Color Parameters and Optical Properties of Silk Fabrics Dyed with Natural Dye (Artemisia Herba-Alba)

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Article Type: Research article.

Abstract

The present work deals with the evaluation of the color parameters and fastness properties of silk fabrics dyed with a natural dye that extracted from the Artemisia Herba-Alba plant at different dyeing conditions such as pH values, temperature, and dyeing time. The reflectance spectra of pure blank and dyed silk fabrics were followed using the spectrophotometer technique. The effect of different dyeing conditions on the optical parameters (CIE tristimulus values, color parameters, absorption coefficient, and color strength) was determined before and after exposure to artificial daylight for 160 hrs. The obtained results indicate that the silk fabrics were highly dependent on either of these different dyeing conditions and/or artificial daylight exposure. Improvements in the dyeing process were produced which may be due to the change in the molecular configuration by variation in the chemical bonds in silk fabrics. The present work gives a chance to use a new traditional natural dye that meets the environmental future technology of high-quality fantastic dyed patterns. Also, fastness properties to perspiration and washing were tested for all silk fabrics under investigate

Keywords**:** *Artemisia Herba Alba* plant, silk fabric, optical properties, color parameters, dyeing conditions.

1-Introduction:

Because the stems and leaves of Artemisia Herba-alba (white wormwood) were white and woolly [1], it was given the epithet Epithetherba-Alba, which means "white herb" in Latin I. In French, it is known as Armoise Herbe Blanche or Armoise Blanche, in Arabic, It is called shiH. [2] In Old Testament Hebrew [3,4], it's called la'anah. It is a perennial shrub in the Artemisia genus that grows in the Mediterranean dry steppes of Northern Africa (Saharan Maghreb), Western Asia (Arabian Peninsula), and South-western Europe. [5] It is used in herbal medicine as an antiseptic and antispasmodic.

Artemisia Herba-Alba" plant, gives an essential oil depending on place grows up it contains primarily 1,8-cineole and trace amounts of alpha and beta-thujone, as well as other oxygenated monoterpenes such as terpinen-4-ol, camphor, and borneol, that identified in parts collected from Sinai desert in Egypt [6]. And also, Davanone, chrysanthenone, and cischrysanthenol have been identified as major constituents in Artemisia Herba-Alba populations from Morocco [7] and Spain. [8]. Non-head-to-tail monoterpene alcohols, such as Santolina and yomogi alcohol, have been identified in some Negev desert populations [9]. Sesquiterpenes eudesmanolide and germacranolide have been found in a methanol extract of aerial parts collected in Egypt [10]. Two bioactive flavonoids, assumed to be hispidulin and cirsiliol, were isolated by chromatography from aerial parts ethyl acetate extract [11].

Silk fibers are protein-based fibers produced naturally by the silkworm, where, silkworms produce protein fiber discovered 2700 BC. The produced silk fiber consists of 97% protein-fibroin, a filamentous protein and sericin (gum), a non-filamentous protein, and also other impurities such as pigments, wax, carbohydrates, and inorganic salts. These fibers must be degummed before dyeing [12]. The proteins in the silk (polypeptide) fiber which is composed of 18 amino acids (–NH–CHR–CO–); imino acid (–NR^1–CHR^2–CO–) monomers linked via amide bonds (peptide bonds) by various reactive functional groups including hydroxyl (OH) [13] including hydroxyl (COOH) and amine groups(NH_2) [14]. This is represented by a weight of approximately 75% fibroin and 25% sericin which is responsible for strength in the silk fiber and makes it lackluster. Silk fiber consists of two bio-macromolecules that have been used as a premium textile material [15], it has genital luster, smooth and soft, good texture, good drapability, good hygroscopicity, and excellent comfortability [16]. In the dyeing process, dyes in solutions are absorbed and diffused into the fiber, establishing with it physicochemical interactions to form strong chemical bonds with the basket material to set the color permanently. It enters deeply into the fiber in the presence of mordants such as Alum (Potassium and Aluminum Sulfate) which are embedded into the fiber to receive the dye molecules thus facilitating the bonding between the dye and the fabric [17].

In this article, optimization of extraction natural dye from *Artemisia Herba Alba* Blanche for dyeing silk fabric at different conditions: pH values, temperature, and time of dyeing bath. The colorfastness properties for light, washing, and perspiration were evaluated for all dyed samples. And also, the optical parameters including CIE tristimulus values (X_r, Y_r, and Z_r), color parameters (L*, a*, b*, ΔE*, C, and H), absorption coefficient (α), extinction coefficient (E) and color strength(K/S) were detected from the reflectance spectra.

2-Research Methodology

2-1-Chemicals &Materials

Pure silk fabric was produced in Akhmim, Egypt, its properties (100%, 55g/m^2 in weight and 0.0006 m in thickness), and natural dye extracted from dried leaves of *Artemisia Herba-*Blanche were used. The fabric was prepared before dyeing by soaking in non-ionic detergent (0.5 g/l sodium carbonate and 2 g/l) with a liquor ratio of 1:50 at temperature 60^{o}C for 15 min., then washed after dyeing with tap water and dried at ambient conditions.

2-2-Dye Extraction Procedure

Dried leaves of *Artemisia Herba*-Blanche (with Arabic name EL-Shieh) were used for obtaining natural dye then crushed. Take 50 g of this natural dye crushed in 500 ml of distilled water and allowed to boil for one hour, then filtrated that solution to drain the undesired portions to obtain a clear solution for use in the dyeing process. [18]

2.2.1 Characteristics of the Extracted Dye

The absorption spectrum of the extracted natural dye was evaluated by using Shimadzu (VIS) Double Beam Spectrophotometer with standard illuminant C (1174.83) model V-530 and bandwidth 2.0 nm with accuracy ± 0.05 % in the UV-visible range(250-700nm). The optical density of the extracted solution after filtration was measured. The determination of its optical density was taken as a measure of concentration as in figure (1a). As noticed from the figure, one peak was detected at 320 nm of optical density 5.386.

Also, figure (1b) shows the FTIR spectra of the extracted natural dye by using of Nicolet 380 (FTIR) spectrometer in Attenuation Total Reflection (ATR) mode with a zinc selenide crystal, in the wavelength range 650-4000cm^{-1}. The characteristic different functional groups for the extracted natural dye are O-H stretching bond at 3427.06 cm^{-1}, C-H vibration at 2922.01 cm^{-1}, C=O antisymmetric stretching at 1632.58 cm^{-1}, C-O-C stretching at 1323.78 cm$^{-1,}$ and C-H bending at 1421.4 cm^{-1}**.**

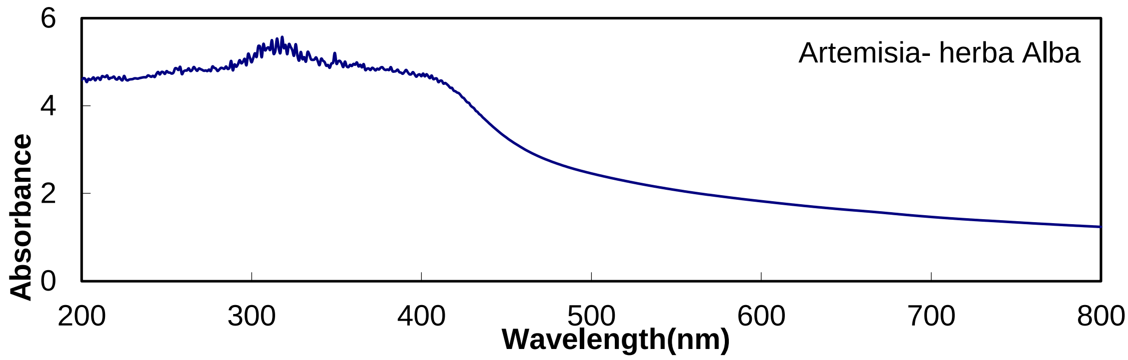

Fig. 1a : Optical density of extracted *Artemisia Herba Alba dye*

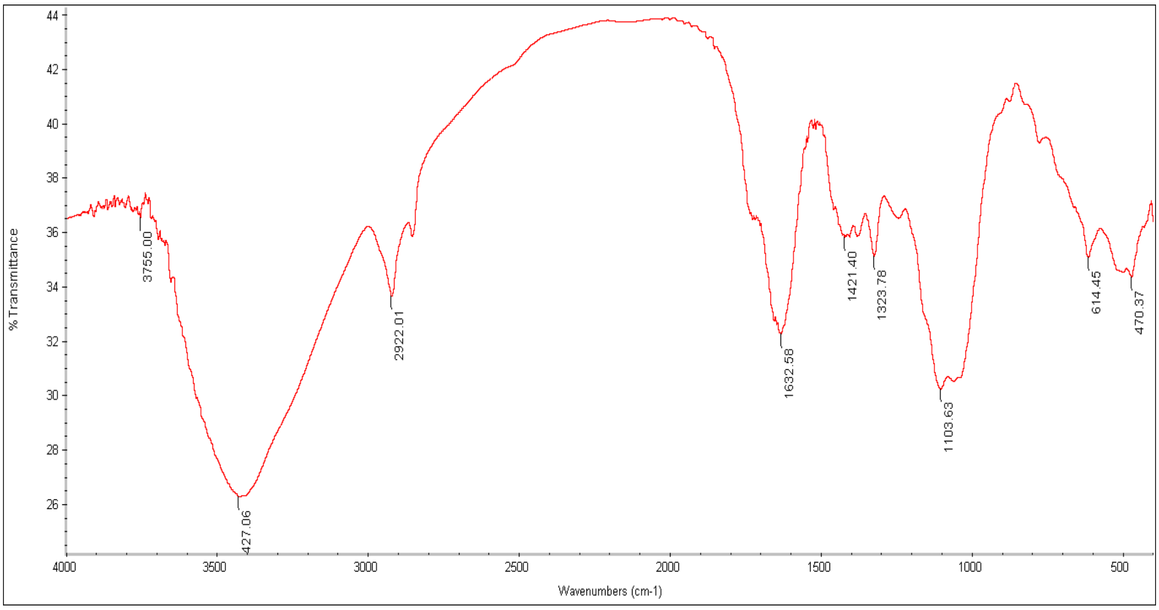

Fig. 1b : FTIR spectra of extracted *Artemisia Herba Alba* dye

2-3- The dyeing method

Silk fabrics were dyed at different dyeing conditions such as pH values, temperature, and dyeing time by using a liquor ratio of 1:50. Where, the fabrics were divided into three groups, which were pre-mordant with Alum (Potassium and Aluminum Sulfate) of concentration 5 g/Liter before dyeing. The first group was dyed at a temperature of 60^{o}C for 45 minutes in dye baths of different pH values (2, 3,4,5,6, and 9). The second group was dyed at pH = 5, with a temperature of 60^{o}C for different times 15, 30, 45, 60, and 90 minutes. The third group was dyed for 45 minutes and pH =5 in a dyed bath for different temperatures (40, 60, 80, and 100^{o}C). All of the examined samples were dyed separately by the pre-extracted dye in a laboratory dyeing apparatus using the conventional exhaustion dyeing method [19].

2-4- Reflection Measurements

Studying reflectance spectra of undyed and dyed silk fabrics with different conditions (pH, time, and temperature) as well as unexposed and exposed groups (clarification is required) were carried out in the visible region (400-700 nm). All the silk fabrics under test were exposed to artificial daylight using “Tera Light Fastness Tester” [20] according to ASTM, G 23 - (1990) to determine fastness to light was performed for 160 hours at a temperature of 25±2^{o}C and at the humidity of 65± 5%. A standard grayscale was used to evaluate the change in color after exposure to artificial daylight according to ISO standard [21].

The color properties were analyzed using the CIE Colorimetric System CIE 1931 2- degree Standard Observe [22,23,24]. On the other hand. From the reflectance spectra, the absorption coefficient (α) and the extinction coefficient (E) were calculated using (Equation 1, 2) [25,26].

The color strength (K/S depends on the dyestuff and the substrate) of the undyed and dyed silk fabrics under investigation were measured in the visible range covered from 400-700 nm.

$$\alpha = \frac{1}{d} \ln \frac{(1-R)2}{T} \qquad \text{Equation 1}$$

$$E = \frac{\alpha\lambda}{4\pi} \qquad \text{Equation 2}$$

Where R is the reflectance, T is the transmittance (~ 10^{-3}), and (d) is the thickness of the sample (about 0.0006 m) (α) represents the absorption coefficient (is dependent on the dyestuff) and (E) is the extinction coefficient (is dependent on the substrate). On the other hand, the color properties were analyzed using the CIE Colorimetric system, CIE 1931 2-degree standard observer. The tristimulus values (X_r, Y_r, and Z_r) the relative brightness (L*: with values from 100 to 0 respectively, color constants a*: illustrates the red green-value, and b*: illustrate the yellow-blue value, the color difference (ΔE*), chroma (C*) and hue angle (H*) were performed [27,28,29].

2-5- Fastness Properties

The fastness properties including perspiration, washing, and light were performed according to ISO 105-E04 [30], ISO 105 C06 [31] and ASTM, G 23 - (1990) [32] according to standards, respectively.

3- RESULTS AND DISCUSSION:

3-1- CIE Tristimulus values and color parameters

The reflectance (R%) spectra in the visible range (400-700 nm) increase with increasing wavelength for samples before and after being exposed to artificial daylight dyed for 160 hrs. at a temperature of 60°C for 45 minutes in the dye baths of different pH values (2,3,4,5,6 and 9) were shown in figure (2a). It was clear that, behaviors of the dyed silk fabrics before and after being exposed to artificial daylight completely change in comparison with the undyed sample. Remarkable the reflectance values were decreased for silk fabrics before and after being exposed to artificial daylight and continuously decreases gradually with increasing the pH values up to 3, almost stable in a decrease in pH 4 and 5 then increase gradually with increasing the pH value from 6 to 9. Similar behaviors and trends with decreasing pH values were detected for all samples after exposure to artificial daylight for 160 hrs. figure (2a)

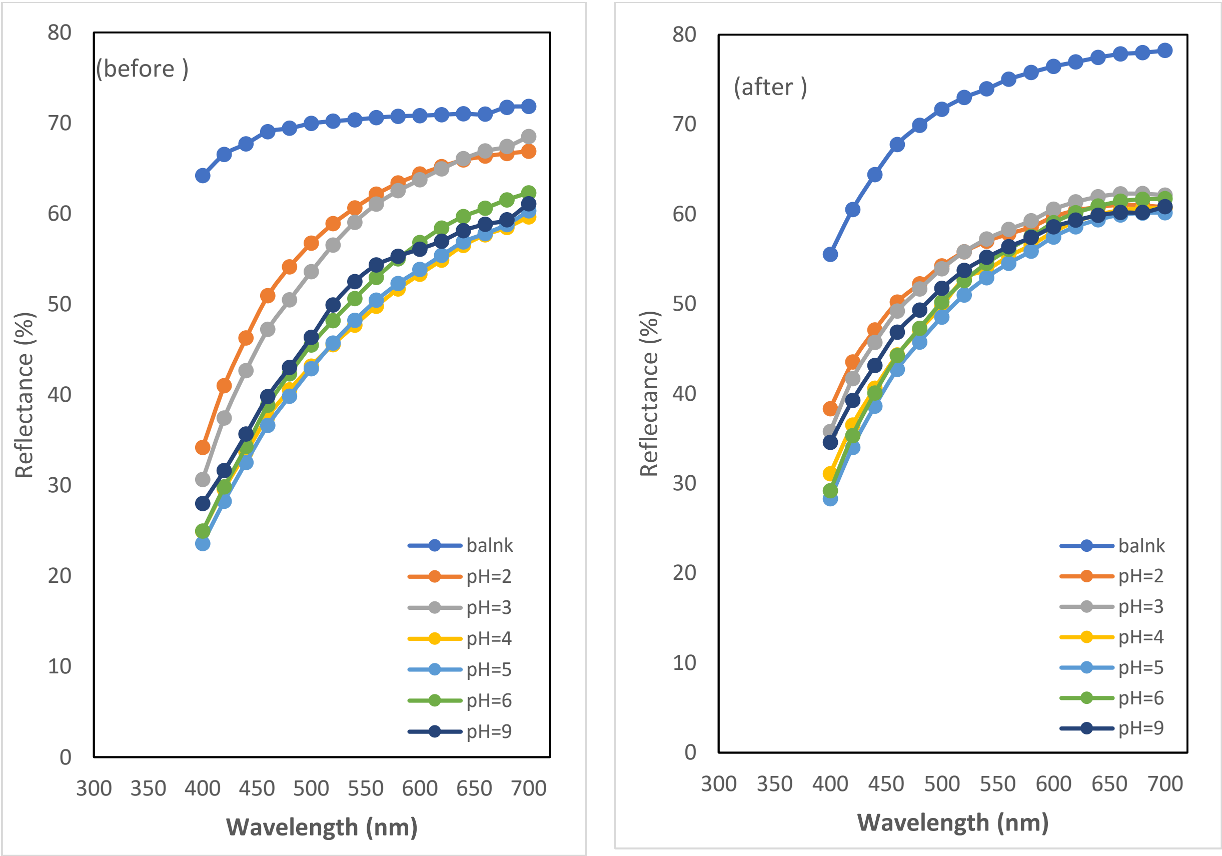

Fig. 2a : The reflectance % spectra of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different pH before and after exposure to artificial daylight for 160 hr., as functions of wavelength in the visible region.

Figure (2b) shows the reflectance % spectra in the visible region for silk fabric dyed with *Artemisia-Herba Alba* before and after being exposed to artificial daylight for 160 hrs. in a medium of pH=5 and temperature 60°C for different dye times (15,30,45,60 and 90 minutes). It was clear that the behaviours of the silk fabric unexposed and exposed to artificial daylight increase in reflectance % with increase wavelength in comparison with the silk fabrics undyed which exposed and unexposed to artificial daylight. Variation was observed for the reflectance % value was decrease gradually with increasing the dye bath time up to 90 minutes for all samples before and after exposing to artificial daylight for 160 hours with increasing wavelength. (Figure 2b).

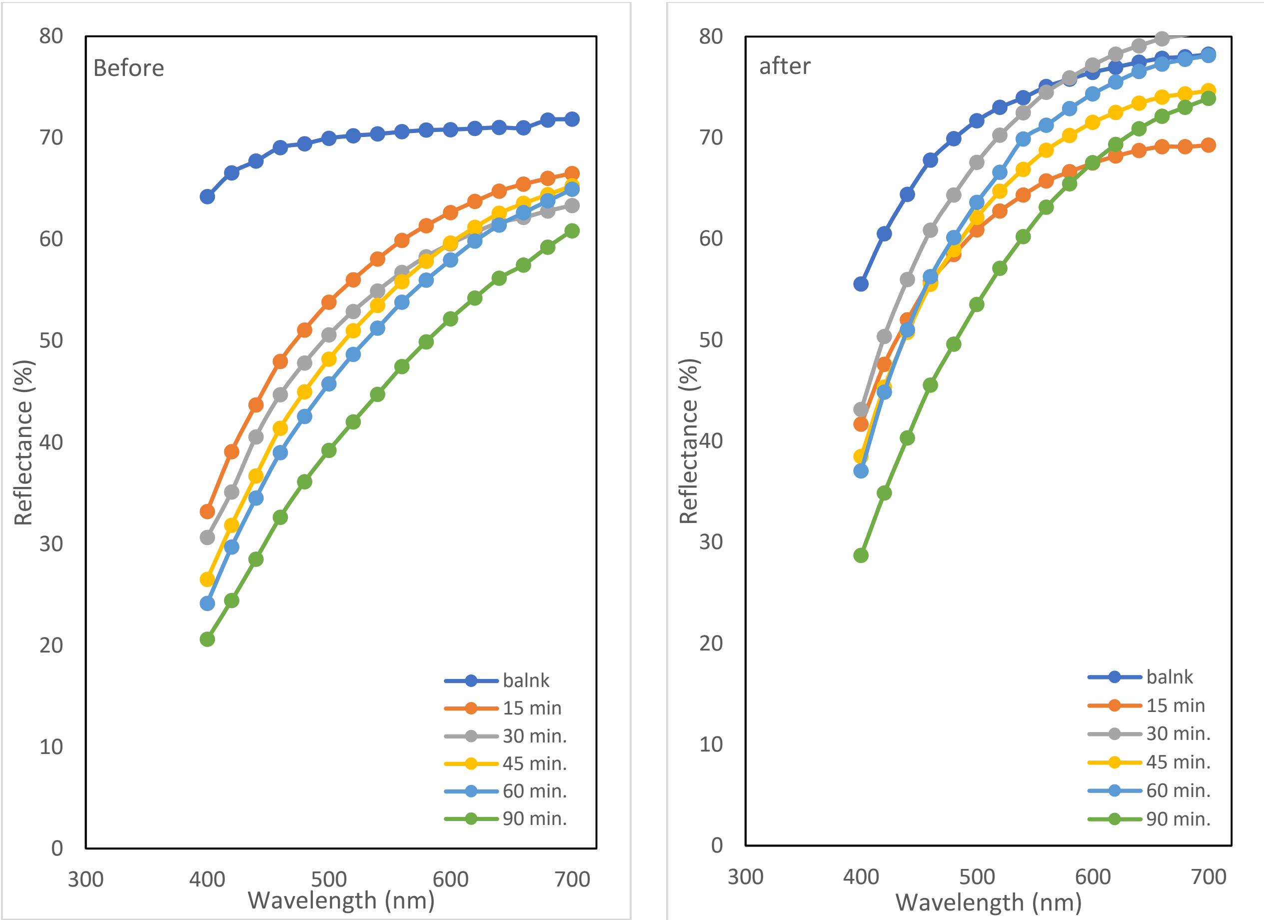

Fig. 2b : The reflectance % spectra of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different times before and after exposure to artificial daylight for 160 hrs. , as functions of wavelength in the visible region.

Figure (2c), the reflectance percentage (R %) as a function of wavelength in the visible range 400-700 nm for the dyed silk fabrics with natural dye *Artemisia-Herba Alba* before and after exposing to artificial daylight. *Artemisia-Herba Alba* dyed silk fabrics in a medium of pH=5 and time 45 minutes at different dye temperatures (40, 60, 80, and 100 ^oC). It was clear from the figure that the behaviors of the dyed silk fabrics before and after being exposed to artificial daylight change in comparison with the undyed fabric, the variation was detected that increase in both the reflectance value and wavelength for all the silk fabrics dyed with *Artemisia-Herba Alba* as natural dye before and after exposed to artificial daylight for 160 hrs. The R% values increase markedly with increasing wavelength and decrease gradually with increasing the dyeing temperature up to 100^{o}C for unexposed fabrics. Similar trends with more variations after exposure to artificial daylight for 160 hrs. were detected and the R% values reached their minimum values for dyeing temperature of 80^{o}C. figure (3c)

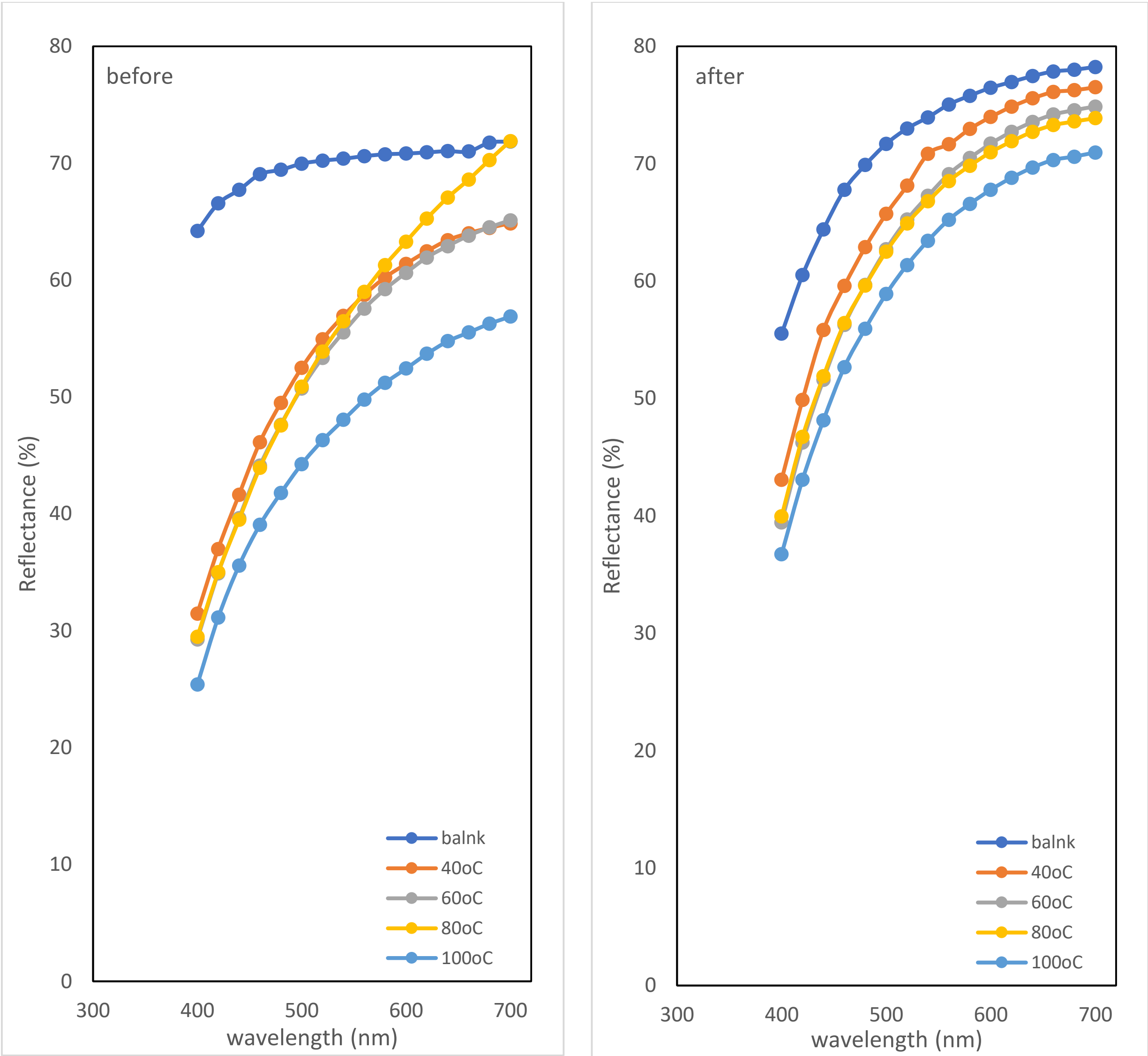

Fig. 2c: The reflectance % spectra of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different temperatures before and after exposure to artificial daylight for 160 hrs. as functions of wavelength in the visible region

From the observed variation, there is a high reflectance (color) change as a function of wavelength by increasing pH value, time as well as dyeing temperature this means that the dye components role, as well as artificial day light, was to strengthen the linkage between the reactive species of the silk fabric chemical groups and their polar groups. As already known, each dye has an optimum dyeing temperature and until that was attained, dye uptake will continue to increase with the increase in temperature as a result of the reduction of the aggregation and increase the amount of dye available to the fibre in the dye bath, the variations of the CIE tristimulus values(Xr, Yr, and Zr) for undyed and dyed silk fabrics using the *Artemisia- Alba* with different dye bath conditions (pH, temperature, and dyeing times) before and after exposure to artificial daylight for 160 hrs. were calculated from the values of the reflectance % spectra figures (2 a,b,c) and were plotted against wavelength as shown in figures (3 a,b,c) respectively. It was observed from the figures that, the behaviors of Xr, Yr, and Zr for all the samples under investigation are similar and there is no measurable change in the peak positions either with or without exposure to artificial daylight

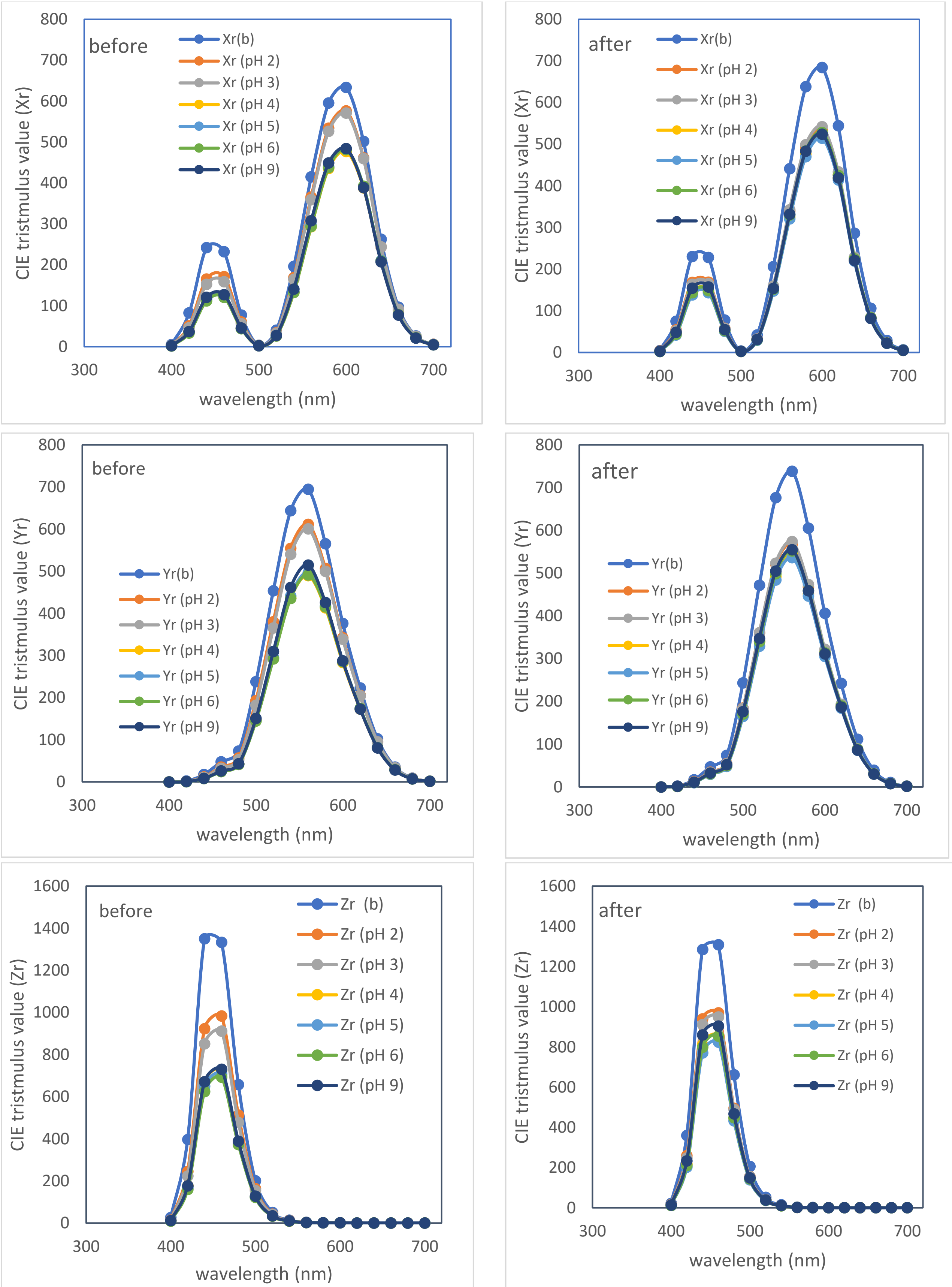

Fig. 3a: Variation of the CIE tristimulus reflectance values (Xr, Yr, and Zr) with wavelength for undyed and *Artemisia Herba-Alba* dyed silk fabrics with different pH before and after exposure to artificial daylight for 160 hrs. as functions of wavelength in the visible region.

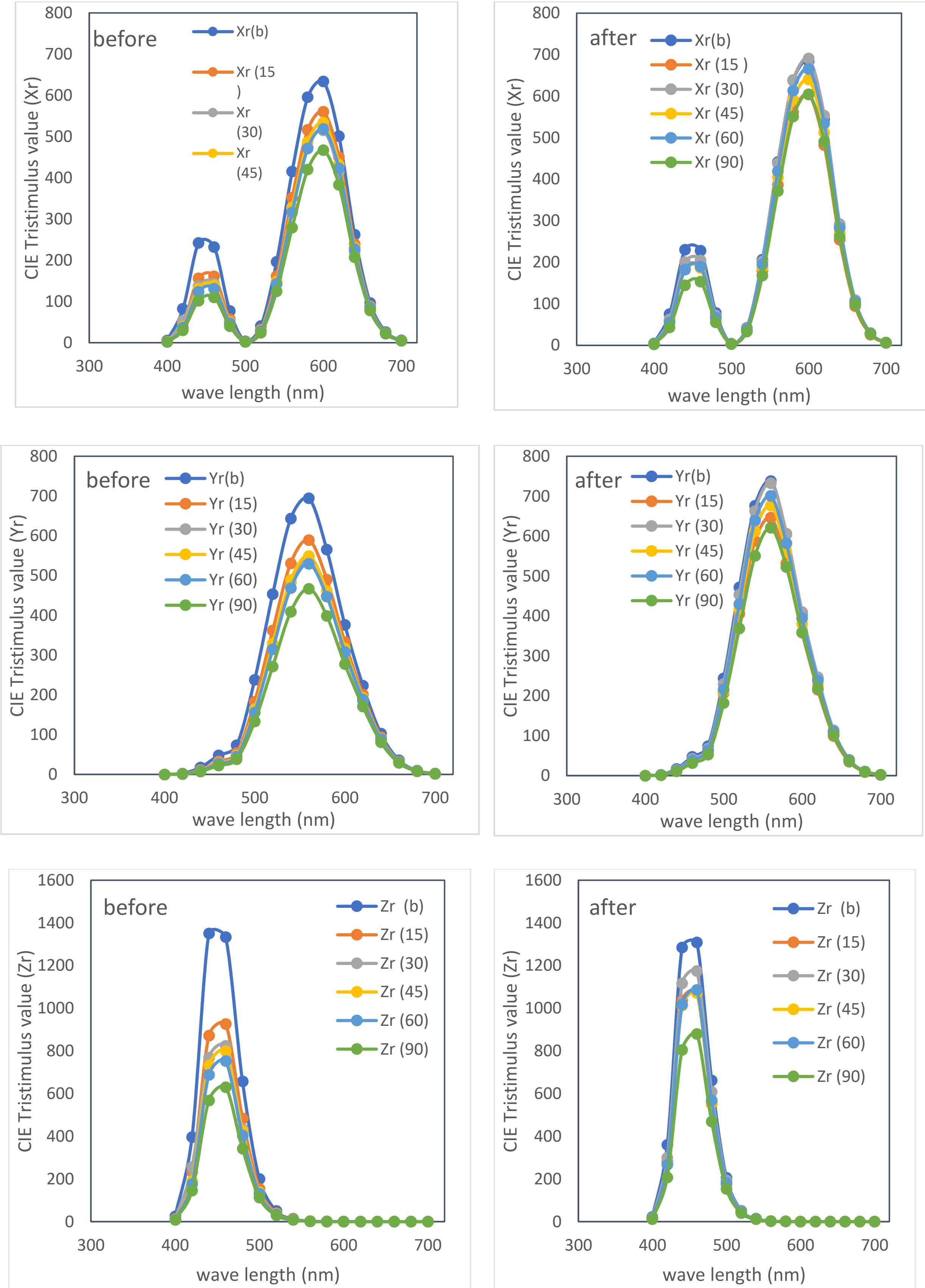

Fig. 3b: Variation of the CIE tristimulus reflectance values (Xr, Yr, and Zr) with wavelength for undyed and *Artemisia Herba-Alba* dyed silk fabrics with different dye bath time (min.) before and after exposure to artificial daylight for 160 hrs. as functions of wavelength in the visible region.

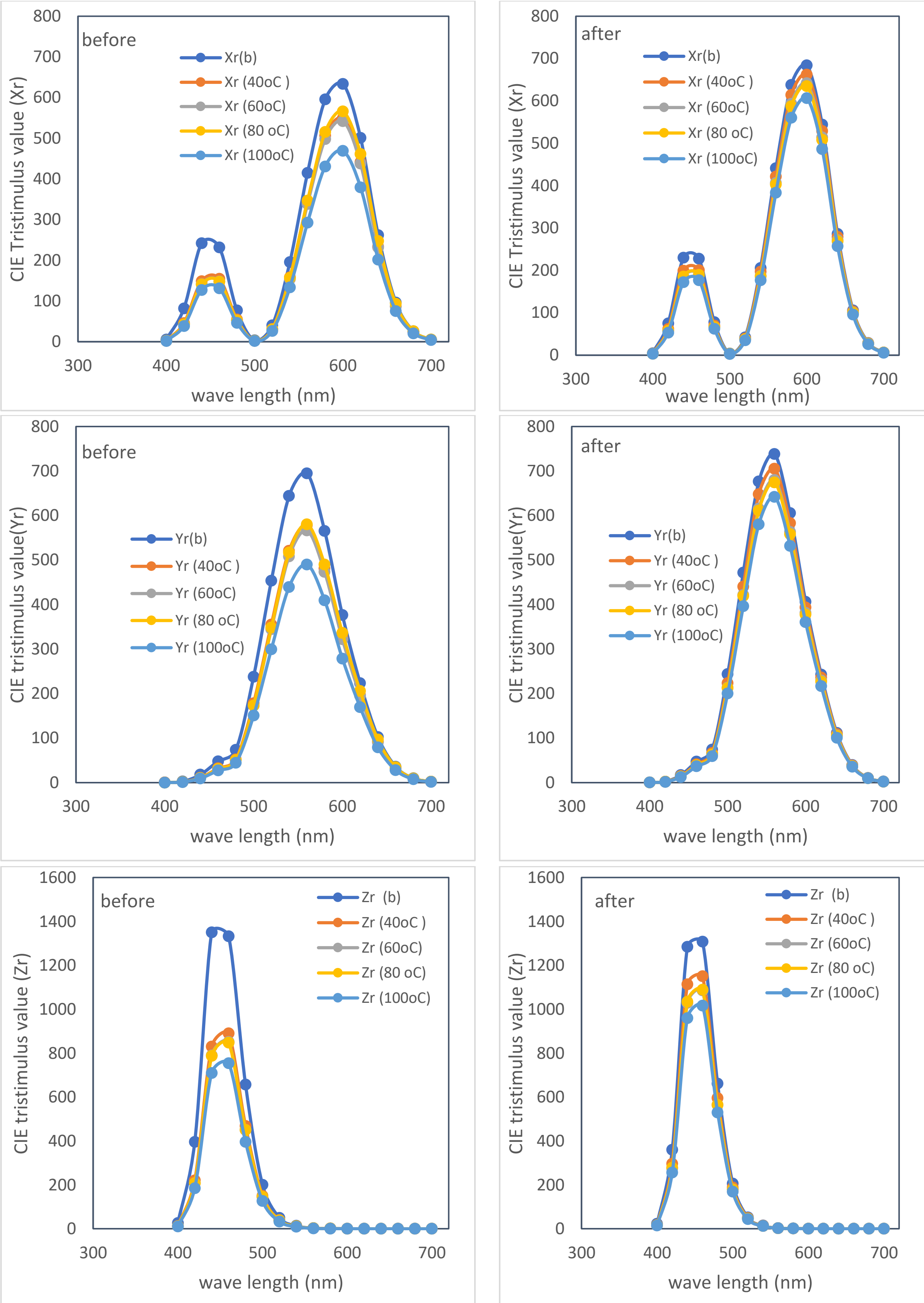

Fig.3c: Variation of the CIE tristimulus reflectance values (Xr, Yr, and Zr) with wavelength for undyed and *Artemisia Herba-Alba* dyed silk fabrics with different dye bath temperature (ºC) before and after exposure to artificial daylight for 160 hrs. as functions of wavelength in the visible region.

Table 1a : The maximum tristimulus reflectance values (Xr, Yr, and Zr) and their peak positions for undyed and *Artemisia Herba-Alba* dyed silk fabrics with different dyeing conditions before exposure to artificial daylight for 160 hrs.

λ (nm)		Xr		Yr	Zr
		440	600	560	460
	Blank	242.06	633.77	694.77	1332.60
pH Values	2	165.45	576.14	611.81	983.09
	3	152.58	570.59	600.89	911.49
	4	120.33	477.25	490.08	725.26
	5	116.37	481.90	496.48	707.12
	6	122.59	508.66	521.28	749.77
	9	127.52	502.04	534.76	768.68
Dyeing times (minutes)	15	156.19	560.57	589.38	925.97
	30	144.93	533.00	558.38	862.47
	45	131.17	533.81	549.32	798.98
	60	123.34	518.68	529.54	752.28
	90	101.82	466.87	467.05	629.73
Dyeing Temperature (°C)	40	148.83	549.20	577.86	890.07
	60	141.68	542.40	566.45	851.47
	80	141.21	566.29	580.52	848.19
	100	127.20	469.20	489.69	754.01

Table 1b: The maximum tristimulus reflectance values (Xr, Yr, and Zr) and their peak positions for undyed and *Artemisia Herba-Alba* dyed silk fabrics with different dyeing conditions after exposure to artificial daylight for 160 hrs.

λ (nm)		Xr		Yr	Zr
		440	600	560	460
	Blank	230.23	684.24	738.47	1307.89
pH Values	2	168.42	534.26	568.81	968.81
	3	163.41	541.86	573.83	949.32
	4	145.11	519.04	544.11	854.95
	5	138.03	514.12	536.53	824.26
	6	143.25	528.44	552.08	853.59
	9	154.19	524.14	554.84	904.16
Dyeing times (minutes)	15	185.83	603.88	646.65	1077.46
	30	200.16	690.59	733.06	1174.34
	45	181.47	639.85	676.77	1071.09
	60	182.33	665.18	701.07	1085.57
	90	144.18	604.24	621.16	879.07
Dyeing Temperature (°C)	40	199.59	662.14	705.30	1150.03
	60	184.47	641.73	680.21	1085.76
	80	185.51	635.20	674.40	1088.85
	100	172.10	606.47	641.93	1016.29

Tables (1 a, b), it was noticed that the variations in the maximum tristimulus reflectance values at their peak position for the undyed and dyed silk fabrics with the *Artemisia Herba-Alba* before and after exposing to the artificial daylight for 160 hrs under investigation were increased in tristimulus reflectance after exposed to artificial daylight rather than before exposed. As appeared in figures (3 a,b,c), it was noticed that the increase in the tristimulus reflectance values was detected either by the *Artemisia Herba-Alba* dyeing or by exposure to artificial daylight. The Xr, Yr, and Zr at the peak positions for all silk fabric samples under investigation with different conditions, the tristimulus for undyed silk fabrics were higher than either unexposed or exposed to artificial daylight, and also, the values of exposed silk dyed fabrics were higher than unexposed ones. That is, the tristimulus values associated with a trichromatic color space determine how much of each of the three primary colors is to be used to select a specific color for the human eye with normal vision in our case it is yellow color.

Table 2a: The color parameters for undyed and *Artemisia-Herba-Alba* dyed silk fabrics with different dyeing conditions before exposure to artificial daylight for 160 hrs.

		L*	a*	b*	ΔE	C*	H*
Blank		87.19	-0.30	1.76	---	1.79	2.26
pH Values	2	82.25	-0.38	12.11	11.46	12.12	-2.06
	3	81.39	0.36	14.61	14.11	14.61	-3.80
	4	75.10	1.36	15.05	18.07	15.11	-0.07
	5	75.30	1.39	16.70	19.17	16.76	-1.62
	6	75.40	1.48	17.59	20.03	17.65	-1.23
	9	76.14	-0.22	16.52	18.44	16.52	3.15
Dyeing times (minutes)	15	80.97	0.42	12.84	12.73	12.85	-0.89
	30	78.04	0.48	13.82	15.16	13.83	1.76
	45	78.54	1.24	16.53	17.19	16.58	1.04
	60	77.34	1.81	17.40	18.60	17.49	5.24
	90	73.44	2.83	19.06	22.32	19.27	2.06
Dyeing Temperature (ºC)	40	80.28	0.14	13.79	13.88	13.79	0.50
	60	79.57	0.55	14.88	15.20	14.89	-0.37
	80	80.37	1.83	16.37	16.26	16.47	-1.92
	100	75.15	0.77	13.10	16.57	13.12	0.27

Table 2b: The color parameters for undyed and *Artemisia Herba-Alba* dyed silk fabrics with different dyeing conditions after exposure to artificial daylight for 160 hrs.

		L*	a*	b*	ΔE	C*	H*
Blank		88.98	-0.36	6.82	---	6.83	-10.51
pH Values	2	80.35	-0.14	8.51	8.97	8.51	-0.51
	3	80.17	-0.02	10.09	9.24	10.09	0.28
	4	78.49	0.44	12.45	11.93	12.46	47.34
	5	77.97	0.48	13.71	13.01	13.72	3.37
	6	77.90	0.50	13.84	12.13	13.85	-1.48
	9	79.20	-0.11	10.78	10.55	10.78	-1.43
Dyeing times (minutes)	15	88.16	-0.32	9.89	5.71	9.90	1.79
	30	87.29	0.01	12.55	5.78	12.55	0.07
	45	85.53	0.02	12.98	7.87	12.98	-0.27
	60	84.65	0.09	14.41	7.95	14.41	-9.04
	90	82.33	1.51	18.31	13.41	18.37	-2.12
Dyeing Temperature (°C)	40	87.06	-0.24	11.48	5.04	11.48	-1.16
	60	85.74	-0.15	12.53	6.57	12.53	0.29
	80	85.49	-0.10	12.60	6.17	12.60	-2.86
	100	83.76	0.02	12.73	7.89	12.73	-0.34

The color parameters: relative brightness (L*), color constants (a* and b*), Chroma (C*), hue (H*) and color differences (ΔE) were calculated using the CIE colorimetric system and appeared in tables (2 a,b) show the detection of color parameter for the different conditions of undyed and *Artemisia Herba- Alba* silk fabric dyed unexposed and exposed to artificial daylight for 160 hrs.

For different dye bath pH values, the relative brightness (L*), shows the decrease in their values with increasing pH values up to 5 for the dyed silk fabrics before exposing to artificial daylight and then L* increase with increasing pH values which means that the fabric becomes firstly fader in color and then becomes more brightness. And also, the values of the color constant a*, increase then decrease in their values which indicates, that there is an increase in a red component instead of green component firstly and then an increase in a green component instead of the red component. The same thing for the value of color constant b* increase then decrease which indicates that there is an increase in a yellow component instead of the blue one and then an increase in a blue component instead of the yellow one. The results of color scales (C* and H*) and color difference (ΔE) indicate there are variations in the color difference between silk fabrics undyed and dyed with *Artemisia Herba- Alba* dye due to the difference in pH or/and exposure to artificial daylight.

For different dye bath temperatures and dyeing time, the relative brightness L* shows the decrease in their value with increasing dyeing times 45 minutes and increasing temperature up to 80°C for both before and after exposing to artificial daylight for 160 hrs. which indicates that the fabric becomes fader in color, and also, the values of the color constant, a* and b*, increase in their values with increasing either dyeing time or temperature which indicates that, there is an increase in a red component instead of green component and increase in a yellow component instead of the blue one, respectively. The detection of a decrease in color scales (C* and H*) and color difference (ΔE) between undyed and dyed using natural dye from *Artemisia-Herba- Alba* silk fabrics due to the presence of different dyes bath time and temperature before and after exposing to artificial daylight for 160 hrs.

The observed changes in the color parameters with the increase in different conditions of dye bath may be attributed to changes in the molecular configuration of the fabric were produced due to the change in the physical bonds which may lead to the formation of new doping centers. In addition, the obtained results of the color parameters are of great importance for the improvement of the optical properties of the fabrics.

3-2- Absorption Parameters

The absorption coefficient values (α), of the undyed as well as the unexposed (a) and exposed (b) silk fabrics dyed with different dyeing conditions (pH values, dyeing time, and dyeing temperature) were calculated in the visible wavelength range 400-700nm by using (Equation 1) from the reflectance% spectra figures (2 a,b,c), were shown in (figure 4 a,b,c), respectively. It was clear from these figures that the absorption coefficient values decrease with increasing the wavelength for all samples. As shown in figure (4a), the absorption coefficient values increase for both the unexposed and exposed samples with increase pH values up to 5 in the *Artemisia Herba-Alba* dye bath through the whole wavelength, this may be followed by fluctuated increase with increasing the pH values up to 9. The detected increase in the absorption coefficient values by increasing pH values up to 5 is due to rupture of the bonds between free radicals and new color centers,

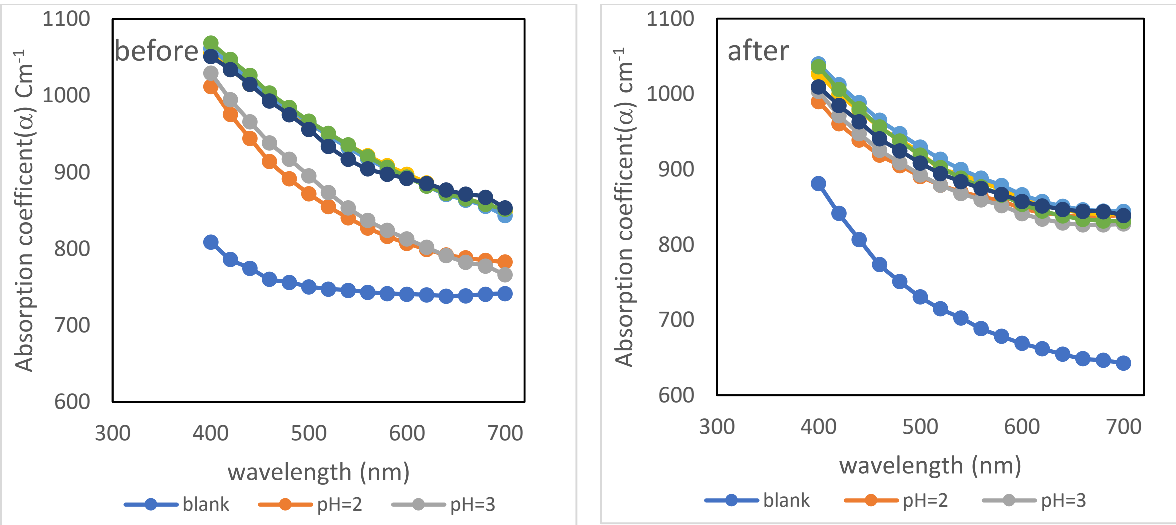

Fig. 4a: The absorption coefficient (α) spectra of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different pH before and after exposure to artificial daylight for 160 hrs. as functions of wavelength in the visible region.

Gradual increase in the absorption coefficient appears in figure (4b), for both exposed and unexposed samples with increasing dyeing time through the whole range of wavelength and a small increase at 60 minutes which appear steady at 45 minutes. It may be attributed to the change in chemical bonds between the fabric and the dye at different conditions (pH, time, and temperature) condition. It is observed in figure (4c) that a gradual increase in the absorption coefficient values for both unexposed and exposed to artificial daylight for 160 hrs (up to 60°C) appear slightly similar value and then slightly decreased (up to 80°C) as a result of the degradation process. So that, we detected that an increase in the absorption coefficient values with increasing *Artemisia Herba-Alba* dye bath pH values up to 5, time up to 45 minutes, and temperature up to 60 °C. From the observed results [33], the variations may be due to modification in molecular structure as a result of the degradation process and the dye component's role was to strengthen the linkage between the reactive species of the silk fabric chemical groups and their polar groups.

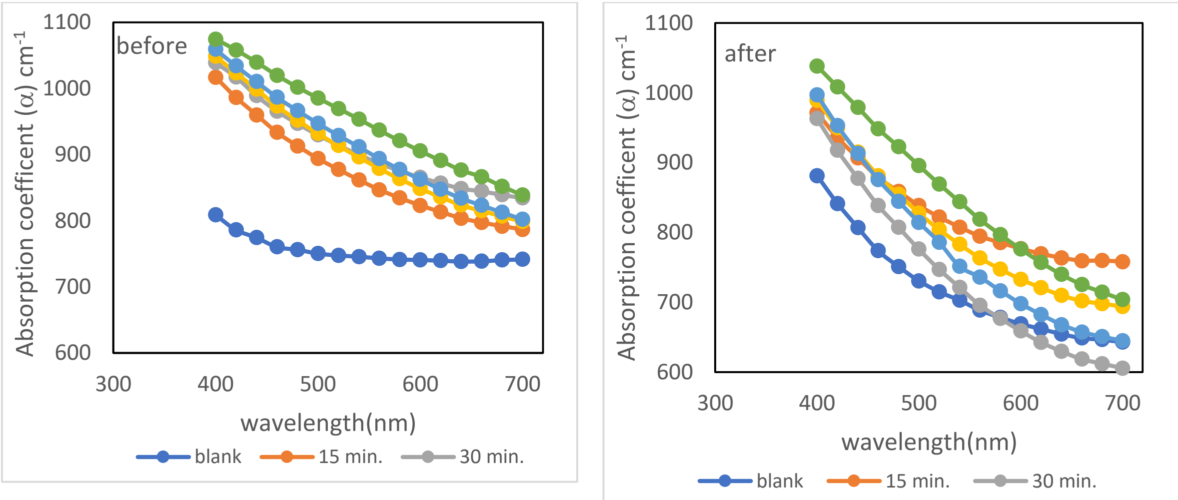

Fig. 4b: The absorption coefficient (α) spectra of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different times before and after exposure to artificial daylight for 160 hrs. as functions of wavelength in the visible region.

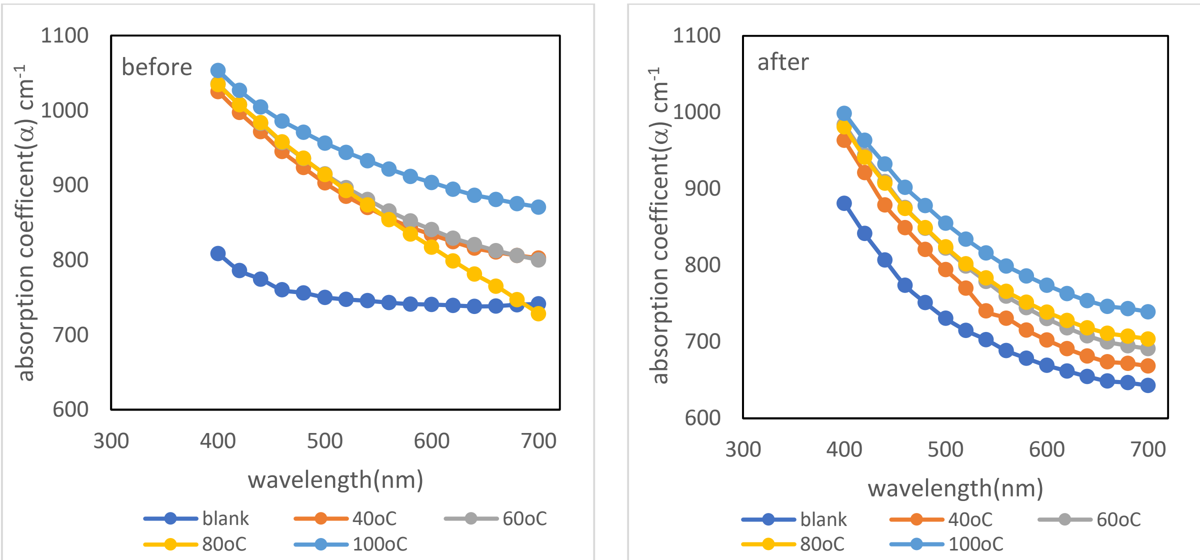

Fig. 4c: The absorption coefficient (α) spectra of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different temperatures before and after exposure to artificial daylight for 160 hrs. as functions of wavelength in the visible region.

3-3- Extinction coefficient

The Extinction coefficient ($E_{co\text{-}efficient}$) of the exposed and unexposed dyed silk fabric was calculated in the visible wavelength range 400-700nm by using (Equation 2) [34] from the reflectance spectra figure (1) and represented as functions of wavelength for undyed and *Artemisia Herba-Alba* dyed silk fabrics with different dye bath conditions (pH values, time and temperature) for the unexposed and exposed to artificial daylight for 160 hrs. were appeared in figures (5 a,b,c) respectively.

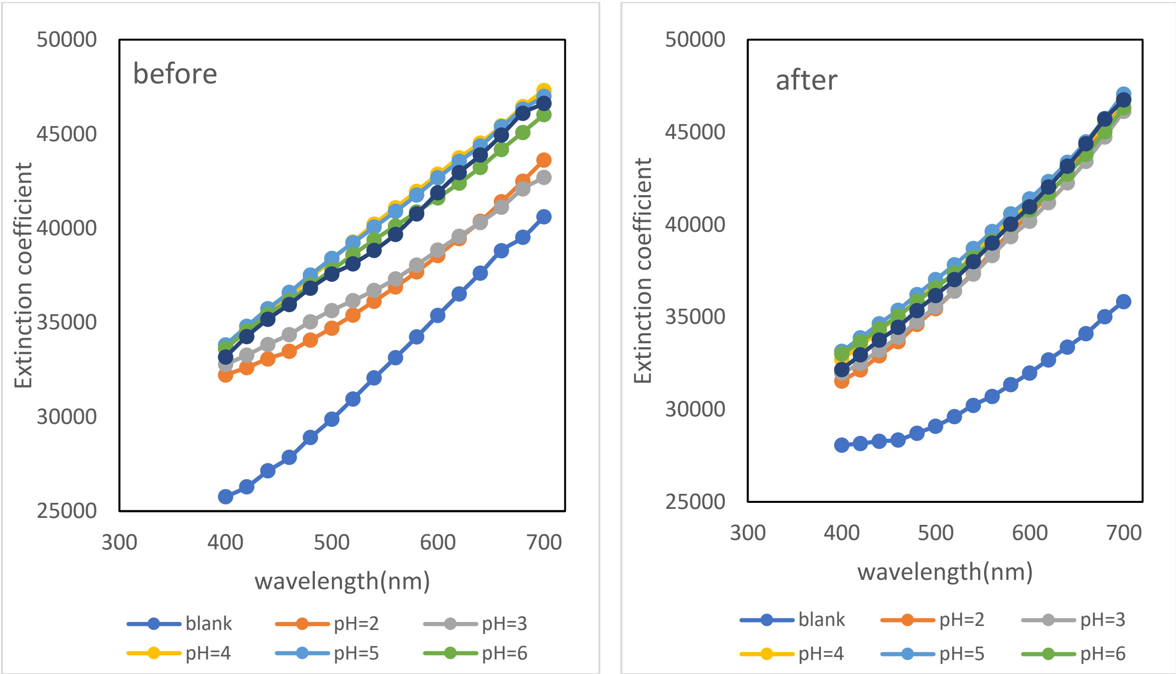

Fig. 5a: The extinction coefficient ($E_{co\text{-}efficient}$) spectra of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different pH Values before and after exposure to artificial daylight for 160 hrs. as functions of wavelength in the visible region.

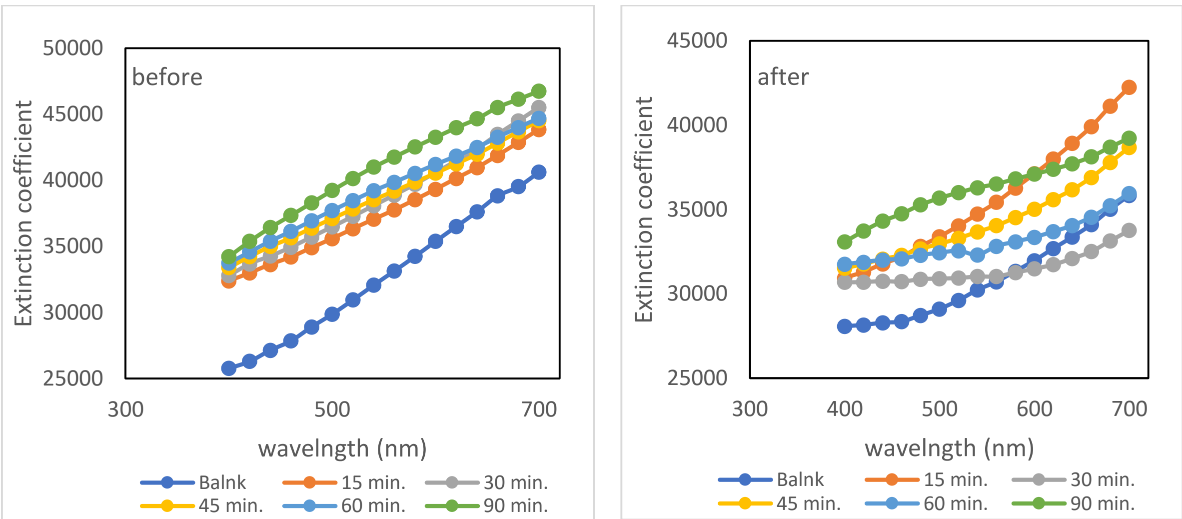

Fig. 5b: The extinction coefficient ($E_{co\text{-}efficient}$) spectra of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different times before and after exposure to artificial daylight for 160 hrs. as functions of wavelength in the visible region.

As known the extinction coefficient represented the properties of the material to light, it was noticed from figures (5 a,b,c), the extinction coefficient ($E_{co\text{-}efficient}$) for all samples under different conditions were similar through the whole wavelength range. As shown, we noticed that the increase in the extinction coefficient values either with increasing dye bath temperature or time with or without exposure to artificial daylight indicated that fractions of light were lost due to scattering which indicates that at room temperature silk fabric was considered to be an insulating material as reported [35].

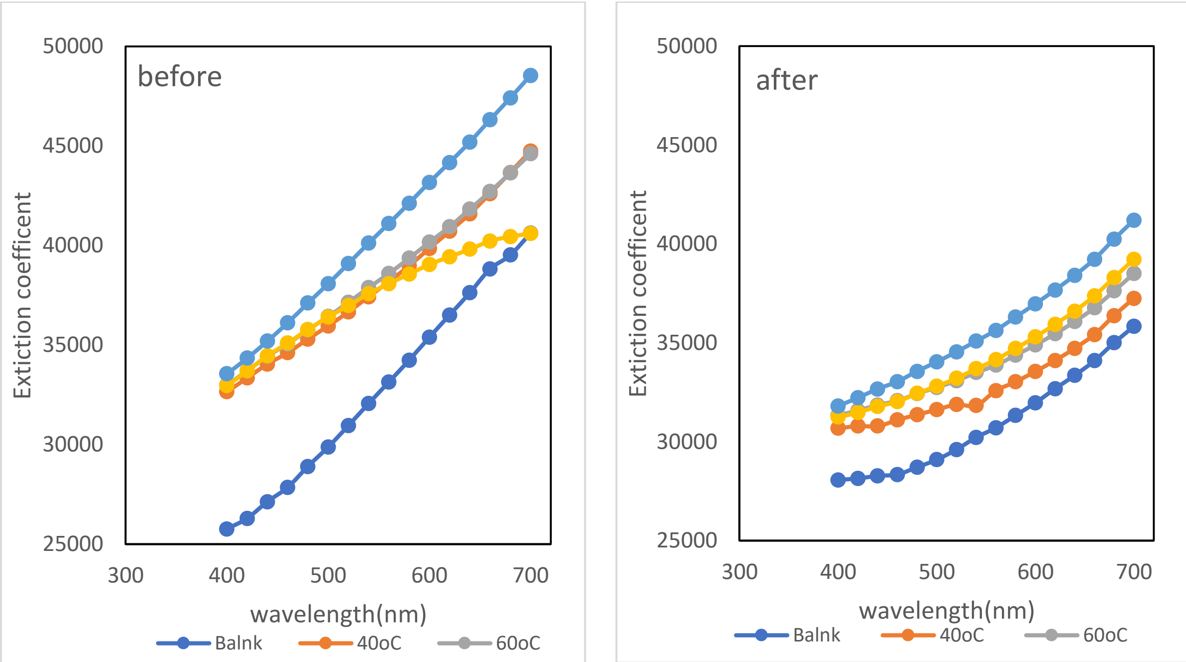

Fig. 5c: The extinction coefficient ($E_{co\text{-}efficient}$) spectra of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different Temperatures before and after exposure to artificial daylight for 160 hrs. as functions of wavelength in the visible region.

3-4-Color Strength

A close relationship to the amount of dye absorbed by the fabric under investigation was obtained by measuring color strength (K/S)., and it was a function of wavelength in the visible range 400-700 nm for unexposed and exposed *Artemisia Herba-Alba* dyes silk fabrics. Figures (6 a-c) show the variation of the color strength as functions of wavelength for undyed and *Artemisia Herba-alba* dyed silk fabrics with different dye bath conditions (dye bath pH values, time, and temperature) before and after exposure to artificial daylight for 160 hrs. All the samples show the same trends, K/S values decrease by increasing wavelength up to 700 nm.

Figure (6 a), shows that the change in color strength (K/S) with different pH (2, 3,4,5,6 and 9). It was clear for the unexposed dyed silk fabrics that color strength (K/S) increases by increasing pH value up to 5 related to less availability of dyed molecules which indicated that dye bath pH value was one of the most important parameters that must be controlled.

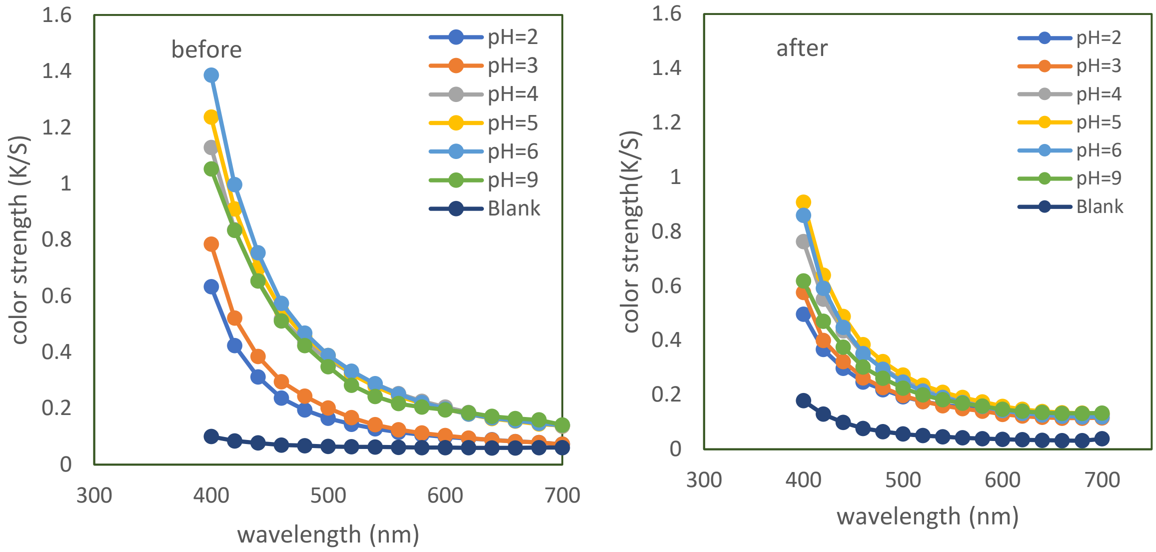

Fig. 6a: The color strength spectra of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different pH before and after exposure to artificial daylight for 160 hrs.

Figure (6 b), shows that the change in color strength (K/S) with different *Artemisia Herba-Alba* dye bath times (15, 30, 45, 60, and 90 min.). It was clear for the unexposed dyed silk fabrics that color strength (K/S) increases by increasing duration time., Decreasing in color strength indicates that the dyeing silk fabrics with time for all of the examined samples before and after exposure to artificial daylight, the (K/S) values for all samples increase by increasing duration time. And also, it could take the suitable amount of Artemisia dye with the time change for dye bath was about 45 minutes any increase in time color strength (K/S) was slightly change

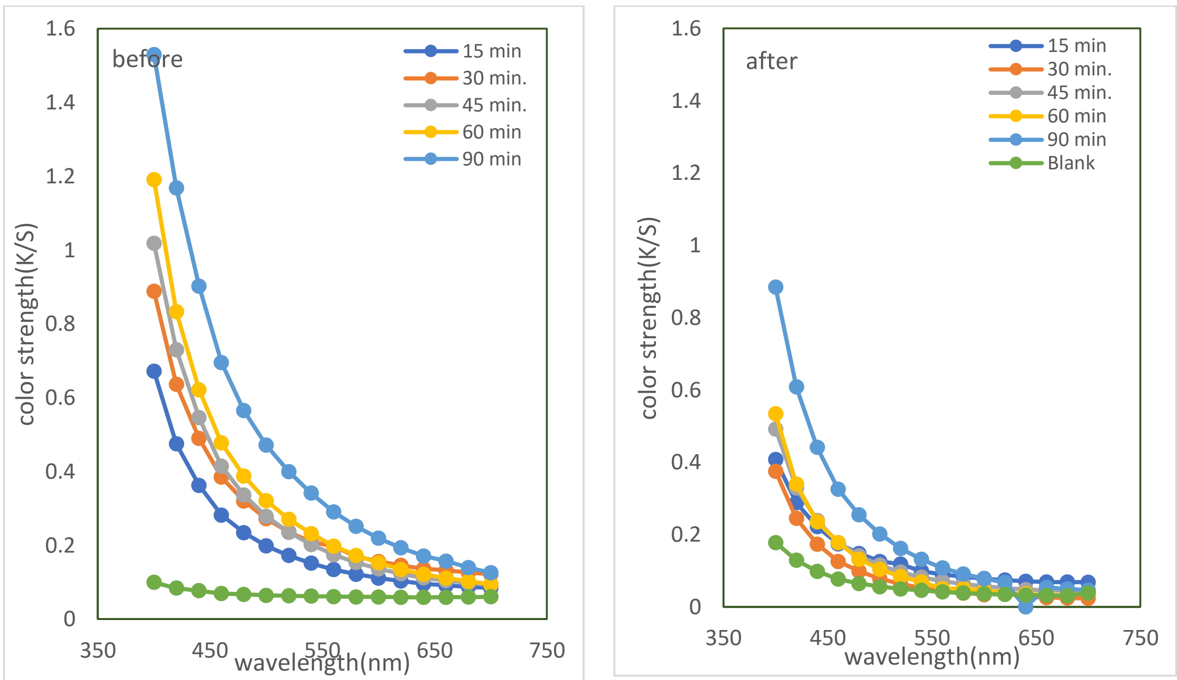

Fig. 6 b: The color strength spectra of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different dyeing times before and after exposure to artificial daylight for 160 hrs.

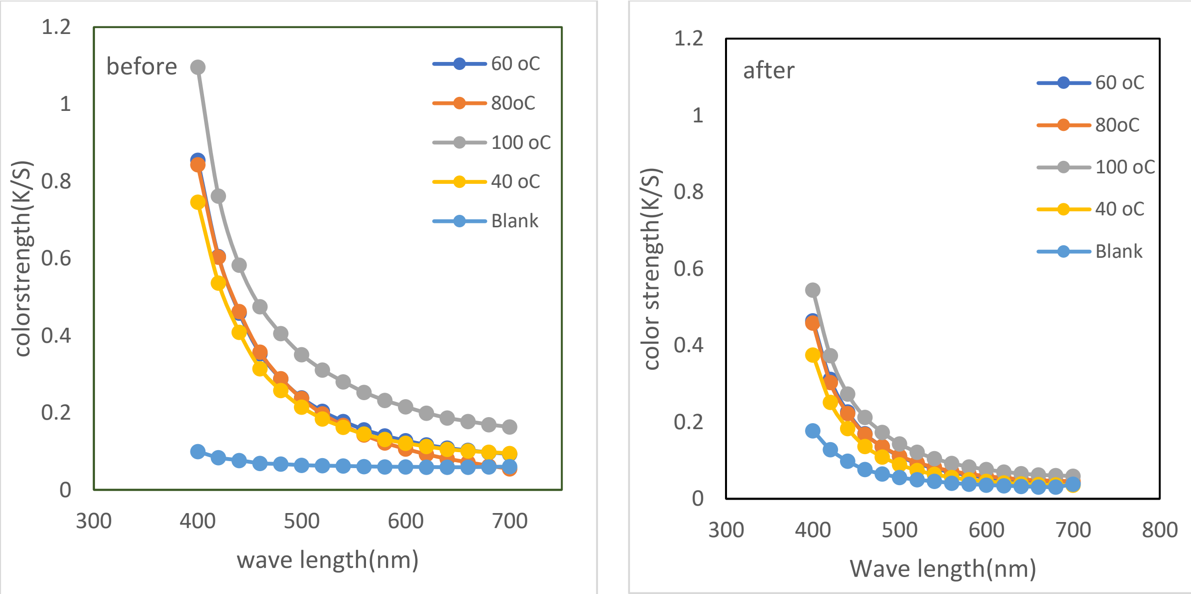

Fig. 6 c: The color strength spectra of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different dyeing temperatures before and after exposure to artificial daylight for 160 hrs.

From figure (6 c), it appears that for silk fabrics dyed with different *Artemisia* bath temperatures, the values of color strength (K/S) increase by increasing temperature up to 80°C then decrease sharply which may be due to shrinkage in silk fabrics. This indicates that the dyed silk fabrics with dye bath temperature equal to 80°C are performable, more than that temperature cause damage to fabrics. After exposure to artificial daylight (K/S) values for all samples increase by increasing temperature up to 80°C.

An increase in color strength (K/S) values by increasing temperature or time were related to some parameters such as (i) affinity, the heat of sorption as well as accessibility dyeing temperature affected the exhaustion of natural dye onto the substrate, (ii) the highest K/S values at high temperature or time may be attributed to the fact of Artemisia dye gives a bright color on the dyed fabrics besides it can be absorbed on silk through interactions with the group along the chain [36,37], However, the number of groups in silk is much enough to give the higher dyeability. (iii) the high value of K/S for the silk samples could be related to the dye structure which allows forming a covalent bond between its groups and non-charged amino groups and ionized hydroxyl groups in silk fabric and the reaction pertain to nucleophilic substation reaction in the aromatic series.[38,39]

3-5- Colorfastness

3-5-1 Color Fastness to Perspiration

From tables (3 a-b) show the effect of (pH values, temperature, and time), on the change in (acid and base) perspiration fastness properties (acidic and basic) of the dyed silk fabrics with *Artemisia Herba-Alba* dyed silk fabrics shows no remarkable variation. The perspiration fastness properties for all studied samples ranged from excellent (5) to very good (4) at Gray Scale.

Table 3 a: The fastness properties for perspiration of *Artemisia Herba-Alba* dyed silk fabrics with different dyeing pH values,

.

pH	Alteration		Staining			
			Cotton		Silk	
	acid	base	acid	Base	acid	Base
2	4	4/5	4/5	4/5	4	4/5
3	4	3/4	4	4	4/5	4
4	4/5	4/5	4	4/5	4/5	4/5
5	4	4	4	4	4/5	4/5
6	3/4	4	3/4	4	4/5	4/5
9	4	4	4/5	4	4/5	4/5

Table 3 b: The fastness properties for perspiration of *Artemisia Herba-Alba* dyed silk fabrics with different dyeing times.

Time	Alteration		Staining			
			Cotton		Silk	
min.	acid	Base	Acid	Base	acid	Base
15	4	4	4	4	4	4/5
30	4/5	4	4/5	4/5	4/5	4/5
45	4/5	4	4	4	4/5	4
60	3	4	3	4	3	4
90	3/4	4	3 /4	4	4	4

Table 3 c: The fastness properties for perspiration of undyed and *Artemisia Herba-Alba* dyed silk fabrics with different dyeing temperatures.

Temp.	Alteration		Staining			
			Cotton		Silk	
	acid	Base	Acid	Base	acid	Base
40	4	4	4	4/5	4	4/5
60	4/5	4	4	4/5	4/5	4/5
80	4	4	4	4	4/5	4/5
100	4	4/5	4	4/5	4	4/5

3-5-2 Color Fastness to Washing and light

From tables (4 a-c) show the effect of (pH values, temperature, and time), on the change in colorfastness to wash and light fastness properties of the dyed silk fabrics with *Artemisia Herba-Alba* dyed silk fabrics shows no remarkable variation. The washing fastness properties for all studied samples ranged between excellent (5) to very good (4) at Gray Scale. And also, fastness to light for all samples is very good (4) at the gray scale. So that, the dyeing by this natural dye *Artemisia Herba-Alba* was eco-environmentally friendly.

Table 4 a: The color fastness to washing of *Artemisia Herba-Alba* dyed silk fabrics with different dyeing pH values.

pH	**Washing fastness**			**Light fastness**
	Alteration	**Staining**		
	Silk	**Cotton**	**Silk**	
2	4/5	4/5	4	4
3	3 /4	4	4/5	4
4	4/5	4	4/5	4
5	4	4	4/5	4
6	4	3 / 4	4/5	4
9	4	4/5	4/5	4

Table 4 b: The color fastness to washing of *Artemisia Herba-Alba* dyed silk fabrics with different dyeing times.

Time (min)	Washing fastness			Light fastness
	Alteration	Staining		
	Silk	Cotton	Silk	
15	4/5	4/5	4	4
30	3/4	4	4/5	4
45	4/5	4	4/5	4
60	4	4	4/5	4
90	4	3 /4	4/5	4

Table 4 c : The color fastness to washing of *Artemisia Herba-Alba* dyed silk fabrics with different dyeing temperatures.

Temperature ºC	Washing fastness			Light fastness
	Alteration	Staining		
	Silk	Cotton	Silk	
40	4/5	4/5	4	4
60	3/4	4	4/5	4
80	4/5	4	4/5	4
100	4	4	4/5	4

4- Conclusion:

The present work shows that natural dye extracted from leaves of *Artemisia Herba-Alba* can be used as a dye for coloring textiles to obtained different shades of yellow, under different dyeing conditions (pH values, time, and temperature). The use of this natural dye can be therefore being a potential substitute for the synthetic dyes to be successfully used as an eco-friendly dye. The obtained results clarified that the CIE tristimulus values and color parameter values, as well as absorption coefficient, extinction coefficient and color strength, were found to be changed by either different dye bath (pH values, dye bath time, and temperature) for unexposed and exposed to artificial daylight for 160 hrs. concerning the chemical structure of the natural dye use.

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