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UTILIZATION OF FEATHER WASTE TO IMPROVE THE PROPERTIES OF THE EGYPTIAN COTTON FABRICS

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ABSTRACT

This work aimed to use chicken feathers wastes (CF) as a natural source of active amino acids after alkali treatments with 0.95N NaOH solution. The soluble feather was analyzed by the liquid chromatography and applied to both the mercerized and bleached cotton fabrics from cotton varieties namely Giza 89 (G89), and Giza 90 (G90) of crop season 2002/2003. The treated and untreated fabric samples were tested for their mechanical properties expressed as the tensile strength N/cm^2, and elongation%. The dyeing behavior expressed as color strength (K/S) using Kubelka-Munk equation, and UV protection values were also investigated. The fixation of CF on the cotton fabric was done by the padding of CF solution onto fabrics followed by dry-cure process. The factors affecting the fixation processes were systematically studied. The finished fabrics show sufficient whiteness, high tensile strength, more dyeing uptake, and more reduction of the UV transmitted as compared to the untreated samples.

Keywords: Egyptian cotton, chicken feathers, feather waste

1. INTRODUCTION

Approximately two or four billion bounds of poultry feathers are produced every year by the poultry producing industry [1]. Poultry chicken feathers represent about 6.0% of the total weight of mature chicken lead to environmental problems as waste – by product at commercially poultry plants [2-5]. Most of the feathers are usually ground up and used as filler for animal [6-7]. However, this use has the potential to pass harmful bacteria along to the animals that ingest the feather meal. CF is bio-source with high keratinaceous protein content (more than 750 g kg^{-1} crude protein).

Walter Schmidt [8] has patented a method of removing the stiff quill from the fiber that make up the feather. Now, with pilot plants starting to use this technology to produce pure fibers and pure quill material. Polyethylene-based composites are prepared using keratin feather fiber obtained from CF's [9-10]. Keratin fibers are mixed into high-density polyethylene at 20 wt% using a Brabender mixing head. George et al. [11-14] twisted 1-to-2 inch-long turkey feather fibers with nylon to make yarns, which they knitted into fabrics. In strength tests, the yarn was weaker than pure nylon, but the fabrics insulated better that nylon cloth. The researchers transforming turkey-feather fibers into nonwoven Erosion control fabrics. They also use a common textile instrument that blows the feather material into a fragile, half-inch-thick mat that's loosely held together by friction between the

fibers. The authors have made nonwoven feather-fiber materials in a different way. Instead of spraying on latex after forming fiber sheets. He mixes synthetic fibers with the feather material and then forms the combination into 2-to-4-inch-thick sheets. When he heats this sheet, the synthetic material partially melts and holds the feather fiber in place. The same authors have found that feather fibers might also find a use in water filters.

Expensive and non-environmental friendly chemicals used widely in the textile industries for treating textile materials to increase their dye uptake or make it more UV-protective for the human skin. Treating textile materials with selected amines from natural resources provide the aesthetics and/or make the materials more respective to dyes. The treatment causes cellulosic material to become more cationic and thus more respective to anionic dyes without stiffening [15, 19]. The influence of plasticizers on the water sorption isotherms and water vapor permeability of chicken feather keratin film was studied by Silvia et al. [16]. The effect of enzymatic and chemical treatments on feather solubility and digestibility was studied by Kim et al. [17]. The experimental treatments were as follows: 1) control, 2) 24-h enzyme, 3) 24-h NaOH, 4) 2-h NaOH, and 5) 2-h NaOH, and 24-h enzyme.

Recently, considerable attention has been paid to the barrier properties of textile designed for clothing as a protection against UV radiation, while also taking into account the trends of current fashion. The finding reported is the literature concerning the barrier properties of fabrics is relation to UV radiation to UV radiation show that attention has been focused on the physical aspects of barrier properties of fabrics or yarns used for fabric production [18].

Comis[19], suggested that chicken feather is the eco-friendly plastics of the 21st century. Feathers could be useful in more products, such as the feather-plastic composites that may provide semi rigid surfaces on the interiors airplanes, and termit-proof material for replacing wood and insulation.

The aim of the present work is to utilize the soluble chicken feather waste to a useful material in the finishing processes as a durable press agent to improve the dye ability, the tensile, and the as a UV protected.

2. MATERIALS AND METHODS

2.1. Materials

Unbleached raw cotton fabrics of Egyptian cotton varieties namely Giza 89, and Giza 90 were purchased during the crop season 2002-2003 and used throughout this study. All chemicals used were of analytical grade using doubly distilled water (18.5 $MO.cm^{-1}$). NaOH was analytical grade (Koch-Light Co.), petroleum ether (40-60^{o}C), ethanol (95%). Hydrogen peroxide (30%. LR grade) came from Aldrich. Sodium carbonate (LR grade), sodium silicate (136?Tw, 27% SiO_2), the wetting agent was the commercially mercerol supplied by Merck. The hydrogen peroxide bleach liquor for each bleaching process was analyzed by titration with potassium permanganate.

2.2.1. Pretreatment of CF

Freshly plucked wet feathers were cleaned with water at 60oC and water at room temperature. Wet feather were dried in a ventilated oven (Memmert-UL500- Italy) at 40^{o}C for 72 hr. The feather was cut into small filaments. 50 g of these materials was treated in a Soxhlet device for 12 hr with petroleum ether (boiling range 40-60^{o}C) to remove grease. The petroleum ether was evaporated and the dry feathers were stored at room temperature in closed conditions.

2.3. Treatment with alkaline solutions [NaOH]

2.0g of CF were stirred at 80 rpm with 20 ml 0.95N NaOH at 70^{o}C for one

hour. The produced solutions were filtered to remove any ash and wax residues.

2.4 Bleaching treatment

For each of the experiments, 1 g of the unbleached cotton fibers was immersed in an alkaline bleach liquor (180 ml deionized water) containing sodium carbonate (0.2 gl^{-1}), sodium hydroxide (1.5 gl^{-1}), sodium silicate (0.4 gl^{-1}), magnesium sulphate (0.2 gl^{-1}), wetting agent (0.5 gl^{-1}) and Hydrogen peroxide (10 ml^{-1}) was added to the bleach liquor and bleaching was done. The samples were removed from the liquor and neutralized with aqueous solution containing 0.1% acetic acid, followed by a through hot water (80-85°C) washing to ensure removal of residual chemicals. Samples were dried in an oven at 100°C for 60 minutes.

2.5. Mercerization treatment

The cotton fabrics were treated with aqueous solution of NaOH (25%) at room temperature. The samples were removed from the liquor and neutralized with aqueous solution containing 0.1% acetic acid, followed by a through hot water (80-85°C) washing to ensure removal of residual chemicals. Samples were dried in an oven at 100°C for 60 minutes.

2.6. Immobilization of amino acid residues on cotton fabrics

Pretreatment consisted of different concentrations of the produced amino acid hydrolyzates of high pH as the pad bath. Fabric was two-dipped/ two-nipped in the bath with a wet pickup of 95 to 100%. After padding, it was dried at 80-85°C for 15 minute and cured at temperature of 130°C for 3 minutes.

2.7 Dyeing procedure

The pretreatment samples were dyed in a bath containing 4 g/l of the dye (Remazole Reactive Yellow R. R), with a liquor-to-goods ratio of 30:1. After dyeing, fabric was rinsed in water at 25°C for 10 minutes and then air-dried.

2.8 Testing and analysis

2.8.1 Chromatographic analysis of hydrolyzed CF

The effect of NaOH concentration (0.5- 1.0 M), temperature (50-90oC), tine (30-150 min) and CF weight (1.0-2.5 g) on the total amino acids were studied were studied by LC3000 amino acids analyzer of model Eppdrof- Germany. The analysis conditions were as follow: Flow rate = 0.2 ml/min, buffer pressure =25 bar, reagent pressure = 100, and bar reaction temperature = 123°C

2.8.2 Mechanical properties

Both the treated and untreated samples were preconditioned before testing at the standard environmental condition at temperature of 20+2°C and relative humidity of 65+5 for 24 hrs. This conditioning was performed using standard conditioning room (SDL-UK 1998). The tensile strength (kg/cm^2) and elongation (%) were measured according to ASTM D412-98a using Zwick testing machine of model Z010 and equipped with 10Kn load cell and the testing was conducted at speed of 100mm/min.

2.8.3 UPF (Ultra violet protection factor) value

UPF is the scientific term used to indicate the amount of UV protection provided to skin by fabric. UPF is defined as the ratio of the average effective irradiance calculated for skin to the average UV irradiance calculated for skin protected by the test fabric. UPF is defined as the ratio of ED and ED_m and calculated as:

$$UPF = \frac{ED}{ED_m} = \frac{\sum_{290nm}^{400nm} E, S, \Delta_\lambda}{\sum_{290nm}^{400nm} E, S, T, \Delta_\lambda}$$

Where:
E_λ = erythermal spectral effectiveness
S_λ = solar spectral irradiance in $Wm^{-2}\ nm^{-1}$
T_λ = spectral transmittance of the fabric
Δ_λ = the bandwidth in nm
λ = the wavelength in nm
ED = a dose for unprotected skin calculated by convolving the incident solar spectral power as relative spectral effectiveness function and summing over the wavelength of 290-400nm

Spectral power as relative spectral effectiveness function and summing over the wavelength of 290-400nm.

UPF's were measured using Perkin-Elmer double beam spectrophotometer of model Lambda 35 according to [20].

2.8.4 Color strength

The color strength expressed as (K/S) was measured using Perkin-Elmer double beam spectrophotometer of model Lambda 35 that is equipped with integrating sphere. The diffuse transmittance was detected at the wavelength 307.02 nm. This wavelength falls in the spectral range of 305-315 nm that is the greatest importance in the various daylight phases (EN13758-1: 2001). According to the Kubelka-Munk that given by: $K/S= (1-R)^2/2R$

2.8.5 Fastness properties

(a) Washing fastness (WF)
Washing fastness of the untreated samples was done according to ISO 105-C01: 1998(E). Two single fiber adjacent fabrics complying with the relevant sections of F01 to F08 of ISO 105-F: 1989. One adjacent fabrics of cotton and the second of wool.

(b) Respiration fastness (PF)
Fastness to synthetic perspiration was measured according to ISO-E04: 1994.

(c) Light fastness (LF)

Fastness to light was measured according to ISO 105:1997 using standard wool blue scale as a reference in all tests. The grads used throughout this research were (1 not fast and 8 is greatly fast to light).

3. RESULTS AND DISCUSSION

3.1 Liquid chromatographic analysis of the CF

CF amount, NaOH concentration, temperature and time for CF hydrolysis yielding maximum total amino acids concentration were being examined.

Table 1. Effect of CF amount, NaOH concentration, temperature and time on CF alkaline treatment.

a) NaOH conc., mole/l	0.5	0.75	0.85	0.95	1.0
Total amino acids conc., mg/l	258.6	281.2	290.7	298.9	296.5

b) Temperature, °C	50	60	70	80	90
Total amino acids conc., mg/l	298.8	321.2	334.0	333.1	331.5

c) Time, min	30	60	90	120	150
Total amino acids conc., mg/l	293.4	334.0	333.9	333.2	333.4

d) CF amount, g	1.0	1.75	2.0	2.25	2.5
Total amino acids conc., mg/l	169.7	298.2	334.0	334.1	334.0

a) Effect of Alkali concentration, using 2.0g CF, at 50°C, for 1h.
b) Effect of Temperature, using 2.0g CF, 0.95N NaOH 1h.
c) Effect of time, using 2.0g CF, 0.95N NaOH at 70°C
d) Effect of CF amount, using 0.95N NaOH at 70°C for 1h

Table 1 shows that, total amino acids concentration of hydrolyzate is increased with NaOH concentration increase till 0.95N, due to decrease in cross-linkage of CF keratin and hydrolysis of peptide bonds yielding active amino acid residues. It is also observed that, as CF amount, temperature and time increased till reach (2.0g, 70°C, 1h), total amino acids concentration increased, due to the enhance in keratin hydrolysis rate. However after these obtained values, some decrease in total amino acids concentration were observed, due to destruction and racemization of some amino acids as threonine, arginine and cysteine in highly alkaline environment [21,23].

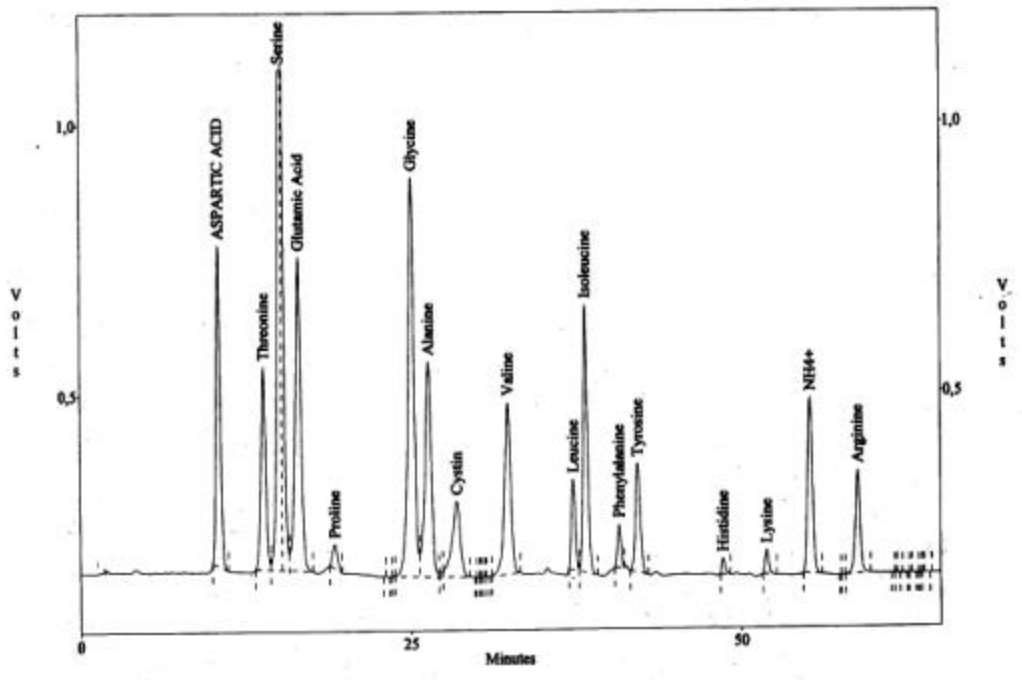


Fig. 1. Amino acid analysis of CF hydrolysis with 6N HCl, at 110°c, for 24 h.

These obtained conditions were be confirmed (i.e. no great difference observed), by comparison amino acid analysis after hydrolysis 2.0mg of CF with 4ml 6N HCl at 110°C for 24h (Fig.1) according to [24], and amino acid analysis of CF hydrolyzed at these experimented conditions (Figs.2).

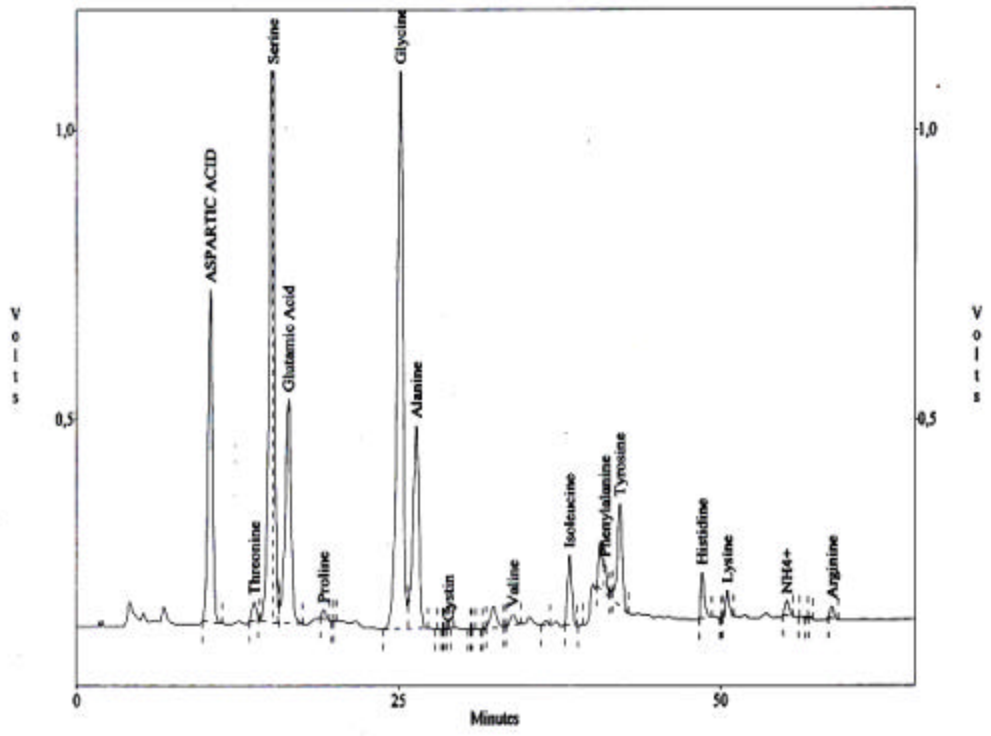
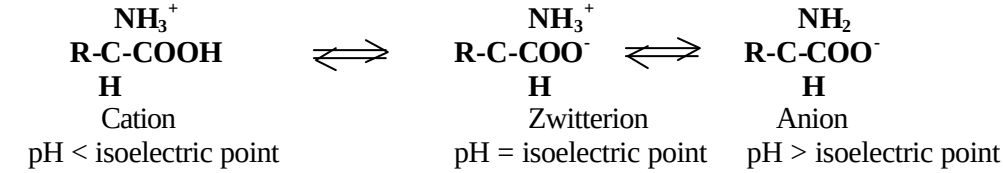


Fig. 2. Amino acid analysis of CF hydrolysis with 0.95N NaOH, at 70°C, for 1h.

3.2 Dye uptake effect

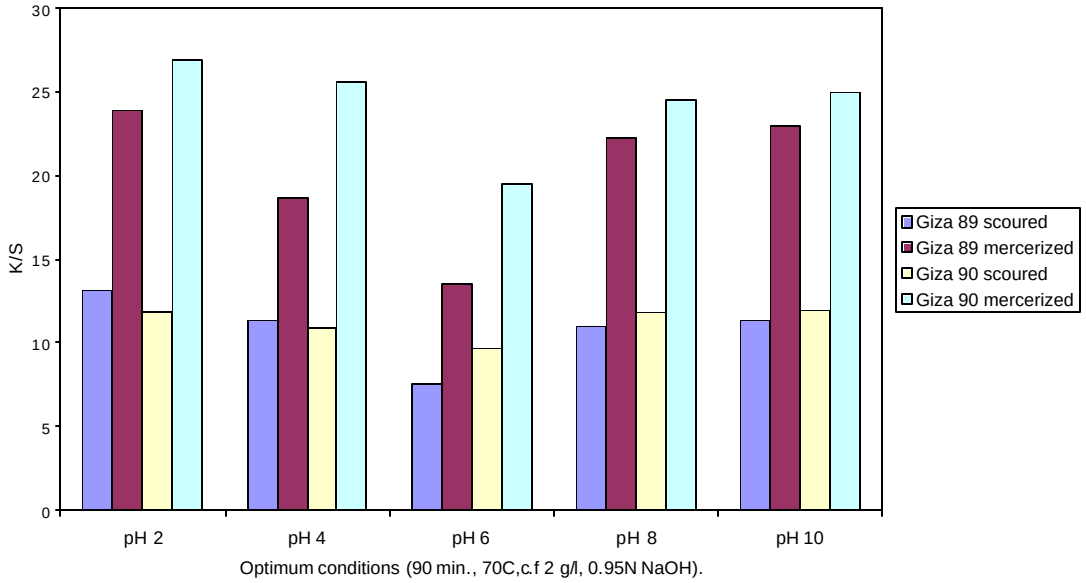
As shown in Fig.4, the K/S values of the samples influenced with the pH of solution. the pH of solution was shown to be the key parameter influencing the structural formula of active amino acids molecules bonded to cotton. The general structural formula of most natural amino acids contain both (-COOH) and (-NH_2) groups, which give them ability to exist either as a cation, anion, or Zwitterion depending on pH. For this reason pH governs the ionic form of the active amino acid sites occurred on cotton.



The open pond of oxygen atoms of the amino acid connect with cotton. In pH < isoelectric point (isoelectric point is pH at which amino acid become neutral), nitrogen on the amino acid adsorb hydrogen ions to create positively charged sites. These sites have a strong attraction to negatively charged dyes, so that the dye uptake increases considerably and the K/S values increased for both mercerized Giza 89, and

Giza 90. Increasing dyebath pH decreased the concentration of hydrogen ions, so the K/S values decrease for the mercerized cotton samples. When pH was equal to or larger than 6, hydrogen ion concentration was so low that the number of adsorbed decreased extraordinarily. The treated cotton fabric was not able to adsorb much dye through ionic attraction. Above pH 10, further increase in dye sorption. This effect due to the hydrolysis of the amino acid from cotton. The decrease in crosslinkages between cotton and the CF amino acid increased dye sorption. Metal can be also coordinated to side chain charged groups (-OH, -COOH and –SH) of some amino acid depending on type of amino acid to complete its coordination sphere [25-27].

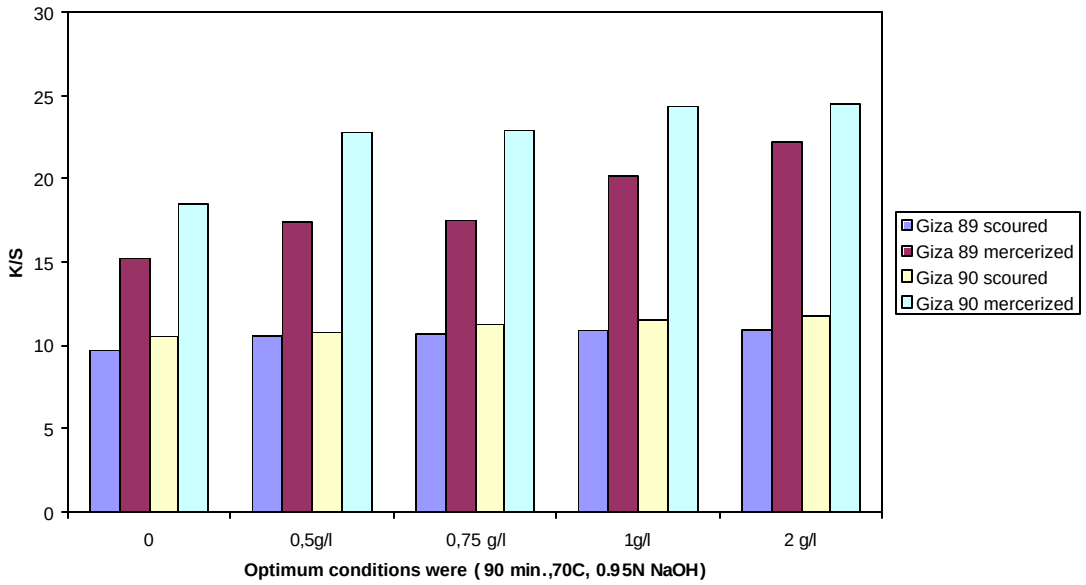
Fig. 4. Effect of pH on the color strength at the optimum conditions>



3.3 CF uptake by the cotton fabrics

As shown in Fig.4, the K/S values of the samples influenced with the concentration of the CF due to the increase of total amino acids concentration and a strong attraction to negatively charged dyes occurred, so that the dye uptake increases considerably and the K/S values increased for both mercerized Giza 89, and Giza 90.

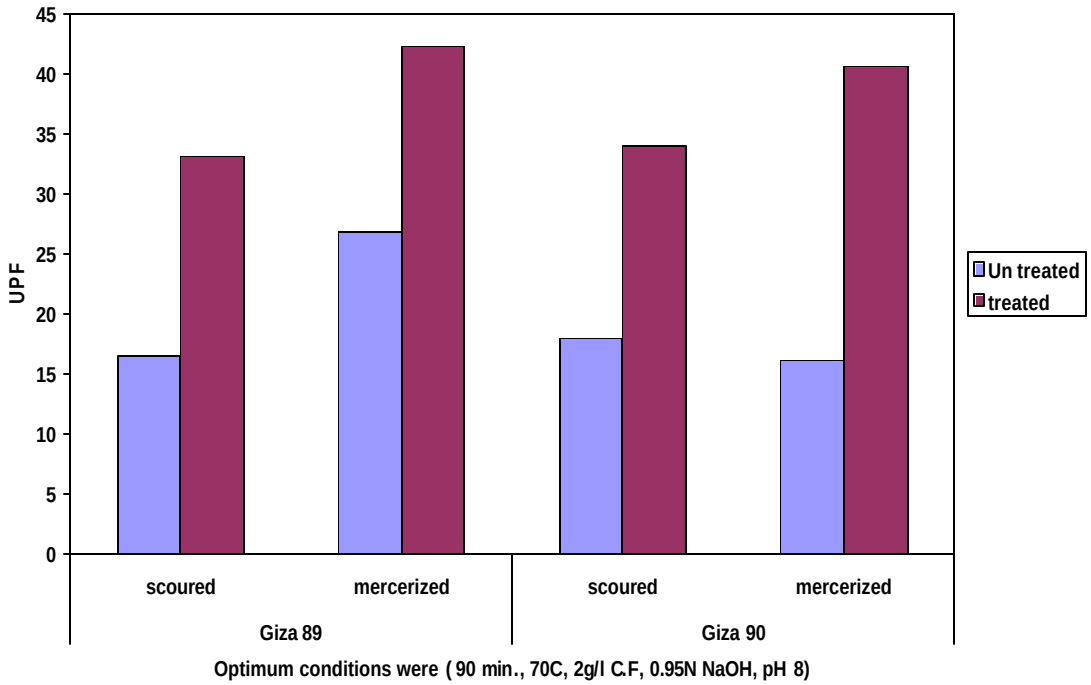
Fig.5 Effect of C.F concentration on the color strength at the optimum condition.



3.4 UPF values

High, short-term exposure to ultra violet radiation (UVR) from the sun causes sunburns leads to skin cancer.

Fig6. The UPF of the C.f treated cotton samples at the optimum conditions.



A primary reason for the increased cancers is attributed to ozone depletion. Each one percent decrease in ozone concentration increase the rate of skin cancer by two percent to five percent. Other reasons for the skin cancer such as excessive exposure to sunlight. UVR band consists of three regions: UV-A (320-400nm), UV-B

(290-320), and UV-C (200-290). UV-B is the most responsible for the development of skin cancers. Fabrics with a UFP value in the range 15-24 were classified as UV protection, when the UPF values were between 25-40 fabrics were classified as having UV protection. Excellent UV protection was used when the UPF value was 40 or greater [28]. As shown in fig. 6, the treated fabric samples with CF after mercerization treatment has the UPF value of more than 40, classified as excellent UV protection for both Giza 89, and Giza 90.

3.5 Fastness properties

Table 2 shows that the fastness properties for the treated fabrics for both the scoured, and mercerized Giza 89, and Giza 90 increase than that of the untreated samples.

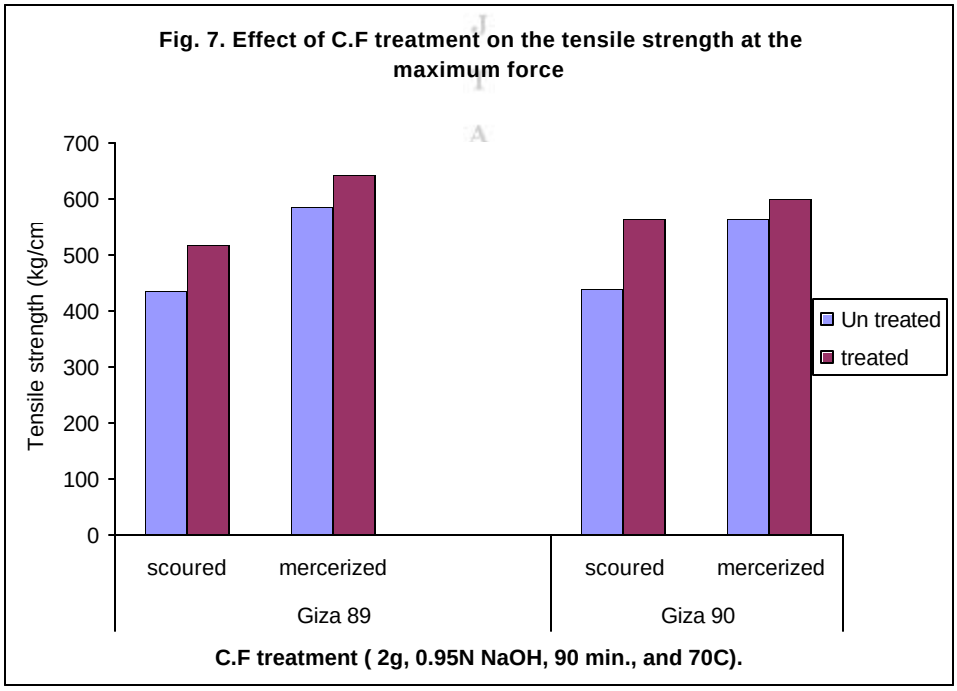
Table 2. Fastness properties of the cotton fabric samples treated with CF

Variety	Giza 89								Giza 90							
Treatment	Scoured				Mercerized				Scoured				Mercerized			
Fastness properties	L.F	W.F	P.F		L.F	W.F	P.F		L.F	W.F	P.F		L.F	W.F	P.F	
			ac	alk			ac	alk			ac	alk			ac	alk
Untreated	4	3/4	3/4	4/5	4	3/4	3	3/4	5	3/4	4/5	3/4	6	4/5	4	3/4
Treated	5	5	4	5	5	5	5	5	5	4	5	5	6	5	5	5

L.F light fastness W.F washing fastness P.F perspiration fastness ac acidic alk alkaline

3.6 Mechanical properties

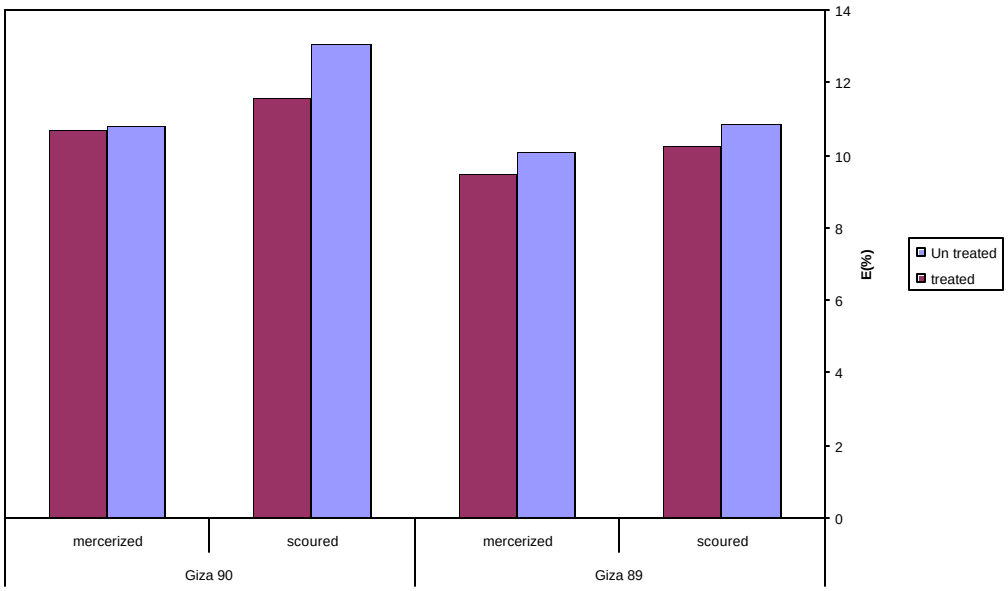
3.6.1 Tensile strength at maximum force



3.6.2 Elongation at break

It has been noted the strength for the untreated Giza 89 is stronger than Giza 90 while the elongation for Giza 89 is lower than Giza 90. Fig.8 shows that the traded samples increase both tensile and elongation in the same trend.

Fig. 8. Elongation at break for Giza 89, and Giza 90 cotton Fbrics treated with CF



CONCLUSION

This work contributes a new application of the chicken feather wastes in the textile industry by the applying the chicken feather onto the cotton fabric. The finished fabrics showed sufficient whiteness, high tensile strength, more dyeing uptake, and more reduction of the transmitted UV as compared to the untreated samples. These achievements will reduce the chemicals and dyes in the wastewaters of the textile industry. As will as more protective textile to the human skin.

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