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Antimicrobial Activity of Dyed Wool Fabrics with Peanut Red Skin Extract Using Different Heating Techniques

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IN THIS study, Peanut red skin (*Arachis hypogaea L.*) colorant extract was applied on wool fabric using alum (aluminum potassium sulfate) and ferrous sulfate as mordant. The effect of treatment variables such as dye concentration, pH of dyeing bath, time and temperature of dyeing process on the color strength and colorimetric data of dyed fabrics was examined. The fastness properties of dyed wool against rubbing, washing and light were evaluated. The use of metal mordants increased the color strength of the dyed fabrics. All mordants improved the fastness properties of the dyed fabrics toward perspiration, rubbing, washing, and light. Peanut red skin extract is a cationic dye Exhibits antimicrobial activity by virtue of its quaternary ammonium structure. So, dyed samples were tested for antibacterial activity using AATCC test method 100-2004. The dyed wool represented a high level of antibacterial activity. The extract of the Peanut red skin can be considered as a natural dye of acceptable fastness properties together with excellent antibacterial activity for woolen fabrics.

Keywords: Peanut red skin (*Arachis hypogaea L.*), Antibacterial activity, Wool dyeing, Ultrasonic, Microwave.

Introduction

Peanut red skin (*Arachishypogaea L.*) is the seed coat of peanut. Peanut red skins extract is high in Catechin and polyphenolic compounds including flavonoids, which means that they have antioxidant properties. Many researches on antioxidants recommend that may protect against oxidative stress, which has been involved in many diseases and cancers of humans. While the kernel of the peanut is a valuable product, the skin is a worthless by-product of peanut processing [1-8]. Skins have been used for feeding animal or as source of energy when burned. On the other hand, advanced research indicates that skin has a high content of phenolic compounds such as flavonoids, phenolic acids, procyanidins dimmers and oligomers as shown in Table 1. For all these reasons, this product has potential benefits for human health and beneficial biological activities [9-19].

The major cause of biodegradation of textile arts is microbial growth on textile materials, particularly natural products that led to development of antimicrobial technologies for preservative purposes. The increase of microorganisms on textiles inflicts a range of undesirable effects not only on the textile itself but also on the user. These effects include the generation of nasty odor, blotch and discoloration in the fabric, a decrease in fabric tensile strength and an increased possibility of impurities. These results have further accelerated the research on antimicrobial textiles with concentrate on improvement of permanent and forceful antibacterial finishing technologies [20].

In utilizing microwave method, the heating procedure happens through the electromagnetic field specifically to the material. This causes rapid heating in all parts of the material and reduces thermal gradients. Volumetric heating may also reduce reaction time and power saving. Microwave field and the dielectric heating are in charge of controlling on the capability of materials heating by utilizing microwave technique of electromagnetic theory and dielectric response Knowledge necessary to enhance the preparing of materials by utilizing microwave irradiation.

Regardless of, there are a lot of researchers in the area of using microwave in textile coloration; its use in dye extraction in addition to textile

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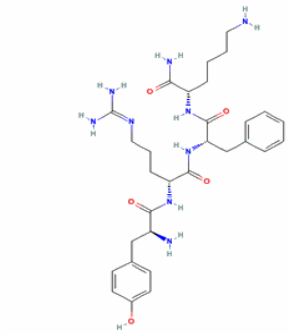
printing is not yet satisfied [21-28]. The target of the current research is to assess microwave irradiation as a source of energy to extract colorants from Peanut red skin. The value of microwave as a novel dyeing extraction and its efficiency in increasing the dye fixation in comparative with the conventional methods (steaming and thermo-fixation) on different fabrics has been demonstrated.

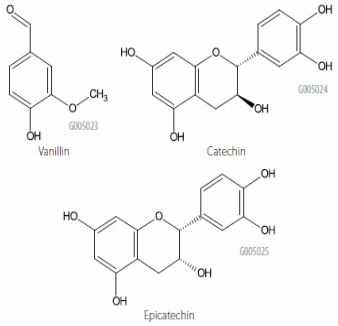
TABLE 1. peanut red skin (*Arachishypogaea L*) .

Property	peanut red skin
Botanical name	Arachishypogaea L
C.I. Name	Natural brown
Class	Alkaloids
Part used	Outer crust
λ_{max}.(nm)	350

Structure of Peanut red skins



Polyphenolic Compounds in Peanut red Skin



Experimental

Materials

Natural coloring matter

Coloring substance used in this work was extracted from Peanut (*Arachishypogaea L.*) colorant

Fabrics

Wool fabrics (172 g/m^2) were supplied from Misr for Spinning and Weaving Company, El-Mahalla El-Kobra, Egypt. The fabric was treated with a solution containing 2 g/l nonionic detergent (Hostapal CV, Clariant), at 45–50 _C for 30 min, then the fabrics were thoroughly rinsed with water and air dried at room temperature.

Methods

Extraction of natural coloring matter

The Peanut (*Arachishypogaea L.*) was peeling and the crust light brown was crushed to the powder form.Then the coloring matter was extracted using (20 g of the powder in 100 ml water) at the boil for one hour. At the end, the solution was filtered off and left to cool down.

Dyeing method

Dyeing of wool fabrics: Wool fabric samples (8.5g each) were dyed with the natural coloring matter extracted from Peanut (*Arachishypogaea L.*) at liquor ratio 1:50. Dyeing was carried out at pH 5.5 for 60 minutes at 100°C. The fabric samples were entered to the dyeing solution in a water bath at70°C then raised to 100°C. The fabrics were dyed for 60 minutes and the dyed samples were rinsed with cold water and washed for 15 minutes in a bath containing 3g/L of non-ionic detergent at 30°C. Finally, the fabrics were rinsed and air dried.

Apparatuses

Ultrasonic water bath

A CREST Ultrasonic, TRU-SWEEPTM ultrasonic seat top cleaner bath, model 575 D with a capacity 5.75 l, was utilized. The trial setup utilized was made out of an electrical generator worked at a frequency of 38.5 kHz and power going from 100W average /500 W. The output power levels are from 100 up to 500 W, and are supplied by three transducers at the bottom of the industrial grade tank. Digital advanced control of time (0– 90 min), thermostatically controlled heater (encompassing to 80 °C), power level and degas functions. The inward measurements of the tank were 11.5 _ 6 _ 6 profundity and 292 _ 152 _ 152 mm. The conventional dyeing device is Julabo SW 20 Julabo LABORTECHNIK GMBH D-77960 Seelbach/Germany, V/Hz 230/50/60.

Microwave Heating System

Extractions were carried out using microwave synthesis systems: Lab station, which is equipped with a magnetic stirrer, and a non-contact infrared continuous feedback temperature system, MILSTON, USA.

Methods

Dyeing of wool fabrics using conventional, ultrasonic and microwave methods

Wool fabric samples (0.5 g each) were dyed with the Peanut (*Arachishypogaea L.*) at liquor ratio 1:50. Dyeing was carried out at different

concentrations of dye (1–9 g) /100 ml H_2O, pH values (2.5–9.5), temperatures (40–80 ^oC), and duration time (40– 80 min) as detailed in the text. In case of ultrasonic for comparison, the same conditions of dyeing were carried out using ultrasonic dyeing (US) method and microwave dyeing method. Then the dyed samples were rinsed with cold water and washed for 25 min in a bath containing 2 g/l of non-ionic detergent (Hostapal CV, Clariant), at 45–50 _C. Finally, the fabrics were rinsed with water and air dried.

Antibacterial test

The antibacterial and antifungal studies of treated fabrics with nanoparticles were accomplished in triplicates using standard methods (AATCC TM100).

The treated fabric (0.5 g) was introduced into 20 ml nutrient broth and inoculated with the respective bacterial strains followed by overnight (24 hrs) incubation at 37^{o}C. Growth of the bacterial strains was determined spectrophotometrically (OD660) in presence of the treated fabric against a blank of un-inoculated sterile medium. Similarly, the fungal strains inoculated into potato dextrose broth and incubated for 48 hrs at 28^{o}C in a shaker incubator followed by measurement of OD450 against a blank of un-inoculated sterile medium. Before recording the OD of the respective media after incubation, the culture tubes were shaken thoroughly in order to bring microorganisms into suspension.

Optical density is directly proportional to the number of microorganisms (bacteria or fungi) in the medium. The percentage of reduction of the microorganisms was expressed as follows.

R = (B - A)/B x100, where; R = percentage of reduction of microbial population; B = absorbance of the media inoculated with microbes and A = absorbance of the media inoculated with microbes and treated fabric. (Baliarsingh, Behera, Jena, Das, & Das, 2015)

Colorimetric measurements

The color strength (K/S)

The color strength (K/S) in visible region of the spectrum (400-700) nm was calculated based on Kubelkae– Munk equation:

$$\frac{K}{S} = \frac{(1-R)2}{2R}$$

Where, (K) is adsorption coefficient, (R) is reflectance of dyed sample and (S) is scattering coefficient.

The colorimetric properties of dyed fabrics were obtained with Hunter Lab DP-9000 Color-Spectrophotometer

Color data CIELAB space

Colour-difference formula CIE (L*, a*, b*):

The total difference CIE (L*, a*, b*) was measured using the Hunter-Lab spectrophotometer (model: Hunter Lab DP-9000).

CIE (L*, a*, b*) between two colours each given in terms of L*, a*, b* is calculated from:

L* value: indicates lightness, (+) if sample is lighter than standard, (-) if darker.

a* & b* values: indicate the relative positions in CIE Lab space of the sample and the standard, from which some indication of the nature of the difference can be seen.

Fastness testing

Washing fastness: The colour fastness to washing was determined according to ISO 105-CO2:1989 test method [29]. The washing fastness tests were conducted in a launderometer (ATLAS–Germany) using 5g/L nonionic detergent at 50^{o}C for 45min., the liquor ratio was 1:50. The composite specimen was removed, rinsed with running tap water, squeezed, then opened and dried in air. It included the test specimen and the two adjacent fabrics in contact of the main sample. The gray scale was used to assess the colour change of the dyed sample and the staining of the two adjacent undyed fabrics were cotton and wool.

Light fastness: This test was evaluated according to ISO 105-B02: 1988 test method [30] using a carbon arc lamp. Samples were exposed to a continuous light for 35 hours in order to determine the degree of colour resistance to light photo- degradation.

Rubbing fastness: Rubbing fastness was determined according to test method ISO 105-X12: 1987 [31] using a crock-meter under conditions for determination of dry and wet fastness.

Results and Discussion

Over the last decade, many authors research a new offering a different effective heat source of several chemical reactions and procedures. It has several advantages comparing to traditional heating such as; non-contact heat, energy transfer

instead of heat transfer, higher heating rate, quick start-up and stopping of heating, homogeneous heating with negligible thermal gradients, choosy heat properties, reversal thermal effects (heating start from the internal of material body), energy savings and higher yields in shorter reaction time. In this context, applying of different heating resource in textile coloration was of interest, thus, exploiting IR, Microwave (MW) irradiation as well as Ultrasonic heating (UH) in dye extraction from peanut red skin as a natural colorant was carried out and applied it as a dye to wool dyeing .

Effect of extracted dye concentration

Table 2 shows the results of K/S and coloring data of dyed wool fabrics with Peanut red skin extract using three different heating methods namely; IR, Ultrasonic and Microwave with different dye extract concentrations. From these results, it can be concluded that the higher K/S was obtained with IR heating method (5.32 at 5 g/100 ml. dye extract conc.) then microwave heating method (5.08 at 3 g/100 ml. dye extract conc.) and finally ultrasonic heating method (3.32 at 3 g/100 ml. dye extract conc.). However, the MW has the best result than UH at the same concentration this may be attributed to microwave irradiation which saves energy and time greatly. While in IR, it gives higher K/S at higher concentration and we observed that it causes a harsh filling and it affects on tensile strength of the fabric.

TABLE 2. Effect of dye concentration on color strength and colorimetric data of wool fabric dyed with Peanut red Skin (*Arachishypogaea L.*) using different heating methods.

Heating methods	Dye extracts conc. (g/100 ml.)	K/S	L*	a*	b*
IR Heating	1	3.03	64.97	9.02	15.19
	3	2.75	64.81	9.60	15.22
	5	5.32	51.70	14.30	17.01
	7	3.23	64.45	9.19	16.43
	9	2.80	66.94	8.32	15.19
Ultrasonic heating	1	2.98	59.56	12.16	13.18
	3	3.32	63.96	9.13	14.63
	5	3.32	62.24	10.97	15.96
	7	3.21	65.04	9.44	15.91
	9	3.21	65.31	9.14	16.46
Microwave heating	1	4.73	53.25	13.54	13.58
	3	5.08	57.73	11.39	16.15
	5	5.08	55.23	12.63	16.29
	7	4.71	58.49	11.22	16.15
	9	3.70	62.34	10.19	16.49

Dyeing cond.: pH 4.5, L.R. 1:40, 80°C, for 60 min at different conc. (1-99/100ml.).

Effect of time on dye extracted

Table 3 shows the results of K/S and coloring data of dyed wool fabrics with Peanut red skin extracted by using three different heating methods namely; IR, Ultrasonic and Microwave at different dyeing time. From these results, it can be concluded that the higher K/S was obtained with microwave heating method (8.83 at 6 min.) than IR heating method (7.18 at 80 min.) and finally ultrasonic heating method (3.63 at 80 min.). From this table, it can be noticed that K/S increased with increasing the time of dyeing except in case of microwave heating method as the K/S decreased after 6 min. This may be attributed to microwave irradiation. The microwave radiation helps and influences the penetration of the shading furthermore the depth to which the infiltration happens in the fabric. This improves microwave than conventional shading methodology.

From Table 3, it can be observed that the results of color data (L*, a* and b*) of the dyed wool fabrics in different dyeing time can be explained as follow; L* values decreased with increasing the time of dyeing in the 3 different heating methods which mean more dark color. Most values of a* and b* increased with increasing the time of dyeing which is indication that color turned to more yellowish red color.

TABLE 3. Effect of time of dyeing on color strength and colorimetric data of wool fabric dyed with Peanut red Skin (*Arachishypogaea L.*) using different heating methods.

Heating methods	Dyeing time (min.)	K/S	L*	a*	b*
IR	40	2.54	62.48	11.77	13.80
	50	4.98	51.95	14.79	13.96
	60	4.64	49.77	14.93	13.92
	70	6.43	45.89	15.66	14.27
	80	7.18	45.90	15.66	14.36
Ultrasonic heating	40	2.64	61.90	13.00	12.96
	50	2.93	61.54	12.44	13.31
	60	2.36	60.92	12.58	13.75
	70	2.52	59.02	14.11	14.10
	80	3.63	56.54	15.34	15.70
Microwave heating	4	3.93	51.07	17.93	12.72
	5	4.93	47.55	19.37	13.52
	6	8.83	37.87	25.06	16.67
	7	7.91	38.56	23.41	15.91
	8	7.77	37.51	24.63	15.70

Dyeing cond.: pH 4.5, L.R.: 1:40, 80°C, Conc. 5 gm/100ml at different time. (40-80 min) for IR&US while (4-8min) for microwave.

Effect of extracted dye path pH

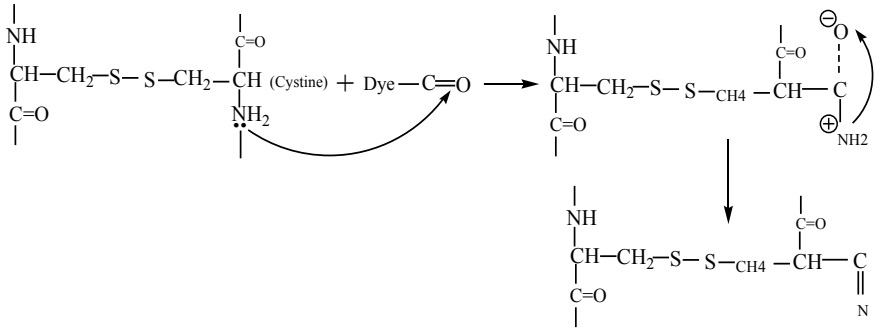
Table 4 shows that the pH values of the dyeing bath have some effects on the color of the dyed wool fabrics with Peanut red Skin. When pH values increased most values of a* and b* increased in the positive direction which means the color of fabric was turned to reddish yellow color and L* values decreased with increasing pH in the three different heating methods and the color of fabric become darker.

TABLE 4. Effect of pH of dyeing bath on color strength of wool fabric dyed with Peanut red Skin (*Arachishypogaea L.)* using different heating methods.

Heating methods	Dyeing bath pH	K/S	L*	a*	b*
IR	2.5	5.69	48.35	18.90	18.05
	4.5	7.32	48.62	14.79	18.75
	6.5	8.85	48.18	10.00	16.86
	8.5	9.02	43.23	20.18	19.65
	9.5	10.42	39.83	20.34	19.88
Ultrasonic heating	2.5	3.04	63.14	8.80	14.95
	4.5	3.18	60.83	10.47	14.40
	6.5	3.28	63.22	12.52	15.83
	8.5	3.48	56.38	14.35	15.17
	9.5	3.96	63.49	15.61	18.45
Microwave heating	2.5	4.64	61.73	9.54	19.25
	4.5	4.71	55.36	11.68	16.26
	6.5	5.48	52.98	13.17	15.92
	8.5	7.35	43.92	19.34	16.15
	9.5	8.05	54.09	12.41	22.30

Dyeing conds.: Dye conc. 5gm/100 ml, L.R. 1:40, 80°C, 6 min for microwave irradiation and 80 min. For IR and Ultrasonic, at different pH.

From these results it can be noticed that wool fabrics dyed in alkali bath possessed reddish and more yellow character and bigger chromatic values compared with that in acidic dyeing bath. The effect of dyeing bath pH could be attributed to the correlation between Peanut red skin structure and wool fabric. Since the Peanut red Skin is a water soluble dye containing cationic quaternary ammonium salt, it would interact ionically with the carboxyl end groups of wool fabric at alkaline pH (8.5 and 9.5) via ion exchange reaction. The number of available anionic sites on wool fabric in alkaline conditions is relatively larger than that in acidic conditions, and thus the exhaustion of the cationic Peanut red skin extract was increased in alkaline dyeing solutions (Scheme 1).



Effect of temperature on dye extract

The effect of temperature on the color strength (K/S) of wool fabrics was occurred at different temperatures (40, 50, 60, 70 and 80°C). As shown in Table 5, it is clear that color values increased with increasing the temperature from 40 to 80°C. When dyed at lower temperature, wool fabric color was bright beige. When raising the temperature, the conglomeration of colorant molecules declined, and the diffusion of peanut red skin extract into the wool fibers could happened very easily and quickly at a higher temperature, which cause the change of lightness, saturation and color difference. From these results, it can be concluded that the higher K/S was obtained with microwave heating method (9.61 at 80°C) then IR heating method (6.48 at 80 °C) and finally ultrasonic heating method (3.72 at 80°C). From this table, it can be noticed that K/S increased with increasing the Dyeing bath temperature.

The results of color data of these samples can be explained as follow; for the three different heating methods L* values decrease with increasing the temperature which mean darker color. This may be due to at higher temperature the diffusion of peanut red skin extract into the wool fibers occurred very easily and quickly which cause more dye molecule penetrated into the fibre that causes darker color.

TABLE 5. Effect of temperature of dyeing bath on color strength of wool fabric dyed with Peanut red Skin (*Arachishypogaea L.*) using different heating methods.

Heating method	Dyeing bath temperature (°C)	K/S	L*	a*	b*
IR heating	40	2.02	69.01	7.58	15.26
	50	2.42	66.74	8.54	16.24
	60	2.49	65.70	9.42	16.83
	70	4.00	52.30	17.26	13.08
	80	6.48	46.30	17.62	14.57
Ultrasonic heating	40	2.34	64.28	10.90	13.31
	50	2.36	67.73	8.02	17.01
	60	2.70	65.39	9.33	18.85
	70	3.65	60.96	11.50	19.99
	80	3.72	54.89	15.66	14.96
Microwave heating	40	2.09	66.83	10.22	11.93
	50	3.82	47.77	21.41	13.27
	60	3.90	49.39	20.69	13.31
	70	6.25	46.09	18.79	14.85
	80	9.61	42.81	18.17	16.31

Dyeing conds.: Dye conc. 5 gm/100 ml, pH 9.5, L.R. 1:40, 80 min for ultrasonic and IR and 6 min. for microwave irradiation, at different temperature.

Effect of mordants

Table 6 illustrates the results of different mordants namely ferrous sulphate and alum of dyed wool fabrics using Peanut red Skin extract with pre and simultaneous mordanting methods and its effect on K/S and color data. This table indicated that best results of K/S were achieved with IR heating method using pre-alum (21.32) then microwave heating method using sem.- alum (14.46) and finally ultrasonic heating method using Sem.- Fe_2SO_4 (8.97).

From Table 6, it is obvious that there is a significant change in K/S for the dyed wool fabrics mordanted with alum as a result of metal complex formation between the dye and the mordant used. Also, with ferrous sulfate, the color was darker and duller. This may be attributed to the change of ferrous sulfate into a ferric form by reacting with oxygen of the air. Ferrous and ferric forms coexist on the fibers and their spectra overlapped, resulting in a shift of λ_{max} and consequently the color change to a darker shade [32].

TABLE 6. Effect of using different mordants on color strength of wool fabric dyed with Peanut red Skin (*Arachishypogaea L.*) using different heating methods.

	Mordant type	K/S	L*	a*	b*
IR	Blank	6.48	46.30	17.62	14.57
	Pre-alum	21.32	29.01	15.52	14.49
	Sem.- alum	12.06	60.92	13.73	39.48
	Pre Fe_2SO_4	11.78	32.56	9.19	7.82
	Sem.- Fe_2SO_4	18.49	37.04	6.25	17.91
Ultrasonic heating	Blank	3.72	54.89	15.66	14.96
	Pre- alum	7.07	47.21	13.64	14.42
	Sem.- alum	7.64	50.26	11.47	18.81
	Pre- Fe_2SO_4	3.37	64.03	7.26	16.43
	Sem.- Fe_2SO_4	8.97	47.94	3.99	13.54
Microwave heating	Blank	9.61	42.81	18.17	16.31
	Pre- alum	9.71	23.26	7.55	5.84
	Sem.- alum	14.46	51.56	13.38	34.81
	Pre- Fe_2SO_4	5.28	49.42	4.80	9.21
	Sem.- Fe_2SO_4	11.21	42.52	3.83	12.96

Dyeing conds.: Dye conc. 5 gm/100 ml, pH 9.5, L.R. 1:40, 80 min for ultrasonic and IR and 6 min. for microwave irradiation, at 80°C and concentration of mordant 1.8 g/L.

The color of fabrics is dependent on type of mordant used. By addition of ferrous Sulphate L* values decrease compared to the control sample which means that color of fabric turned to a darker shade. It is noted that after mordanting the greenish of wool fabric increased obviously. It is clear from these data that ferrous sulfate mordanted wool fabrics yielded darker and less bright shade, as it is concluded from color measurements in table 6 for the ferrous Sulphate mordanted dyed fabrics. These changes of color values may be due to the impact of ferrous sulfate on dye chemical structure. The color of wool fabrics mordanted with ferrous sulphate was significantly changed as function of iron content on fabrics, by growing the iron content the values of a* increased in the negative direction while b* increased in the positive direction. The color of wool fabrics mordanted with ferrous sulphate was turned to greenish yellow and became darker at using ferrous sulphate as higher iron content was recorded.

On the other hand, by the addition of alum L* values decreased compared to the blank in case of pre- alum for the 3 heating methods which mean more dark color, but in case of simultaneous-mordanting for the 3 heating methods the L* values increased compared to the blank which mean lighter color. For a* and b* values the addition of alum the color turn to more reddish yellow color compared to the control sample in case of simultaneous- mordanted alum but in case of pre- mordanted alum the color of fabric turned to less reddish yellow color. These changes of color values may be due to the impact of alum salt on dye chemical structure.

Fastness properties

Table 7 shows the wash-fastness, rub-fastness, Perspiration fastness and light fastness properties of wool fabrics dyed with Peanut red Skin(without and with mordant). Dyeing with Peanut red skin showed excellent washing, perspiration and light fastness except in case of blank using IR and Ultrasonic heating method. As it was expected using mordants gave good improvement in most of color fastness properties used in case of IR and Ultrasonic heating methods except in case of rubbing fastness with IR heating method which gave fair results. Also, it can be noticed that the best results of color fastness properties were achieved with microwave heating with or without using mordants.

The chemistry of bonding of PES extract to wool fiber is complex. It involves chemical bond, H-bonds, and hydrophobic interactions. Generally, mordants help binding of PES extract to wool fabric by forming a chemical bridge from coloring matter to the fiber, thus improving the staining ability of a PES extract along with increase in its fastness properties (see Scheme 1).

TABLE 7. Fastness properties of mordanted dyed wool fabrics with natural coloring matter extracted from Peanut red Skin (*Arachishypogaea L.*) using different heating methods.

Heating methods	Dyeing condition	Washing		Perspiration				Rubbing		Light
				Acidic		Alkaline				
		Alt	St.	Alt	St.	Alt	St.	Dry	Wet	
IR Heating	Blank	4	3	3	3	3	3	2-3	2	5-6
	Pre alum	4-5	4-5	4-5	4-5	4-5	4-5	3	2-3	5-6
	Sim. Alum	4-5	4-5	4-5	4-5	4-5	4-5	3	2-3	5-6
	Pre Fe_2SO_4	4-5	4-5	4-5	4-5	4-5	4-5	3	2-3	5-6
	Sim. Fe_2SO_4	4-5	4-5	4-5	4-5	4-5	4-5	3	2-3	5-6
Ultrasonic heating	Blank	3-4	3-4	4-5	4-5	4-5	4-5	2-3	2-3	5-6
	Pre alum	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	5-6
	Sim. Alum	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	5-6
	Pre Fe_2SO_4	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	5-6
	Sim. Fe_2SO_4	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	5-6
Microwave heating	Blank	5	5	5	5	5	5	5	5	5-6
	Pre alum	5	5	5	5	5	5	5	5	5-6
	Sim. Alum	5	5	5	5	5	5	5	5	5-6
	Pre Fe_2SO_4	5	5	5	5	5	5	5	5	5-6
	Sim. Fe_2SO_4	5	5	5	5	5	5	5	5	5-6

Change of color after different washing cycles

Table 8 illustrated the results of change of color (ΔE) after many washing cycles (5, 10, 15, 20 and 25). From these results, it can be observed that wool fabric dyed with natural coloring matter and extracted from peanut red Skin using IR heating and ultrasonic heating methods achieved best results when using pre-mordanting method with alum and ferrous sulphate respectively. On the other hand, wool fabric dyed with natural coloring matter and extracted from peanut red skin using microwave heating method achieved best results when using simultaneous mordanting method with alum and ferrous Sulphate, respectively. For all heating methods, the best results was achieved with microwave heating method then ultrasonic heating method and worst one is Infra-red heating method. The best results were achieved with simultaneous mordanting method with alum using microwave heating method after 25 washing cycles (2.35). Alternatively, the worst results were given with simultaneous mordanting method with alum using Infra-red heating method after 25 washing cycles (15.73). From these results, it can be concluded that results of (ΔE) depending on the type of mordant used and kind of heating method used during dyeing and mordanting.

TABLE 8. Effect of using different mordants on the color change for wool fabric dyed with natural coloring matter extracted from Peanut red Skin using different heating methods after 5, 10, 15, 20 and 25 washing cycles.

Heating methods	Mordant type	Change of color (ΔE)					
		without washing	5W	10W	15W	20W	25W
IR	Blank	0	0.62	0.76	1.81	2.39	2.69
	Pre- alum	0	0.64	2.00	2.13	2.28	2.68
	Sim- alum	0	9.19	12.41	14.27	15.45	15.73
	Pre- Fe_2SO_4	0	1.40	1.63	1.79	1.93	2.69
	Sim- Fe_2SO_4	0	3.94	4.07	4.20	5.07	6.22
Ultrasonic heating	Blank	0	3.18	3.43	3.94	6.76	8.83
	Pre- alum	0	1.02	2.08	2.61	2.90	3.95
	Sim- alum	0	1.42	1.66	3.20	4.17	6.06
	Pre- Fe_2SO_4	0	1.30	2.14	2.64	2.86	4.86
	Sim- Fe_2SO_4	0	3.74	3.74	3.82	4.25	6.78
Microwave heating	Blank	0	0.77	1.06	4.71	4.56	5.86
	Pre- alum	0	2.48	3.70	3.97	4.25	4.73
	Sim- alum	0	1.04	1.37	1.62	1.62	2.35
	Pre- Fe_2SO_4	0	1.11	1.98	2.47	2.76	3.15
	Sim- Fe_2SO_4	0	0.77	2.00	2.33	2.34	2.41

(W) : washing cycle.

Infrared spectrum results

As shown in Fig. 1, the characteristic peaks of peanut red skin extracted macromolecule, appear at 3406 cm^{-1} for O-H broad stretching vibration, 2924 cm^{-1} (C-H stretching of aromatic ring), while peak at 2856 cm^{-1} (C-H wagging for Aliphatic group), 1800 cm^{-1} (C=O bending), 1736cm^{-1} (C=O bending), 1618 cm^{-1} (C=C bending) of aromatic ring, 1522.52 (CN bending), 1455.99 Cm^{-1} (C-C bending), beak at 1165.76 cm^{-1} expressed C=O. The extract had aromatic ring, O-H, C=O C=C as well as CN group through infrared spectrum analysis. These were clear from the above data that is catechin structure.

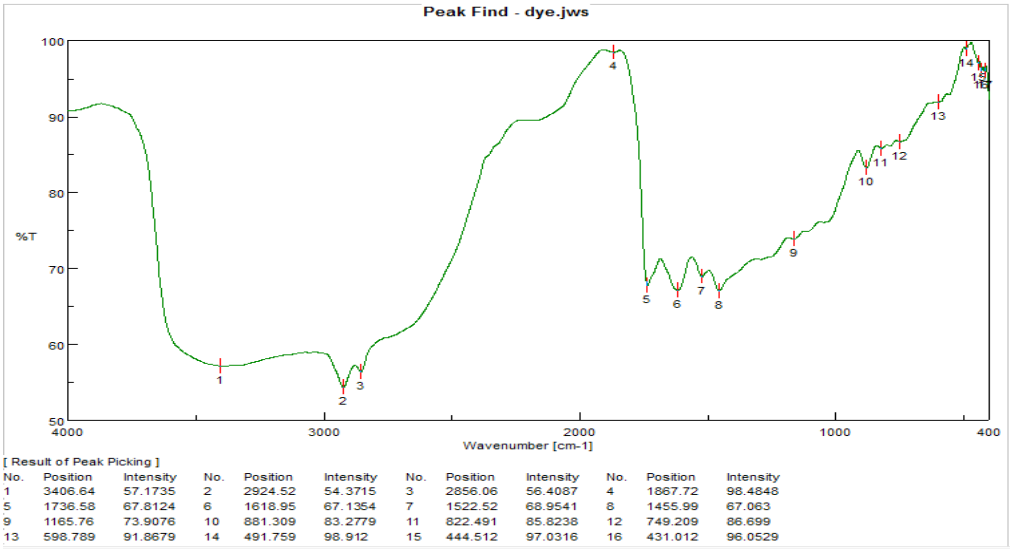


Fig. 1. Infrared spectra of peanut red skin extract.

FT-IR spectra of non-dyedwool (blank) and dyed woolen fabrics were given in Fig. 2. Wool fabric contains more than 18 amino acids. Carboxyl (–COOH), amino ($–NH_2$), and hydroxyl (–OH) groups are the main functional groups of wool. FTIR spectra of wool fabrics showed characteristic absorption peaks particular for peptide bond[10][8][33, 34] specified as amide-I, amide-II, and amide-III bands[35]. The IR spectra of wool fabric (blank) showed specific absorption bands: a broad one in the range of 3448–2966 cm^{-1} (–NH-stretching, –SH and OH stretching), strong peaks at 1690, 1562, and 1304 cm^{-1} are referring to amide I, amide II, and –C–N stretching of amide III, respectively[36].

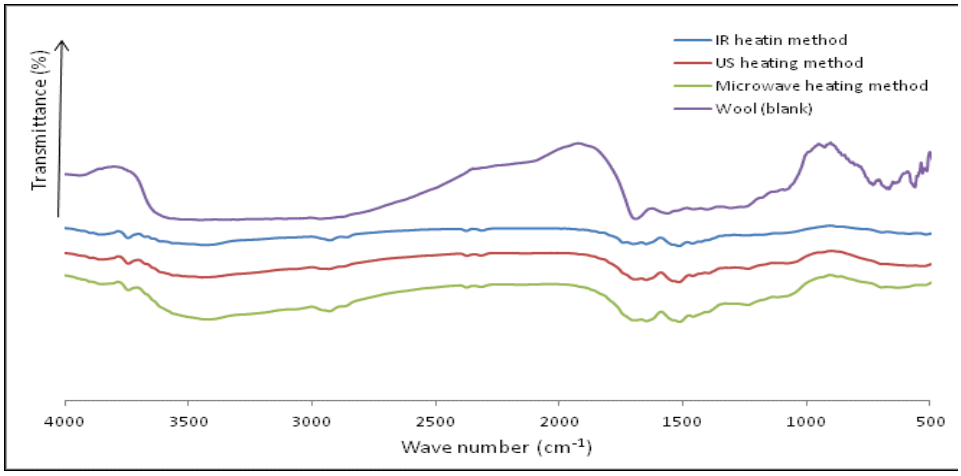


Fig. 2. Infrared spectra of dyed wool fabric with peanut red skin extract using IR, ultrasonic and microwave heating method.

There was a remarkable change in the peaks between non dyed wool (blank) and dyed wool. Whole characteristic peaks of non-dyed wool fabric (blank) were found in the dyed wool fabric with lower intensities. Low intensity and shifting of peaks related to amide-I and C–N stretching frequency of amide-III bands of dyed wool fabrics at 3648 cm^{-1} and 1278 cm^{-1} were observed. Additionally new peaks at 1496 and 2877 cm^{-1} are recorded. These are finding indicate to the involvement of amino groups in the interaction between wool fabric and colorant in the peanut red skin extract [33, 34] (see Scheme 1).

Antibacterial property

Peanut red skin extract possess significant antimicrobial activity especially those containing natural tannins, curcuminoids, quinines etc. and which persist after application on textile fabric [37]. Antimicrobial activity of peanut red skin extract is dependent on chemical structure and functional groups present in the peanut red skin extract and fastness properties of wool dyed fabrics. Hence the antimicrobial properties of dyedwool fabrics against both S. aureus (G^+) bacteria, K. Pneumoniae (G^-) bacteria and C. albicans (Fungi) were studied by optical density method and data were introduced in Table 9.

From data in Table 9, for all heating methods (IR, Ultrasonic and Microwave), the blank samples showed better antimicrobial activity comparing to the mordanting samples. It is known that there is a considerable relation between the release amount of materials and its antimicrobial potency, as higher release is resulted in higher microbial reduction [38-40]. From the fastness properties results in Table 7, the blank samples exhibited less wash fastness which reflects higher release of peanut red skin extract from fabrics surfaces. The antimicrobial activity of peanut red skin extract is a result of methoxy and hydroxyl groups which exist in its structure according to literature [37, 41]. Hence the higher microbial reduction observed for un-mordanted fabrics is attributed to the antimicrobial effect of peanut red Skin extract via higher release.

However, good fastness observed for mordanted fabrics resulted in much lower release and consequently lessen the microbial viability. Both of mordants (alum and Fe_2SO_4) have no significant difference in microbial reduction by considering the results after washing.

The antimicrobial properties against bacteria were found to be greater than that of fungi and

the reduction in S. aureus **(G^+)** bacteria was higher than K. Pneumoniae **(G^-)** bacteria. This could be attributed to the differences in the structure of bacteria and fungi [42].

TABLE 9. Antibacterial activity of wool fabric dyed with natural coloring matter extracted from Peanut red Skin using different heating methods after 10 washing cycles.

Heating methods	Sample	Total bacteria count (%R)		Total fungal count (%R)
		Staphylococcus Aureus (G^+) bacteria	Klebsiella Pneumoniae (G^-) bacteria	Candida albicans (Fungi)
		Reduction (%)	Reduction (%)	Reduction (%)
		10W	10W	10W
IR	Blank (non-mordanted)	60	65	38
	Pre alum	18	48	26
	Pre Fe_2SO_4	31	10	10
Ultrasonic heating	Blank (non-mordanted)	71	43	51
	Pre alum	32	57	37
	Sim. Fe_2SO_4	35	9	2
Microwave heating	Blank (non-mordanted)	32	14	43
	Pre alum	38	40	53
	Sim. Fe_2SO_4	58	28	22

Comparing between the three different heating methods, ultrasonic heating method exhibited the best antimicrobial reduction. For dyed mordanted fabrics using ultrasonic method, percentage of microbial reduction were 88%, 82% S. aureus **(G^+)** bacteria, 61% and 30% K. Pneumoniae **(G^-)** bacteria and 74% and 13% C. albicans (fungi) for alum and Fe_2SO_4, respectively. Using of IR heating method showed much higher microbial reduction than that of microwave heating one.

By studying the durability of dyed fabrics against repetitive washing cycles (10 washing cycles), reduction in microbial colonies was diminished after washings owing to leaching of dye in washing environment.

Conclusion

A convenient method for extraction of peanut red skin by using different heating methods namely; IR, ultrasonic and microwave heating methods were developed to realize the various red colors. The extraction of peanut red skin was successfully assisting of microwave heating as time and energy saving system, as well as the using of this extracted dye to wool fabric. A positive correlation was observed between extraction concentration, dye bath pH, dyeing temperature, dyeing time and K/S value. Among all factors, the effect of pH value on color characteristic was most noticeable. Results from fastness testing indicated that the blank dyed samples exhibited less wash fastness which reflects higher release of peanut red skin extract from fabrics surfaces and gave excellent antibacterial property as a result of this release. However, good fastness observed for mordanted fabrics resulted in much lower release and consequently lessen the microbial viability. Above all, peanut red skin as a natural dye with medical function is deserved of further study.

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النشاط المضاد للميكروبات للأقمشة الصوفية المصبوغة بالصبغة المستخلصة من قشرة الفول السوداني باستخدام تقنيات مختلفة من التسخين

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أهتمت هذه الدراسة بأستخلاص صبغات لونية من قشرة الفول السوداني الحمراء واستخدامها قي صباغة الأقمشة الصوفية بأستخدام الشبه (الألومنيوم كبريتات البوتاسيوم) وكبريتات الحديدوز كمثبت للون. وقدتمت دراسة تأثير بعض العوامل المختلفة التي تؤثر علي عمليات الصباغة مثل تركيز الصبغة، الأس الهيدروجيني لحمام الصباغة، زمن الصباغة وكذلك درجة حرارة الصباغة علي كلا من الشدة اللونية والبيانات اللونية للأقمشة الصوفيه المصبوغة. كما تم تقييم خواص الثبات لكلا من الغسيل، الأحتكاك والضوء. وقد أوضحت النتائج التي تم الحصول عليها ان المثبتات المعدنية تزيد من الشدة اللونية لأقمشة الصوف المصبوغة بالصبغة قيد الدراسة. كما أوضحت النتائج ايضاً ان كل المثبتات المستخدمة قد أدت الي تحسين خواص الثبات للأقمشة المصبوغة باللصبغة قيد الدراسة لكلاً من العرق، الآحتكاك، الغسيل وكذلك الثبات للضوء. هذا وقد اثبتت النتائج ان الصبغة المستخلصة صباغات كاتيونية ولها تأثير مضاد للميكروبات وذلك بسبب تركيبها الرباعي الألمونيوم. ولهذا، تم اختبار العينات المصبوغة للنشاط البكتيري بأستخدام طرق الأختبارات القياسية (AATCC-١٠٠-٢٠٠٤). وقد أثبتت النتائج ان الأقمشة الصوفية المصبوغة بالصبغة المستخلصة قد حققت مستوي عالي من النشاط المضاد للبكتيريا. ولهذا يمكن القول ان الصباغات المستخلصة من قشرة الفول السوداني الحمراء يمكن ان تستخدم كصباغات طبيعية مع تمتعها بخواص ثبات عالي بالأضافة الي مقاومتها العالية للبكتريا المختلفة بالنسبة للأقمشة الصوفية.