama özellikleri araştırılmıştır. Bu amaçla, bu malzemelere ön, meta ve son mordanlama işlemleri uygulanmıştır. Mordanlama işlemleri $FeSO_4$, $CuSO_4$, $AlK(SO_4)_2$ ve Resadiye kil mordanları varlığında gerçekleştirilmiştir. Sonuçlar boyanmış numunelerin renk analizi ile değerlendirilmiştir. Sürtme (kuru/ıslak), yıkama ve ışık haslığı değerleri belirlenmiştir. Renk kodları, K/S ve CIE-Lab değerleri Konica Minolta CM-3600d Spektrofotometresi ile ölçülmüştür. Haslık analizleri ISO 105-C06 standartlarına ve CIS'ye göre gri skala kullanılarak değerlendirilmiştir. Sonuç olarak, zerdeçal ve zencefil ekstraktları karışımının pamuk, yün, deri ve odun numunelerinin doğal boyanması için uygun bir boyarmadde kaynağı olabileceği sonucuna varılmıştır.

**Anahtar Kelimeler:** Zencefil, pamuklu kumaş, yün iplik, deri, boyama, haslık

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## INTRODUCTION

Dyeing thread or fabric with vegetable dyes has been done since ancient times and continues today both in our country (Turkey) and in other countries (especially in the Asian continent). Early humans used the roots, stems, leaves and flowers of plants to dye their clothes and ornaments, and sometimes they used stones, soil and some parts of seashells.[1]

A synthetic dye development process took place from 1771, when the first synthetic dyes were discovered, to 1956, when reactive dyes were discovered, and after that, interest in vegetable dyes gradually decreased.[2]

Although synthetic dyes are widely produced and consumed, people in the 21st century still prefer naturally dyed products because natural dyes are healthier than synthetic dyes, and carpets, rugs, ornaments, etc. made from natural dyes. It is a known fact that products gain more value over the years. The only disadvantages of natural dyes compared to synthetic dyes are their low color diversity and low binding power (affinity) to yarn or fabric. Although this is the case for every plant, these problems can often be encountered.[3] To solve this problem, people have used mordant substances as binders (fixing the dye) as well as plant parts in dye pots since ancient times. It is known that they use soil and stone containing natural clay, metal oxide or metal salt mixtures.[4]

Different fabric types were examined using Turmeric (*Curcuma longa.*L.). For this purpose, cotton and woolen fabrics were dyed with Curcuma longa extract.[5] Turmeric is not toxic in cell culture and all animal studies. However, it has been reported to have bactericidal effects at very high concentrations that it showed a strong phototoxic effect in micromolar amounts.[6,7]

The effect of gamma radiation on dyeing cotton with *Curcuma longa* L. powder was investigated. Dyeing parameters such as temperature, pH and mordant concentration have been optimized. To investigate the effect of radiation, dyeing was done using irradiated and non-irradiated cotton with irradiated and non-irradiated turmeric powder extracts. Color fastness to light, rubbing and washing fastness properties have shown that gamma irradiation improves the dyeing properties moderately.[8]

Ginger (*Zingiber officinale)* is a spice plant that is well known among the public and is used today. In the literature review, a study on dyeing textile fibers with ginger was found. It is noteworthy that more medical studies are being conducted. Ginger, a medicinal aromatic plant, has been used in the treatment of diseases such as rheumatic diseases, respiratory problems, asthma, cough, heart palpitations, migraine and vertigo.[9–11]

The aim of this study is to determine the dyeing properties of cellulose and protein type samples using $FeSO_4$, $CuSO_4$ and $AlK(SO_4)_2$ mordants in turmeric and ginger aqueous extract mixture. As a result of the experimental study, the effect of the turmeric/ginger mixture in terms of both dyeing capacity and antimicrobial effect was interpreted according to the results obtained.

## METHODS

All mordants ($CuSO_4.5H_2O$, $FeSO_4.7H_2O$, $AlK(SO_4)_2.12H_2O$) were purchased from Merck. The cotton fabric, wool yarn and wool fabric were obtained from Toga Textile Ltd., Tokat, Turkey. Sheepskin was taken from Maturation Institute, and pine wood samples were obtained from Tokat Organized Industrial Workshop (Tokat, Turkey).

### Natural Dye Extraction

30 g of powdered turmeric and powdered ginger were extracted separately with distilled water in a soxhlet apparatus at boiling temperature until colorlessness. Each extract was combined at a ratio of 1/9 for ginger and turmeric after obtaining a total of five liters of colored solution.

### Dyeing methods

In this study, the mordants used were prepared as in our previous studies.[12-15] Pre- mordanting, meta-mordanting, post- mordanting and wihhout-mordanting methods were performed given below.[2]

### Pre-mordanting method

The samples were heated with 100 mL of 0.1 M mordant solution at 90°C (at 40°C for leather) for 20 min. and filtered. After this process, all samples were heated in an erlenmayer with 100 mL of dyestuff solutions at 75°C for 1h. for wool yarn, at 90°C for 1 h. for cotton fabrics, at 90°C for 1 h. for wood, and at 40°C for 2 hours for leather samples. Finally, they were cooled, filtered, rinsed with distilled water and dried.[2]

### Meta-mordanting method

The samples are placed in to the 100 mL of dyestuff solution. Then, solid mordant equivalent to the amount of 0.1 M in 100 mL of the substance was added and heated for 1h. in an erlenmayer with dyestuff at 75°C for 1h. for wool yarn, at 90°C for 1 h. for cotton fabrics, at 90°C for 1 h. for wood, and at 40°C for 2 hours for leather samples. Finally, they were cooled, filtered, rinsed with distilled water and dried.[2]

### Post-mordanting method

In this method, all samples were heated in an erlenmayer with dyestuff at 75°C for 1h. for wool yarn, at 90°C for 1 h. for cotton fabrics, at 90°C for 1 h. for wood and at 40°C for 2 hours for leather samples. They cooled, filtered, rinsed with distilled water. They were heated with 100 mL of 0.1 M mordant solution at 90°C (for leather at 40°C) for 20 min. Finally, all samples were cooled, filtered, rinsed with distilled water and dried.[2]

**Without-mordanting method**

The samples were heated in an erlenmayer with 100 mL of dyestuff solution at 75°C for wool yarn/fabric 1h., at 90°C for 1h. for cotton fabrics, at 40°C for 2 h. for leather, and at 90°C for 1h. for wood samples Finally they were cooled, filtered, rinsed with distilled water and dried.[2]

**RESULTS**

Color codes of dyed samples with the dyestuff obtained from turmeric and ginger are given in Table 1, *L* a*b** values are given in Table 2, and fastness values are given in Table 3.

The *L**, *a** and *b** values of samples dyed with turmeric/ginger are given in Table 2. Wet, dry, washing and light fastness values of dyed samples are given in Table 3.

When Table 3 is examined, it is seen that good results are obtained with all $CuSO_4$, $FeSO_4$, $AlK(SO_4)_2$ and Reşadiye clay mordants in dry rubbing fastness of cotton fabric, wool fabric, wool yarn and leather samples dyed in turmeric / ginger mixture. Rubbing fastness is 5 for all fabric types.

The highest results in wet rubbing fastness (4-5) are obtained with Reşadiye clay mordant while $CuSO_4$, $FeSO_4$, $AlK(SO_4)_2$ mordants have a lower wet fastness value (2-3) compared to Reşadiye clay.

The highest fastness values (4) in wet rubbing fastness of the samples dyed meta- and with the post-mordanting method were obtained with Reşadiye Clay mordant, as in pre-mordanting. On average, the lowest values (2-3) compared to other mordants were observed in fabrics dyed with $FeSO_4$ mordants. The fastness values of the samples dyed with the mordant-without- mordanting method are lower than the mordant dyeing method, and this result can be interpreted as the chemical bonds formed in the without—mordanting dyeing are lower than the mordant dyeing. Color codes of cotton fabrics dyed with turmeric/ginger mixture are given in Table 1.

When washing fastnesses were examined, a decrease was observed in the order of alum, ferrous sulfate and copper sulfate in washing fastness, while a decrease was observed in the dyeing method in the post-, meta-, and pre-mordanting method. The washing fastness of cotton fabrics is higher than that of woolen fabric and woolen yarn (4-5). In the wash fastness analysis, the best score (5) in pre-mordanting was given by $AlK(SO_4)_2$ mordant. In meta-mordanting, $AlK(SO_4)_2$ and Reşadiye clay mordant gave the highest value (5), while Reşadiye clay gave the best result (4-5) in the post- mordanting. In without- mordanting dyeing, the best score (5) in washing fastness was obtained in cotton fabrics.

When the light fastness in Table 3 was evaluated, $CuSO_4$ and $FeSO_4$ mordant gave the best results (6-7) in pre-mordanting for wool yarn and leather. $CuSO_4$ mordant gave the best result (cotton fabric 5, wool yarn 7, leather 7) in meta-mordanting, and Reşadiye Clay gave the worst result (cotton fabric 2, wool fabric 1, wool yarn 2).

In the post –mordanting method, $CuSO_4$ mordant gave the best value in light fastness as in meta-mordanting (cotton fabric 5, wool fabric 4, wool yarn 7, leather 7). The fact that the best light fastness value is obtained in leather samples can be explained by the fact that the leather has a tighter protein structure and consists of more types of amino acid units.

Kocatürk et al.[16] dyed wool fibers with turmeric and natural indigo, they did not determine the fastness and K/S values, they only measured *L*, a*, b** values. The values they obtained are in accordance with the values in this study.

Kaynar et al.[17] examined the fastness of colors obtained from turmeric plant with natural and chemical mordants for wool yarns. The color tones they obtained are similar to the color tones we obtained. In this study, dry rubbing fastness values were found to be 2/3 for $AlK(SO_4)_2$ and 2 for $FeSO_4$, while these values were 4 for both mordants in our study, which were higher. In the same study, wet rubbing fastness values were found to be 4/5 for $AlK(SO_4)_2$ and 3 for $FeSO_4$, while these values were found to be 5 for both mordants in our study.

Scale of cotton fabrics are given in Figure 1, for wool fabrics are in Figure 2, for wool yarns are in Figure 3, for leather samples are in Figure 4 and for wood samples are in Figure 5.

**Table 1.** Color codes of dyed samples.

| Mordant | | Heat (°C) | Time (min) | $CuSO_4$ | $FeSO_4$ | $AlK(SO_4)_2$ | Reşadiye Clay |
|---|---|---|---|---|---|---|---|
| **Pre-Mordanting** | Cotton | 90 | 60 | #DACB89 | #DBC980 | #D8C474 | #D7C986 |
| | Wool | 90 | 60 | #F0DC8D | #EFDA8D | #E4CF83 | #EBDA8C |
| | Wool yarn | 90 | 60 | #B69D38 | #918233 | #A79C40 | #A88049 |
| | Leather | 40 | 120 | #BF9C45 | #A98251 | #94645 | #917B5B |
| **Meta-Mordanting** | Cotton | 90 | 60 | #D4C699 | #D1BE84 | #D9CF94 | #DBD59F |
| | Wool | 90 | 60 | #EAD98B | #E6CE9D | #EFDA83 | #F5E798 |
| | Wool yarn | 90 | 60 | #927447 | #9C7438 | #D2AA4D | #E8B54D |
| | Leather | 40 | 120 | #625340 | #665847 | #C59D6B | #AB8851 |
| | Pine wood | | 2880 | #DDB837 | #AC8A55 | #F5C348 | #E8B248 |
| **Post-Mordanting** | Cotton | 90 | 60 | #DCD6A7 | #D8CE95 | #D8D395 | #D9D7AF |
| | Wool | 90 | 60 | #F7EC9E | #F0E18E | #EFE098 | #EFE6B5 |
| | Wool yarn | 90 | 60 | #E6BB5D | #CDA74F | #CCAB5C | #B3995B |
| | Leather | 40 | 120 | #AE8B5B | #CFAE7F | #BC9363 | #C19C6A |

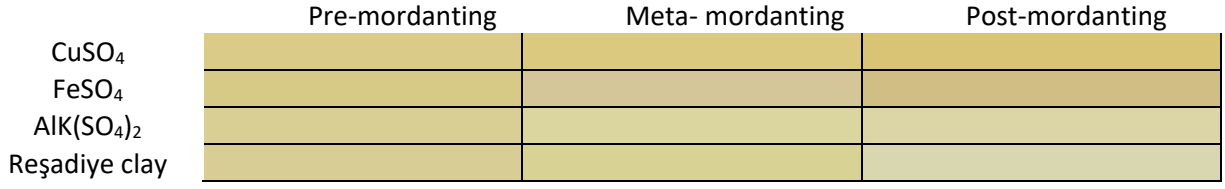


**Figure 1.** Color scale of cotton fabrics

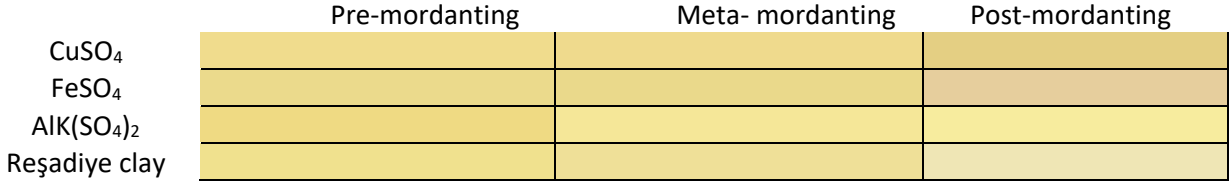


**Figure 2.** Color scale of wool fabric

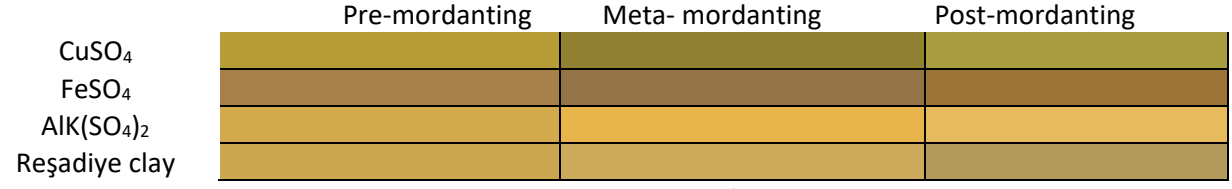


**Figure 3.** Color Scale of wool yarn

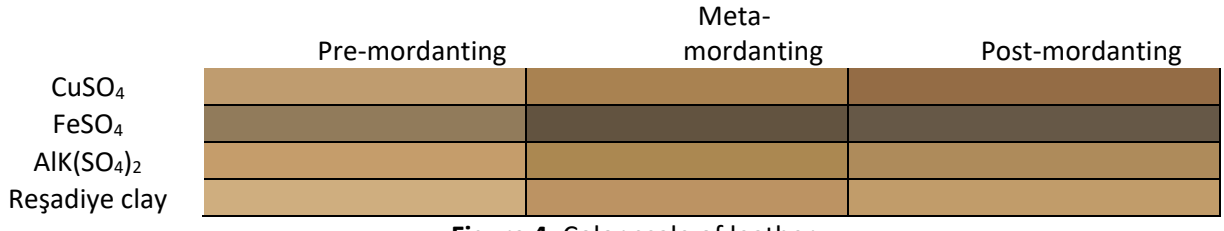


**Figure 4.** Color scale of leather

**Table 2.** *L* a*b** values of dyed samples.

| | | Cotton | | | Wool | | | Wool yarn | | | Leather fabric | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dyeing Method** | **Mordant** | ***L**** | ***a**** | ***b**** | ***L**** | ***a**** | ***b**** | ***L**** | ***a**** | ***b**** | ***L**** | ***a**** | ***b**** |
| **Pre-Mordanting** | **$CuSO_4$** | 81.6479 | -4.1641 | 34.9708 | 87.7531 | -3.6231 | 41.4013 | 65.3080 | -2.0424 | 53.9499 | 66.5260 | 7.2769 | 28.6604 |
| | **$FeSO_4$** | 80.6534 | -4.3337 | 35.0915 | 86.7749 | -4.4042 | 40.5281 | 56.4342 | 8.6447 | 35.5240 | 53.0165 | 3.6511 | 20.9368 |
| | **$AlK(SO_4)_2$** | 82.5815 | -5.2001 | 30.4870 | 87.1028 | -4.4167 | 45.3741 | 71.5580 | 4.4433 | 52.3613 | 67.3996 | 8.2819 | 31.9809 |
| | **Reşadiye clay** | 82.4527 | -5.2071 | 29.6656 | 89.2087 | -6.3578 | 42.4587 | 70.2810 | 4.1304 | 49.7137 | 72.9137 | 5.8497 | 28.4178 |
| **Meta-Mordanting** | **$CuSO_4$** | 80.9814 | -3.7471 | 38.7291 | 87.0777 | -2.9016 | 40.4056 | 54.4217 | -4.0180 | 43.5251 | 57.1765 | 8.8656 | 32.2563 |
| | **$FeSO_4$** | 79.9702 | -1.8444 | 24.5118 | 86.5038 | -4.5317 | 40.4070 | 50.7282 | 6.2509 | 29.1513 | 38.3901 | 2.5694 | 11.8315 |
| | **$AlK(SO_4)_2$** | 84.4866 | -5.9672 | 27.5320 | 91.2660 | -6.3882 | 40.1887 | 76.6141 | 8.2100 | 58.3235 | 58.7938 | 6.7996 | 34.5097 |
| | **Reşadiye clay** | 83.6890 | -7.5899 | 31.4831 | 88.8579 | -4.9581 | 36.8599 | 71.4885 | 2.3455 | 44.6924 | 63.8464 | 9.2905 | 31.4220 |
| **Post-Mordanting** | **$CuSO_4$** | 79.1343 | -3.2207 | 42.1650 | 83.4222 | -2.9411 | 40.3297 | 63.6006 | -7.5522 | 48.4050 | 48.8846 | 10.7937 | 28.1291 |
| | **$FeSO_4$** | 77.3253 | -1.3627 | 31.8594 | 83.7020 | 1.5685 | 27.3148 | 51.6432 | 9.5072 | 38.5973 | 36.1886 | 3.6141 | 13.6106 |
| | **$AlK(SO_4)_2$** | 85.1789 | -5.2509 | 24.0254 | 92.6982 | -7.1589 | 39.1505 | 78.0158 | 4.7251 | 52.7204 | 60.1918 | 6.9334 | 30.9254 |
| | **Reşadiye clay** | 85.3008 | -5.7712 | 20.3215 | 90.8214 | -4.1107 | 24.9839 | 64.3392 | 1.6904 | 35.8158 | 66.5547 | 7.5357 | 31.0123 |

**Table 3.** Wet, dry, washing and light fastness values of dyed samples.

| Dyeing Method | | Wet fastness | | | | Dry fastness | | | | Washing fastness | | | | Light fastness | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $CuSO_4$ | $FeSO_4$ | $AlK(SO_4)_2$ | Reşadiye clay | $CuSO_4$ | $FeSO_4$ | $AlK(SO_4)_2$ | Reşadiye clay | $CuSO_4$ | $FeSO_4$ | $AlK(SO_4)_2$ | Reşadiye clay | $CuSO_4$ | $FeSO_4$ | $AlK(SO_4)_2$ | Reşadiye clay |
| Pre-Mordanting | Cotton | 5 | 5 | 5 | 5 | 4 | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 3 | 3 | 3 | 2 |
| | Wool | 5 | 5 | 5 | 5 | 4 | 4 | 3 | 4 | 3 | 3 | 4 | 3 | 2 | 2 | 1 | 1 |
| | Wool yarn | 5 | 5 | 5 | 5 | 4 | 3 | 4 | 4 | 3 | 3 | 4 | 3 | 6 | 6 | 2 | 3 |
| | Leather | 5 | 5 | 5 | 5 | 2 | 3 | 3 | 3 | 4 | 3 | 3-4 | 4 | 7 | 7 | 6 | 6 |
| Meta-Mordanting | Cotton | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 3 | 3 | 5 | 4 | 5 | 4 | 3 | 2 |
| | Wool | 5 | 5 | 5 | 5 | 3 | 3 | 3 | 4 | 2 | 3 | 3 | 4 | 7 | 7 | 3 | 2 |
| | Wool yarn | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 1 |
| | Leather | 5 | 5 | 5 | 5 | 3 | 2 | 3 | 4 | 3 | 4 | 3 | 4 | 7 | 7 | 6 | 6 |
| Post-Mordanting | Cotton | 5 | 5 | 5 | 5 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 2 | 1 |
| | Wool | 5 | 5 | 5 | 5 | 4 | 3 | 4 | 4 | 3 | 3-4 | 4 | 4 | 4 | 3 | 2 | 1 |
| | Wool yarn | 5 | 5 | 5 | 5 | 4 | 3 | 4 | 4 | 3 | 3 | 3 | 4 | 6 | 6 | 2 | 2 |
| | Leather | 5 | 5 | 5 | 5 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 4 | 7 | 7 | 6 | 6 |

**Table 4.** K/S values of wool and cotton fabrics dyed with turmeric/ginger extracts.

| | | | Wool fabric | Cotton | Wool yarns | Leather |
|---|---|---|---|---|---|---|
| | **Dyeing Method** | **Mordant** | ***K/S*** | ***K/S*** | ***K/S*** | ***K/S*** |
| **Turmeric/ginger extract** | **Pre-mordanting** | **$CuSO_4$** | 1.3937 | 1.22989 | 9.06506 | 2.3889 |
| | | **$FeSO_4$** | 1.26854 | 1.37782 | 6.52296 | 4.171175 |
| | | **$AlK(SO_4)_2$** | 1.51673 | 0.98052 | 4.75156 | 2.5897 |
| | | **Reşadiye clay** | 1.20579 | 0.9680 | 5.22092 | 1.56339 |
| | **Meta-mordanting** | **$CuSO_4$** | 1.13937 | 1.49684 | 12.31667 | 5.09457 |
| | | **$FeSO_4$** | 1.27823 | 0.86968 | 7.3911 | 7.41906 |
| | | **$AlK(SO_4)_2$** | 0.90599 | 0.75671 | 4.45746 | 4.95247 |
| | | **Reşadiye clay** | 0.91521 | 0.99645 | 3.83241 | 2.17598 |
| | **Post-mordanting** | **$CuSO_4$** | 1.45602 | 1.95258 | 7.94071 | 7.46135 |
| | | **$FeSO_4$** | 0.77595 | 1.47302 | 10.70364 | 9.61682 |
| | | **$AlK(SO_4)_2$** | 0.76696 | 0.57565 | 3.27866 | 3.85056 |
| | | **Reşadiye clay** | 0.43100 | 0.50019 | 4.09496 | 2.63145 |

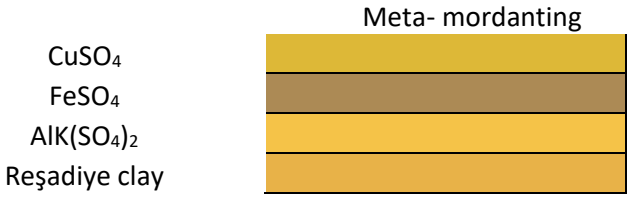


**Figure 5.** Color scale of wood

The K/S values of cotton fabrics dyed with turmeric/ginger extract are given in Table 4. According to the Table 4, the highest value (K/S=1.95) in the K/S measurements of cotton fabrics dyed with turmeric/ginger extract was obtained in the last mordanting method with $CuSO_4$. The lowest value (K/S = 0.50) was obtained in the last mordanting method with Reşadiye claymordant. When we evaluate the Table 4, we can see that the highest value in K/S values of woolen fabrics (K/S= 1.51) was obtained in the pre-mordanting method with $AlK(SO_4)_2$ mordant. The lowest result (K/S=0.43) was obtained in the post- mordanting method with Reşadiye clay mordant. When the data in Table 4 is evaluated, the highest value in the K/S of wool yarns was obtained in the meta- mordanting method with $CuSO_4$ mordant (K/S=12.31), while the lowest value was obtained with in the last mordant method with $AlK(SO_4)_2$ mordant (K/S=3.27). According to the Table 4, the highest value (K/S=7.46) in the K/S of the leather dyed with turmeric and ginger was obtained in the post- mordanting method with $CuSO_4$ mordant, while the lowest value (K/S=1.56) was obtained in the pre-mordanting method with Reşadiye Clay mordant.

In the study conducted by Önal et al.[5] on the dyeing of different types of fabrics with turmeric extract, the results obtained in wool and cotton fabric dyeing were in the range of (4–5) for $CuSO_4$ and $FeSO_4$ in pre-mordanting, together and post- mordanting, and it is noteworthy that they are slightly higher than in our study. The low values we found may be due to the low turmeric concentration in the dye mixture we used. In the same study, the K/S value for cotton fabric was found to be 12.60 for $FeSO_4$, while it was found to be 1.37 in our study. The highest K/S value for wool yarn was found to be 2.55 for $FeSO_4$, while the highest K/S value in our study was measured as 1.51. The low results can be explained by the decrease in the turmeric concentration in the dye bath.

## DISCUSSION

In the study, the extracts were prepared from dried and ground turmeric and ginger. The samples were dyed with $FeSO_4$, $CuSO_4$ and $AlK(SO_4)_2$ and Reşsdiye clay mordants using pre–, meta–, post–mordanting and without–mordanting methods. When the results obtained in this study were evaluated, it was concluded that the light, washing and friction fastnesses of the dyed samples were at a good level and that turmeric and ginger extracts could be a suitable dye source in natural dyeing of cotton, wool, leather and wood. Additional research is required to increase color efficiency and fastness values. Our working group is making the necessary plans in this regard**.**

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