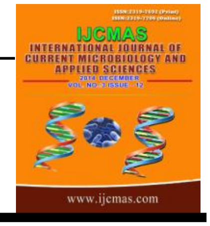

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Original Research Article

Antimicrobial activity of silk fabrics dyed with saffron dye using microwave heating

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A B S T R A C T

The antimicrobial activity of silk fabrics dyed with natural coloring matter extracted from saffron (*Crocus sativus*) using a traditional and microwave heating methods. Some kinds of bacteria and fungi were used .The antimicrobial activity of chitosan treated silk fabric is tested in accordance to diffusion agents, test organisms such as *Escherichia coli*, *Asperigillus niger*, *Asperigillus flavus*, *Bacillus subtilis*, *Pseudomonas aeruginosa* and *staphylococcus aureus* are used and the results indicate that the samples treated with chitosan exhibit higher inhibition zone than the untreated samples. Factors affecting the dyeing properties such as dye extraction amount, dye concentration, time of extraction and time of treatment with microwave. Eco friendly pre-treatment with chitosan were used instead of using mordant. Color strength (K/S) was measured for dyed Silk fabrics. The dye extraction and color strength (K/S) of Silk fabrics indicates that microwave heating is highly effective.

Keywords

Saffron,
Crocus sativus,
Silk fabrics,
Saffron dye

Introduction

In recent years, the textile industry must go towards developing of new technologies to reduce the energy and water consumption. The use of microwave in textile wet processing is one way for this purpose. The advantages of microwaves, which it is use much less liquid, they can exhaust or save dyes and leave no waste of liquid dye compared to conventional methods. Microwave dyeing has other advantages such as less power consumption, easy production of desired shades, and quick dyeing.

On the other hand natural dyes have been used since ancient times for coloring and printing fabrics. Several studies on the application of natural dyes have been reported (Hebeish *et al.*, 2012) to protect the environment for indiscriminate exploitation and pollution by industries. Recently, the potentiality of using natural dyes in textile coloration as UV-protection and anti microbial has been investigated (Ali *et al.*, 2011)

There has been a revival of interest in natural dyes throughout the world as some synthetic dyes are being banned by the Western countries due to their toxic, carcinogenic and polluting nature. A natural dye is a colorant (dye or pigment) obtained from vegetable or animal matter without any chemical processing (Singh, 2000; Kamel *et al.,* 2005).

In recent years, there has been a manifested interest in natural dyes. The reasons are manifold, including the ecological movement, biodegradability and higher compatibility of natural dyes with the environment (Teli *et al.,* 2000, Shin and Cho 2003). Some natural dyes require the inclusion of one or more types of metallic salt (mordants), such as aluminum, iron, chromium, copper and tin, to ensure reasonable color fastness to sunlight and washing. These metallic salts combine with the dyestuff to produce dye aggregates, which cannot be removed easily (Tiwari *et al.,* 2001).

However, natural dyes do not necessarily help improve the environment because some of the mordants like chromium and copper are deadly poisons. Only non-hazardous chemicals like aluminum, tin and iron help produce favorable colors without harming the eco-cycle (Tiwari and Vankar, 2001).

It is known that textile materials and clothing are susceptible to microbial attack because they provide the basic requirements for microbial growth (Cardamone, 2002). For example (keratin) and silk as natural fibers is made of protein, which provide moisture, oxygen, nutrients and temperature for bacterial growth and multiplication. This often results in objectionable odour, infection, product deterioration allergic responses and often related diseases (Thiry, 2009).

With the advent of improved human life, a new area has developed in textile finishing (Qinguo *et al.,* 2008). The control of microorganisms, e.g., bacteria, mildews molds, yeasts and viruses on textile fabrics extends into diverse areas as hospital, environment and every day household. Thus, various antimicrobial finishes and disinfection techniques have been developed for all types of textiles (Purwar and Joshi, 2004; Rajni *et al.,* 2005).

There are only two or three places in the world where Saffron (*Crocus sativus*) grows. Kashmir has the proud privilege of being one of these places. Saffron (*Crocus sativus*) plants very small and its flower is the only part which is seen above the ground. The blooming time of this flower is autumn. Saffron (*Crocus sativus*) has a unique sweet smell and it is widely used as natural dye in dyeing, cosmetic industry and cooking (Bechtoldt *et al.,* 2006).

It is commonly known as Crocus, it consists of dried stigmas and upper parts of styles of plant *Crocus sativus* Linn. The image of the Crocus plant was showed in the Figure 1. In this work silk fabrics were dyed with natural dye extracted from Saffron (*Crocus sativus*) powder using a traditional and microwave heating methods. The antimicrobial activity was then measured for saffron dye using different kinds of microbes as *Escherichia coli*, *Asperigillus niger*, *Asperigillus flavus*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*.

It is necessary to promote non-polluting natural dyes, which involve inexpensive equipment and small-scale operations. The exploration of natural dyes can be environmentally and economically viable.

Our aim is to show the feasibility of providing high-quality natural dyes extracted from plants, this improving our environment and giving opportunities to the fabric industry to catch up with the current consumer trends towards more aesthetic fabrics with natural products.

The present work is undertaken with a view to establish a green strategy for dyeing and antimicrobial activity. So that environmentally friendly pre-treatment with chitosan were used instead of using mordants. This treatment was carried out by microwave.

Materials and Methods

Silk Fabric

Silk fabric (53 g/m²), supplied by Akhmim Upper, Egypt, was treated with a solution containing 2 g/l anionic detergent and 2g/l sodium carbonate at 45ºC for 30 min, thoroughly washed and then air dried at room temperature.

Microwave Equipment

The microwave equipment used in this experiment was the Samsung M 245 with an output of 1,550 watts operating at 2450 MHz.

Dyestuff

Scientific classification

Saffron plant: Saffron (*Crocus sativus*) was classified based on chemical nature
Class: Carotenoid pigment
C.I. name: Natural Yellow 6
Part used: The dried stigmas of flowers
Kingdom: Plantae
(unranked): Angiosperms
(unranked): Monocots
Order: Asparagales
Family: Iridaceae
Subfamily: Crocoideae
Genus: Crocus
Species: *C. sativus*
Binomial name: *Crocus sativus*

Microwave extraction

Microwave extraction was carried out in 100ml distilled water using varying amounts of the dried stigmas of flowers (0.1–1.5%). After filtration and dilution, the optical density of the dye liquor was measured at λmax440 nm (El-Khatib *et al.*, 2014). The best concentration at higher optical density of the dye liquor was used for different time periods (1–6 minutes).

Pretreatment with chitosan

Chitosan (high molecular weight) solution was freshly prepared by dissolving (2.0 g/l) of chitosan in distilled water containing acetic acid (4 g/l) (Shin *et al.*, 2010). The silk fabrics were immersed in this solution at a liquor ratio 20:1. Fabrics were then squeezed. The samples were dried at microwave for 1–6 min.

Dyeing procedure

In a dye bath containing (10 g/l) of saffron dye with a liquor ratio 1:100, the silk fabric was dyed by microwave heating at pH 3 for 4 sec. The dyed samples were rinsed by warm water and then cold water, washed in a bath containing 5 g/l non-ionic detergent at 50ºC for 30 minutes, then rinsed and dried in shade at room temperature.

Measurements

Color strength (K/S value)

An UltraScan PRO spectrophotometer was used to measure the reflectance of the samples and hence, the K/S over a wavelength ranges of 390–700 nm. The K/S of untreated and treated wool fabric with chitosan was evaluated.

UV/V is absorption spectra

The spectra of UV/Vis absorption in water were recorded by the Shimadzu UV/Vis spectrophotometer. The quantity of dye uptake was estimated by the following equation:

$$Q = (C_o - C_f)\ V/W$$

Where Q is the quantity of dye uptake (mg/g), C_o and C_f are the initial and final concentrations of dye in the solution (mg/l) respectively. V is the volume of the dye solution in (L). The concentrations of the dye solutions were determined after reference to the respective calibration curves of saffron dye using the Lambert-Beer's law.

Antimicrobial activity

Antimicrobial activity of chitosan-treated silk fabric was tested according to diffusion aganted (Rajni *et al.*, 2005). follow: Nutrient agar medium (g/L: peptone 5.09 beef extract 1.5; yeast extract 1.5; NaCl 5.0, agar 20.0; pH 7.5) was prepared and autoclaved at 121^{o}C for 20 min. sterilized Petri plates were prepared with an equal thickness of nutrient agar. Test organisms i.e. *Escherichia coli*, *Asperigillus niger*, *Asperigillus flavus, Pseudomonas aeruginosa* and *staphylococcus aureus* were grown over right at 32^{o}C, 120 rpm in 10 ml nutrient broth, this broth was used for seeding the nutrient agar plates. A small disks of chitosan-treated and untreated colored silk fabric were placed at four corners of the prepared previous plates. After 72 h of incubation at 32^{o}C, the zones of inhibition of each tested microbe were measured (Avadi *et al.*, 2004).

Results and Discussion

Effect of concentration of dye

The extraction of saffron (0.1g/100ml water) by microwave irradiation was carried out for different concentrations (0.1–1.5 g/L) (Fig. 2). Figure 4 shows that dye extraction by microwave irradiation exhibited the highest value of absorbance at 0.3 g/L

The extraction of saffron (0.3g/100ml water) by microwave irradiation was carried out for different lengths of time (1–6 minutes). Figure 3 shows that dye extraction by microwave irradiation exhibit maximum values after 4 minutes. This can be attributed to microwave irradiation producing an intensive movement in the liquor due to the wave-guides. The resulting distribution of microwaves gives a uniform exposure to which any material moves through.

Pretreatment with chitosan by microwave

The effects of time of treatment by chitosan on the K/S of silk fabrics were evaluated. As shown in Figure 3, it is clear that the K/S value of the dyed silk fabrics is mostly increased by the pretreatment with chitosan. The K/S increases with an increase in time till 4 min. The figure also show that the treated samples exhibit higher values of K/S than the untreated samples This may be due to the easier formation of coordination between the amino groups (-NH2) of chitosan and the hydroxyl groups of the silk fabrics (Park& Yu, 2006). Where, K = Absorption coeffictent and S = Scattering coefficient.

The antimicrobial activity

The antimicrobial activity of different concentrations of chitosan of treated silk was studied. The data in Table 1 clearly show that an increase in chitosan concentration leads to increased inhibition zone of all tested microorganisms for treated silk in comparison to untreated colored silk. It may be concluded that a high inhibition zone is recorded with chitosan.

Chitosan is a highly effective antimicrobial against all tested microorganisms. *Pseudomonas aeruginosa* and *Asperigillus nige*r are highly affected by chitosan treatments of each microbe respectively. Meanwhile, *Escherichia coli* show a moderate effect.

Silk fabrics treated with chitosan and dyed with saffron natural dye under investigation display high growth reduction of microbes because the amino groups of chitosan afford dyeing sites for the dye. The antimicrobial activity for the dyed fabric pretreated with chitosan increase compare to the untreated and also increases by increasing the concentration of chitosan (Ali *et al.*, 2010). Antimicrobial activity, expressed as growth reduction of the bacteria and fungi, could be explained as follows. The amino groups in chitosan interfere with the bacterial metabolism by stacking at the cell surface and binding with DNA to inhibit m-RNA synthesis (Rajni *et al.*, 2005; Shin *et al.*, 2010). Chitosan of higher molecular weight shows more of a tendency to deposit on the surface of the fabrics, resulting in amino groups more easily accessible to bacteria and fungi (Ali *et al.*, 2011).

Figure.1 Saffron plant

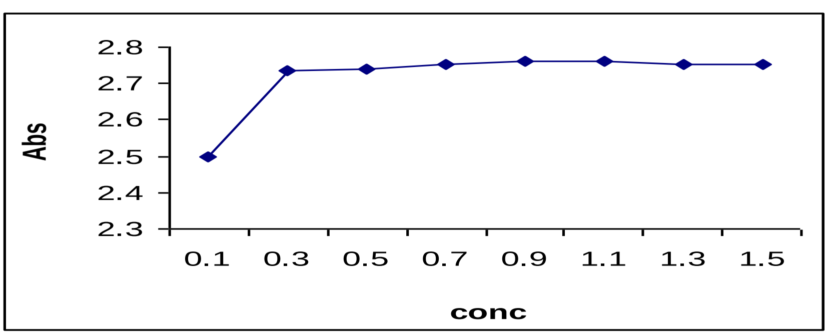

Figure.2 Effect of concentration of dye on the extraction of dye by microwave

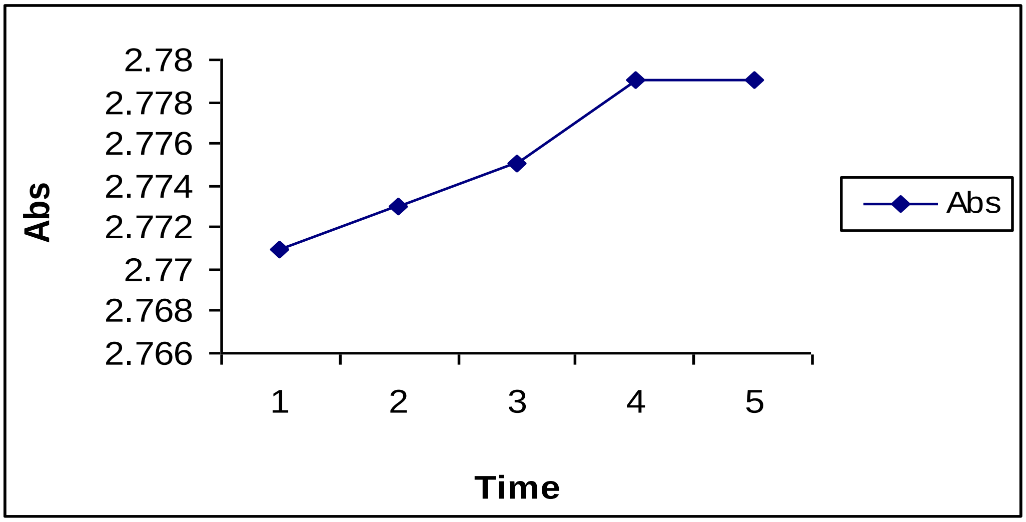

Figure.3 Effect of time on the extent of dye extraction by using microwave irradiation

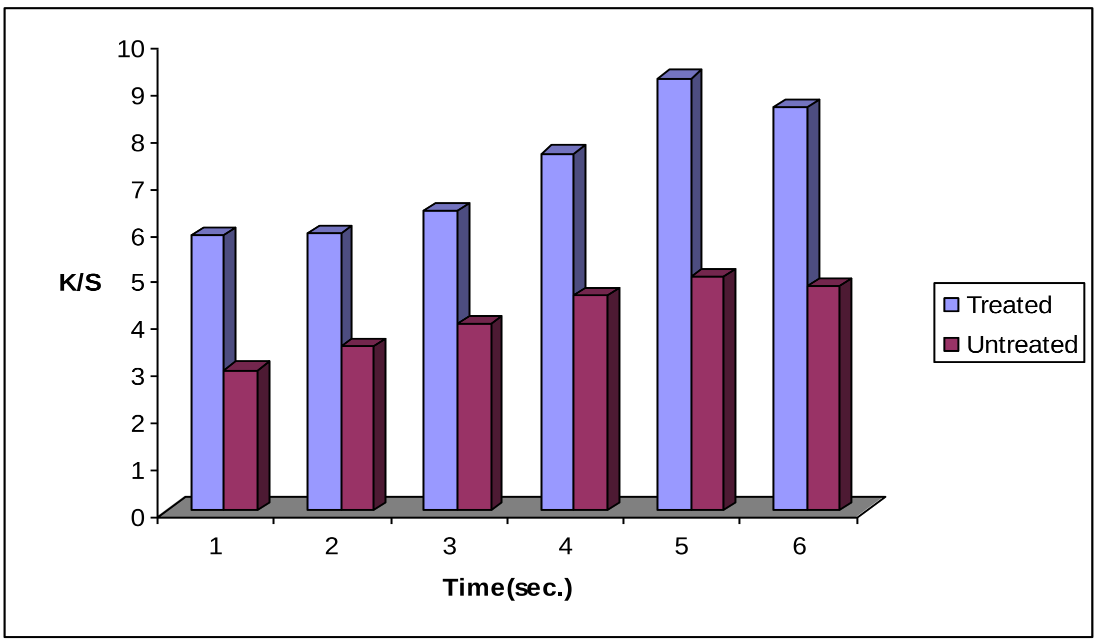

Figure 4 Effect of time of treatment by microwave method on color strength (K/S) on dyed silk fabric

Table.1 Antimicrobial activity of silk fabric pre-treated with different concentrations of chitosan and dyed with saffron dye (10g/L, time 5 sec.)

Conc. chitosan %	% Growth reduction of the tested microbes				
	Asperigillus flavor	*Asperigillus niger*	*Staphylococcus aureus*	*Pseudomonas aeruginosa*	*Escherichia coli*
0	14..0	2 2.0	18.2	24.0	16.5
0.5	30	33.2	36.0	40.0	35.8
1	45.0	48.0	44.2	52.0	45,8
1.5	54.0	60.8	56.0	60.4	57.0
2	60.0	70.0	65.0	75.0	68.0
2.5	58.3	65.21	60.3	73.0	63.5

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