Volume 10, Issue 2, 2020, 5174 - 5181 ISSN 2069-5837
Biointerface Research in Applied Chemistry
www.BiointerfaceResearch.com
https://doi.org/10.33263/BRIAC102.174181
Original Research Article **Open Access Journal**
Received: 29.11.2019 / Revised: 25.01.2020 / Accepted: 28.01.2020 / Published on-line: 03.02.2020

Treatment and optimization of unconventional heating to enhance the printability of Rami fabric by using Brewer's Yeast enzyme

Heba El-Hennawi [1], Nagla Elshemy [1,*], Karima Haggage [1], Amira Zaher [1], Asmaa Shahin [1]
[1]National Research Centre (NRC, Scopus affiliation ID 60014618), Textile Research Industrial Division (TRID), Dyeing, Printing and Textile auxiliaries Department (DPTID), El-Behouth St. (former El-Tahrir str.), Dokki, P.O. 12622, Giza, Egypt
*corresponding author e-mail address: ***nanaelshemy@hotmail.com*** | Scopus ID 55207312300

ABSTRACT
Treatment and optimization of a non-traditional heating to enhancement the printability of Rami fabric by using Brewer's Yeast enzyme was studied. The treatment of raw and semi-finished ramie fabrics was submitted to innovative treatment using microwave irradiation and under a variety of conditions. Variables studies including yeast concentration, duration of treatment, and treated temperature to optimize the treatment condition. Conditional changes in the innovatively treated fabric vis-à-vis those of untreated fabric were presented. The obtained results showed that the innovative treatment process using microwave irradiation consumes less time and energy. Besides that, there is an enhancement of physical and chemical properties of fabrics under study, which leads to enhancement of its printability with the reactive dye. The treated, as well as untreated fabrics, were characterized by using scanning electron microscopy (SEM) coupled with Fourier transforms infrared spectroscopy (FTIR). The effect of treatment with Brewer's Yeast enzyme coupled with microwave irradiation on physical and mechanical properties was investigated by using X-ray analysis. The effects of treatment with yeast enzyme on the multifunctional properties of the fibers including coloration, and antibacterial activity for E. coli as an example for gram-negative and S. aureus as an example of gram-positive bacteria were evaluated. The overall results point out that, the treated fabrics exhibited excellent color fastness as well as good antibacterial if compared to the untreated fabrics, in straightforward, the procedure adopted for fabricating these multifunctional ramie fabrics is environmentally friendly beside time and energy-saving.
Keywords: *Microwave irradiation; Ramie fabric; Brewer's Yeast enzyme; Textile printing.*

1. INTRODUCTION

Ramie is made from the plant stalks that called Chinese Nettle (*Boehmerianivea*). It is like Linen, but it is made from the stalks of the flax plant. Ramie has been known for over five centuries in various countries as China, India as well as Indonesia, therefore it's older than cotton. It was customarily very popular in Japan, and it is hardly known in North America [1].

Ramie is a white fiber and it looks like silk lustrous, however, it lacks stretch and elasticity, extremely absorbent much more than cotton. Like linen, its threads spun have an inseparable stiffness, and it can be woven into a lightweight open-weave pattern that makes it is very cool and comfort in humid climates, it does not shrink and it does not rot easily(resistant to bacteria and mildew) [2].

Ramie fiber has many advantages the most of them, its ability to hold shape, reduce wrinkling, and introduce a silky luster to the fabric appearance, is usually used as a blend with other fibers like cotton, and wool but it has not dyeability as cotton, however, it is slightly similar to linen [1,3].

Textile industries always in a continuous exploration for novel and unconventional technologies to meet both the quality and ecological production as well as to reduce energy consumption and water pollution [4]. Recently, Plasma technology, ultrasonic, enzymatic processes and microwave irradiation are the new and unusual technologies used in the textile industry.

To improve the final product quality, reduce the energy consumption, water, raw-materials, as well as increased sensibility of environmental attention related to the use and disposal of chemicals released into water and air during different chemical processes, textile industry focused on apply of enzyme as an ideal for white/industrial biotechnology which let the development of eco-friendly technologies [5,6].

As we know, applying the bio treatment technique before textile coloration will lead to ease of dye penetration into the fabric and achieving desirable properties. These days, researchers are discovered new sources of natural enzymes for textile applications such as lipase, amylase, protease and others that lead to open a new era for enzymatic applications in the textile's fields. Brewer yeast having many advantages such as it has a combination of enzymes, very simple preparation steps and accompanied by a very low price [7].

Because Rami fabric has some disadvantage such as a high degree of crystallinity, polymerization as well as orientation, all of this leads to low dye absorption, permeability, and low color strength. As we know, dye molecules are easy to penetrate into the amorphous regions while it is difficult to penetrate into crystalline ones because of the formed of the hydrogen bond in the inner part of the rami fabric. So, it is important to modify it to enhancement its surface properties [8, 9].

There is a lot of researches[3-10] work in the field of utilization of microwave in textile dyeing and synthesis, but textile treatment is not yet fulfilled. Current work addressed the treatment of semi-finishing and un-finishing Rami fabric through innovative heating and investigates its printing properties for the standardization of printing process as well as color reproducibility. The innovation based on the treatment Rami fabric under the influence of heat induced by microwave irradiation (MW) and compared with the untreated one. The treatment was conducted under different conditions as, (different concentration of Brewer yeast (gm/100 ml), temperature (ºC) for intervals time (min), for best standardization and color reproducibility of printing process.

2. MATERIALS AND METHODS

2.1. Materials.

- Fabric: semi-finished and unfinished Rami fabric was kindly supplied by Textile Indus-tries Egyptian Co. Ointex, Egypt
- Enzyme: Brewer's yeast filtrate, contains different enzymes (protease, lipase and amylase), supplied from starch and yeast company, Cairo, Egypt, was used throughout this study.
- Dyes: Reactive Red HE7B (RR141), dye is a complex di-azo dye with the chemical formula $C_{52}H_{26}C_{12}N_{14}Na_8O_{26}S_8$, molecular weight1,774.19 g/mol^{-1}

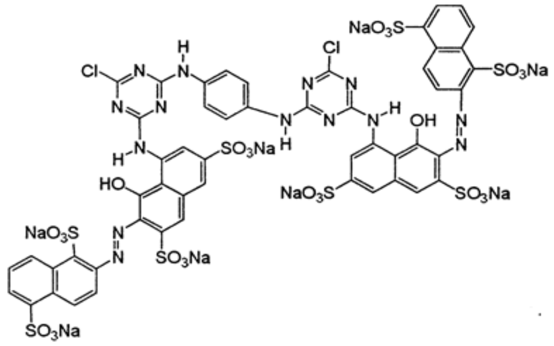


Figure 1. Chemical structure of Reactive Red HE7B dye.

Chemicals: Sodium hydroxide (NaOH), acetic acid (CH_3COOH), urea (CO $(NH_2)_2$), and sodium alginate thickener (high viscosity), from all supplied by El Nasr Pharmaceutical Chemicals.

2.2. Technical Procedures.

2.2.1. Preparation of Brewer's yeast filtrate

450 g dry weight of Brewer's yeast was pasted with 150 g sugar, and then 1 L of warm water (40 ◦C) was added to the paste of yeast while stirring for a period of time until the yeast was brewed. Finally, the solution was filtered and frozen.

2.2.2. Bio treatment of fabrics with enzymes:

The semi-finishing and un-finishing Ramie fabrics were treated with brewer's yeast filtration at different concentrations (0, 100, 200, 300 and 400 ml/l) at L:R 1:50 using pH level which adjusted at different degrees (6-7-8-9). The enzymatic treatment was applied at different treatment temperatures (40-50-60-70°C) for different intervals of time (0-15-30-45-60 min). After bio treatment time, the temperature was raised to 80°C to stop the enzymatic activity, and then the treated fabrics were rinsed with cold water and printed using the optimum printing paste.

2.2.3. Printing technique:

Treated and untreated Rami fabrics were printed with Reactive Red H-E7B by applying flat screen-printing method.

2.2.4. Printing paste:

The printing pastes were prepared according to the formulation given in table 1. Fixation step was also done by steaming at 102°C for 15 min

Table 1. Formulation of the printing paste.

Components	Weight/gm
Reactive dye	30
Urea	100
Sodium alginate	30
Sodium carbonate	30
Resist salt	10
Water	Y
Total	1000 g

2.2.5. Fixation

The resist printed fabrics were fixed via steam fixation at 102°Cfor 15 min.

2.3. Apparatuses.

2.3.1. 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.

2.3.2. Scanning Electron microscopy (SEM)

ZEISS LEO 1530 Gemini Optics Lens scanning electron microscopy (SEM) with 30 kV scanning voltages was employed to observe the morphologies of untreated and treated Ramie fibres. The samples were sputter-coated with gold before scanning to avoid charging.

2.4. FTIR analysis.

FTIR spectra were created for selected samples using a Spectrum 65 FTIR spectrometer (PerkinElmer Co., Ltd., MA, USA).

2.5. Evaluation of colorimetric properties.

2.5.1. 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:

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

Where, (K) is adsorption coefficient, (R) is reflectance of dyed sample and (S) is scattering coefficient [14]

2.5.2. Penetration and color unevenness%:

The printing dye penetration of samples was determined as follows [15]:

$$Penetration\% = \frac{(K/S)_b}{0.5\left((K/S)_f + (K/S)_b\right)} \times 100 \ldots\ldots\ldots\ldots (2)$$

Where:$(K/S)_f$ and $(K/S)_b)$ are the K/S values of the face and back of the printed square samplesrespectively.

The color unevenness for 13 K/S values of the face was calculated as follows [15]:

$$Color\ unevenness\% = \frac{\sqrt{\frac{1}{12}\sum_{i=1}^{13}(K/S_i - K^-/S^-)^2}}{K/S} \times 100 \ldots\ldots\ldots (3)$$

Where K/S_i represents the K/S values of the face of the printed square samples and K^-/S^- is the average K/S value.

2.5.3. Fixation percent (F %):

The extent of dye fixation ratio of Basic blue on polyester fabric was determined by measuring K/S values of the dyed samples before and after soaping using equation 4:

$$F\% = \frac{K/S\ after\ saoping}{K/S\ before\ soaping} \times 100 \ldots\ldots\ldots\ldots (4)$$

2.5.4. Wettability:

The wettability was evaluated by measuring the wetting time according to the AATCC method (1). A drop of water is allowed to fall from a fixed height on to the surface of polyester fabric under examination. The time that has been measured and taken as wetting time and the result were the average values of four readings [16].

2.5.5. Tensile strength:

The test was carried out according to the ASTM Standard Test method D 682 1924 on a tensile strength apparatus type FMCW 500 (VebThuringer Industries Work Rauenstein 11/2612 German) at 25 ± 2 ◦C and 60 ± 2% relative humidity [17].

2.5.6. X-ray diffraction analysis

X-ray diffraction measurements of treated and untreated raw and semi-finished rami fabrics were carried out with a X-Ray Diffractometer – D 5000, given 40 kV Cu Ka, radiation of 30 mA. The diffract grams were recorded over 2θ = 50 to 300 continuously at a scan rate of 20/min.

2.5.7. Antimicrobial test:

Against *E. coli* as an example of gram-negative bacteria (G^-) and S. aureus as an example of gram-positive bacteria (G^+). Antimicrobial activity was tested by the filter paper disc diffusion method 27. SMA and Mueller Hinton agar (Difco) containing 100 ppm of 2, 3, 5-triphenyltetrazolium chloride were used for antibacterial assay. 2, 3, 5-triphenyltetrazolium chloride was added to culture media to differentiate bacterial colonies and to clarify the inhibition zone (28). Each plate was inoculated with bacterial, Escherichia coli as an example of gram-negative bacteria (G^-), *Staphylococcus aurous* as an example of gram-positive bacteria (G^+) (0.1 ml) directly from the broth. All plates were incubated at 32ºC for 4 days, after which the inhibition zones were measured and recorded in millimeters (mm). The scale of measurement was the following (disc diameter included): ≥28 mm inhibition zone is strongly inhibitory ≤16 to 10 mm inhibition zone is moderately inhibitory; and ≤ 12 mm is no inhibitory 26-28. Control plates were prepared by placing antibiotic to evaluate culture for antibiotic resistance patterns that might affect sensitivity of the assay. The antibiotic used was penicillin 10 IU [18].

2.6. Fastness properties.

Fastness properties to washing, rubbing (dry &wet), perspiration as well as light fastness were measured according to a standard method [19-22].

3. RESULTS

The main objective of this study was to improve the multifunctional properties of Ramie fabric surfaces by incorporating the functionally important enzyme. Many researchers worked on the modified textile with different enzyme type but there are no reports about the modification with an enzyme to improve cellulosic fabric surfaces via microwave heating.

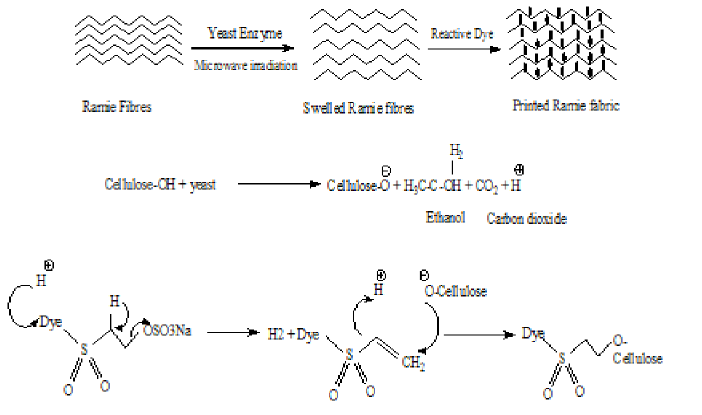
The effects of modification parameters, such as Brewer's yeast amount, modified time and modified temperature were investigated to obtain the optimal modification conditions of Brewer's yeast onto raw a semi-finishing ramie fabric. The effect of this modification on the enhancement of printing properties and their effect on its physical and chemical properties of these fabrics were also investigated.

3.1. Optimization of fabric treatment.

3.1.1. Effect of initial Brewer's yeast amount on modified of raw and semi-finishing fabrics:

This step was carried out by using innovative techniques to modify ramie fabric at 60°C, pH 4, at different Brewer's yeast amounts (H_2O: Yeast ml/gm) (15:35, 50:50, 35:15, and 50:0) for 30 min. Table (2) shows the effect of Brewer's yeast amount on Ramie fabrics printability in terms of K/S values. The force responsible for Brewer's yeast removal from treatment bath to the surface of the fabric is the concentration gradient function of Brewer's yeast in two phases (treatment solution and fiber). The resulted data listed in Table (2) clarify the following points: i) the un-finished fabric gives a higher K/S value, if compared with the semi-finished one, ii) the treated fabrics gives higher K/S value than the untreated one, iii) the K/S values depended on the Brewer's yeast amount in treatment bath, iv) the highest K/s values are obtained at 0:50 ml/ gm, v) the extent of Brewer's yeast transfer from treated solution onto the fabrics under study was enhanced with increasing the amount of Brewer's yeast in treatment bath, and thus apparent shades depth also increased.

Enzyme transfer from treatment solution incorporated into the fabric can be divided into three steps: i) pre-nucleation, ii) nucleation and iii) growth. In the first step, Ramie fabrics, which are cellulosic materials, have a negative zeta potential in the acidic solution due to the presence of carboxyl or hydroxyl groups in their chemical structure. After the immersion of Ramie fabrics into the treatment solution; Brewer's yeast in the solution will react with the fabric and hydrolyze forming H^+ and carbon dioxide. The later will adsorb and diffuse into the fabric surface which may be caused fiber swelling which in turn helped in distribution of dye molecule and more easily to dye penetration inside the fabric, which leads to forming more covalent bond with the dye molecules and hence improving the color homogeneity (scheme 1).



Scheme 1. Reaction mechanism of yeast, cellulose and Reactive dye.

On the other hand, cellulase is formed from three major enzymes: (1) endoglucanase (EGs), (2) exocellobiohydrolase, and (3) beta glucosidases. The first one hydrolyzed cellulase randomly along the chains preferred tially the amorphous region. Then the second will attack the chain and produce primarily cellobiose connected with the binding associated with the enzyme. The cellobiose and any small chain oligomers produced by exocellobiohydrolase are then hydrolyzed by the third enzyme into glucose [24]. Besides that, the extracellular enzyme can be degraded crystalline cellulose region and its soluble derivatives which lead to an increase the amorphous region. This may lead to improve its properties without any damage, due to the slow enzymatic degradation of crystalline region.

Table 2. Effect of Brewer's Yeast amount on printability of un-finished and semi-finished Ramie fabric.

H_2O:Yeast ml/gm	Color strength (K/S)	
	Un-finished	Semi- finished
50:0	9.08	8.16
35:15	15.08	13.96
50:50	15.91	14.82
15:35	15.38	14.44
0:50	17.07	15.1

pH 4, temp 60°C, 30 min

3.1.2. Effect of treated bath temperature on raw and semi-finishing Ramie fabrics:

Temperature affects the mechanism of treatment process through altering the energy of Brewer's yeast molecules in treatment-bath which cause fabric swelling extent and makes their interaction practicable to absorption. The result of the study of the effect of temperature on absorption of enzyme onto the different Ramie fabrics at pH 4 with initial Brewer's yeast amount of 50 gm for 30 min in MW is illustrated by (Fig. 2). It can be clearly concluded that with an increase in temperature, yeast absorption increases first due to the more swelling extent of fabric at high temperatures. It was observed that the highest K/S value obtained at 60ºC for raw fabrics while at 80°C for semi-finished one, after that with an increase in temperature the K/S was decreased owing to the shift of adsorption–desorption towards equilibrium.

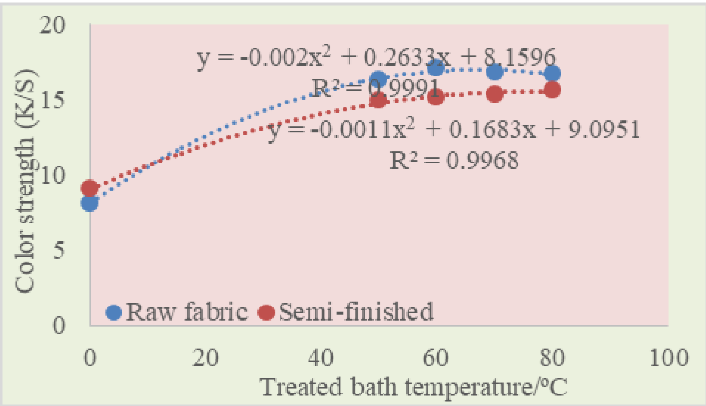


Figure 2. Effect of modified bath temperature on color strength of raw and semi-finished Ramie fabric.

One of the main advantages provided by microwave heating is homogenized, as the heating is uniformly distributed in homogeneous manner and in all directions. This results in a very fast non-contact internal heating, which leads to a rapid rise in temperature which able to heat up the reaction medium homogenously, allowing uniform and rapid reaction occurred between functional group of reactant material and enhancement of the reaction rate. In addition, microwave characteristic by used selective heating, 'the ability of the microwaves to interact with materials and transfer energy affects by molecular structure', when interact materials have dielectric properties, couple with the higher loss material will selectively by microwaves. Consequently, it may be possible to produce materials with new or individual microstructures by selectively heating distinct stage. However, microwave irradiation can able to initiate chemical reactions through selective heating of reactants; so, new materials may be formed, which is not possible in classical processing.

3.3. Effect of modified time on raw and semi-finished Ramie fabric:

Fig. 3 shows the color strength of the printed fabric after treatment at different microwave heating times at the fixed concentration of yeast and microwave temperature 60ºC. The highest K/S value obtained at 20 min. These results implied that the fabric swelling increased with increased microwave heating time.

Time is valuable; this was applying for all daily operations, especially in the textile filed, where a lot of time and energy were wasted. Though, the idea of using ''Microwave irradiation" was considered as an ecological and economical breakthrough technology for textile industry, where the time energy is supplied by an electromagnetic field directly to the material resulting rapid heating throughout the material thickness with reducing thermal gradients. The electromagnetic theory and the dielectric response are major to optimize any processing of materials through microwave heating. The one main advantages of the microwave heating are reducing the reaction time, energy consumption, chemical wasting and the product yields without agglomeration.

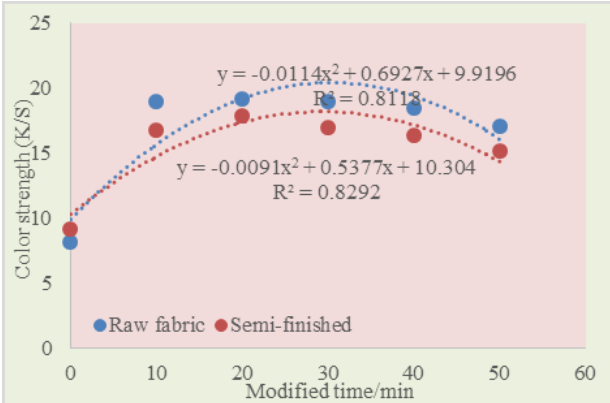


Figure 3. Effect of modified bath time on color strength of raw and semi-finished Ramie fabric.

From all the above data we can conclude that, an initial yeast concentration of 0 ml (H_2O):50g yeast, temperature 60ºC, at pH 4 for 20 min used as optimized condition for determining modified characteristics of raw as well as semi-finished rami fabric.

3.1.3. Printing performance of printing fabric using raw and semi-finished fabric:

The printing fabrics add-on, color strength (K/S), color unevenness, dye penetration and fixation% were displayed in Table 3. From the data listed in table 3 it was observed that i) the color yield of raw ramie fabric is higher than the semi-finished one, ii) the color yield of raw treated with the yeast enzyme was increased by 135.058% while in treated semi-finished it was increased by 96.163%, iii) the penetration of treated raw fabric was better if compared with the semi-finished one, which can be concerned with the differences in chemicals nature and composition of the fabric as well as to the effect of microwave irradiation. Pulsed MW irradiation can control temperature and eliminate the exothermic temperature through the fast reaction between fabric and yeast's enzyme which lead to maintain the homogeneity in temperature distribution at all the treatment process.

The result of Table 4 shows the fabric handle (Stiffness, wettability, fiber diameter, tensile strength (T.S) and elongation (E%)) using treated and untreated of raw and semi-finished fabrics. The data listed in table 4 illustrated that there are slightly increased in tensile strength and elongation% of all the fabric. On the other hand, the wettability of the enzyme-treated fabrics was enhanced remarkably compared to the untreated. In a word, treated raw rami fabric has excellent color yield, penetration%, fixation%, wettability and handling properties. It has an extensive development and application potentiality, which could be used as the substitution for semi-finished fabric.

Table 5 shows the washing, rubbing, and perspiration as well as light fastness properties of treated and untreated ramie fabrics printed with reactive dye. Printed treated of raw fabric showed excellent washing, rubbing, if compared with untreated and treated semi finishing fabrics. As it was expected using yeast enzyme gave a good improvement in most of color fastness properties except in case of rubbing fastness with untreated semi-finished which gave fair results. Also, it can be noticed that the best results of color fastness properties were achieved with treated raw fabric.

Table 3. Printing performance of the rami fabric treated with yeast enzyme.

fabric	K/S	Penetration %	Unevenness %	F %
Raw				
Blank	8.16	80.000	12.1813	84.74
Treated	19.18	91.000	9.35	95.48
Semi-finished				
Blank	9.08	81.4768	14.062	83.84
Treated	17.88	86.2745	10.0052	87.48

Table 4. Handle properties of treated and untreated rami fabric.

Fabric	T.S (Kg/f)	E (%)	Stiffness (%)	Wettability (sec)	Fibre diameter / mec.
Raw					
Blank	6.166	45.198	1922.4	28	155
Treated	7.000	74.518	2136.0	13	228
Semi-finished					
Blank	11.000	38.121	2385.2	25	320
Treated	11.334	97.784	2670.0	17	475

Table 5. Fastness Properties of the printed treated and untreated Ramie fabrics.

Fabric	Washing		Rubbing		Perspiration				Light fastness
					Acidic		Alkaline		
	Alt	St.	Dry	wet	Alt	St.	Alt	St.	
Raw									
Blank	3	3	3	2-3	3	3	3-4	4	5-6
Treated	4	4	4-5	4	4	4	4-5	4-5	7
Semi-finished									
Blank	2-3	2-3	2-3	2-3	2-3	2-3	3-4	3	5
Treated	3	3	3	3	3	3-4	3-4	3	5-6

The chemistry of bonding of yeast enzyme to ramie fabric involves direct bonding, H-bonds, and hydrophobic interactions. Generally, yeast enzyme as well as microwave irradiation effect help binding of enzyme to the fabric by forming a chemical bridge from dyes to the fabrics, thus improving the staining ability with increase in its fastness properties.

3.2. Characterization of treated fabric using yeast enzyme.

3.2.1. X-ray diffraction analysis

To investigate the influence of the treatment with Brewery's yeast under microwaves irradiation on fabrics crystallinity, experiments with rami fabric in a treatment bath at 500 W powers were carried out at yeast concentration of 0 ml (H_2O):50g (yeast), temperature 60ºC, pH 4 for 20 min. The crystallinity of the untreated rami fabrics and those treated one with Brewery's yeast enzymes under the effect of microwave irradiation are shown in Figure 4. The crystallization index (CI) of rami fabrics is calculated using the following equation [25,26].

$$CI\% = (I_{22} - I_{15})/I_{22}) \times 100 \ldots \ldots \ldots \ldots \ldots \ldots (5)$$

Where I_{22} is the intensity at $2\theta = 22°$ and I_{15} at $2\theta = 15°$

On the basis of Equation (5), CI results of the untreated and Brewery's yeast enzymes treated fabrics under microwave irradiation are listed in Table 6. It can be seen from Table 1 that compared with the untreated raw fabrics, the crystallinity of the treated fabric in a treatment bath under microwave irradiation was decreased by 18.27%, while it decreased by 11.85% in semi-finished one, which can be attributed to the modification of the fine structure of Rami fabrics in a treatment bath by absorption of microwave energy. Microwave heating is more efficient than the traditional heating source. Through traditional heating, heats are generated outside the treated bath and transmit, by conduction or convection. On the contrary, under microwave irradiation, heat is created, in a distributed manner inside the material; give more uniform and faster heating. The microwave irradiation technique has good potential for industrial application as a microwave is a clean, environmentally friendly heating technology.

Table 6. CI value of untreated and Brewery's yeast treated raw and semi-finishing fabric.

Fabric type	I_{15}	I_{22}	I%
Raw			
Untreated	22.64	100.00	77.36
Treated	34.59	100.00	65.41
Semi-finished			
Untreated	27.72	100.00	72.28
Treated	35.38	100.00	64.62

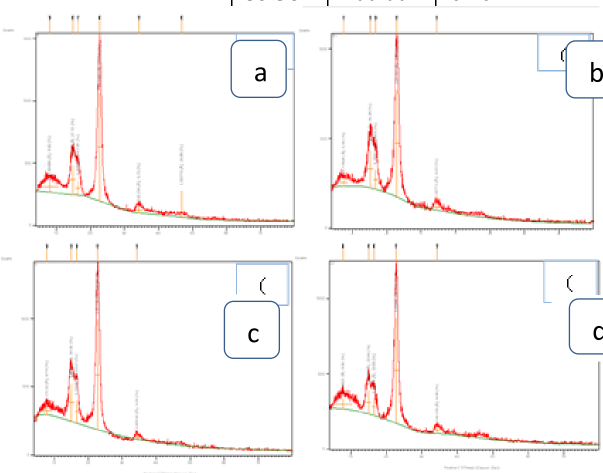


Figure 4. XRD Curve of untreated and treated raw (A, B) and semi-finished rami fabric (C, D).

3.2.2. *Scanning electron microscope (SEM)*

To get insight into the morphology of the treated raw and semi-finished ramie fiber surfaces, scanning electron microscopy (SEM) characterization was performed to detect the effect of yeast enzyme on the fiber surfaces, Fig. 5. The image of the untreated of raw ramie fiber as well as the semi-finished show an accumulate fibril structure surface (Fig. 5 a & c), while the surface of the treated fiber in the presence of yeast enzyme (Fig. 5 b & d) show the clear and smooth longitudinal fibril structure surface. We can also observe that i) there is an increase in fiber diameter of treated fiber if it compared with the untreated one in both fabric, ii) the increase in fiber diameter is higher in case of treated raw fiber. Again, these may be attributed to homogenized of microwave heating, as the heating is uniformly distributed in homogeneous manner and in all directions, besides to the yeast enzyme effect which formed of cracks in the direction of the fiber axis [23,24].

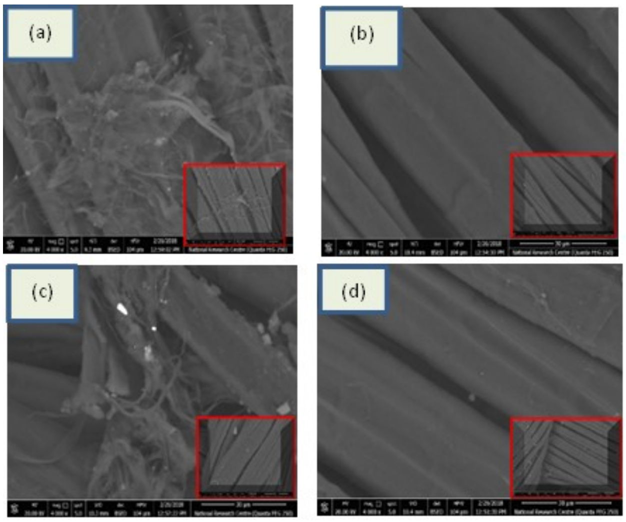


Figure 5. Scanning electron microscope image for, (a) untreated raw ramie fiber, (b) treated for raw fibers in presence of yeast enzyme, (c) untreated semi-finished fiber, (d) treated of semi-finished one, respectively.

3.2.3. *Fourier Transform Infrared Spectra.*

The chemical interaction of the Brewer's yeast with the fabric was examined by FTIR, (Fig. 6). As shown in Fig.5, the characteristic a strong absorption stretching peak of untreated raw ramie fabric appears at 3266.11 cm^{-1} with correlation intensity 30.8336 while treated raw one it appears at 3826.08 cm^{-1} with correlation intensity 91.1377 this is due to the presence of (O-H) bond. The same figure also shows an absorption stretching broad peak at 1024.02 cm^{-1} with correlation intensity 57.774 this is due to the presence C-C bond in untreated raw fabric while in the treated raw fabrics appears a wagging broad peak at 1023.05 cm^{-1} with correlation intensity 58.738 approve the presence of conjugate of bending C-O of the yeast enzyme. This proves the success of the yeast penetration process into the fabric and caused the fabric swelling. While the appearance of a broad stretching peak at 3285.14 cm^{-1} and 2804.27 cm^{-1} with correlation intensity 34.3996 and 54.5305 248 cm^{-1} originates from the bending vibration O-H and C-H group which present in the semi-finished untreated fabric groups.

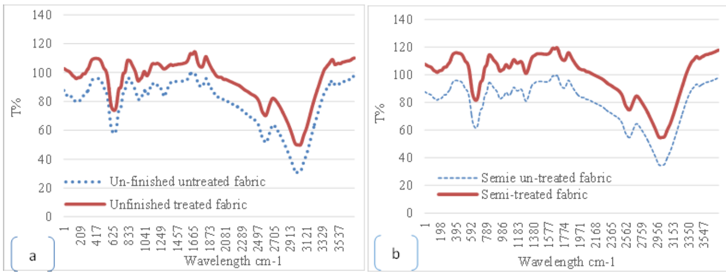


Figure 6. FTIR of Un-finished untreated and treated ramie fabric (a), and semi-finished untreated and treated ramie fabric (b).

While the appearance of a strongly stretching broad beak at 3286.11 cm^{-1} with correlation intensity 30.8336 and abroad peak at 2904.27 cm^{-1} with correlation intensity 51.4135 in the semi-finished treated fabric, this due to the presence of O-H bond, while the appearance peak at 1042.02 cm^{-1} with correlation intensity 57.774 of C-O, a point which means the swelling process occurs at the fabric surface without causing any damage of the fabric.

Table 7. Antibacterial activity of treated and untreated of raw and semi-finished ramie fabrics.

Fabric	Bacterial reduction%			
	E. coli		S. aureus	
	1 washing cycles	10 washing cycles	1 washing cycles	10 washing cycles
Raw				
Blank	8.3	6.3	8.3	6.3
Treated	20.0	18.5	17.0	16.0
Semi-finished				
Blank	9.0	5.6	9.0	5.6
Treated	15.0	15.0	10.5	9.0

3.2.4. *Antibacterial Activity.*

Besides the enhancement of physical and chemical properties of fabrics, yeast enzyme on surface of fabrics can acquire the treated fabrics antibacterial properties. The enzymes have been exhibiting wide range of activity against bacteria and viruses. The antibacterial activity of treated fabrics was tested against E. coli as an example of gram-negative bacteria (G^{-}) and S. aureus as an example of gram-positive bacteria (G^{+}). The inhibition zone method was used for the detection of antibacterial efficacy and data was reported in Table 7. It is quite clear that the blank raw and semi-finished fabrics did not show any antibacterial effect. After enzyme treatment, all fabrics were exhibited excellent bacterial action before and after washing. Regardless the fabrics type, the bacterial colonies were almost reduced after 10 washing cycles. These results manifested that the raw and semi-finished ramie fabrics possessed remarkable antibacterial properties after direct treatment by using yeast enzyme. The antibacterial results presented here for raw and semi-finished fabrics after treatment is much better comparing to the results of untreated fabrics. This is assured of the efficiency and applicability of our simple methodology compared to the other methods reported in literature [25-27].

4. CONCLUSIONS

The present study focused on preparation of multifunctional textiles based on treated raw and semi-finished rami fabrics using Brewer's Yeast enzyme, which reacted directly with the surface of the fabric. The multi-functionalization (color strength (K/S), color unevenness, dye penetration and fixation %) of printed fabrics were successfully fabricated by assisting of microwave heating as time and energy saving system during treatment processes. The obtained result showed the enhancement of fabric handle properties, the data illustrated that there are slightly increased in tensile strength and elongation % as well as fibre diameter of all the fabric. On the other hand, the wettability of the enzyme-treated fabrics was enhanced remarkably compared to the untreated fabric. According to the colorimetric data, the microwave assisted treatment of rami fabrics imparted bright color with excellent all over the color fastness properties that related to the surface plasma resonance properties of yeast enzymes, fabrics as well as microwave irradiation. The image of SEM showed that there is an increase in fibre diameter besides the enhancement of the fabric surface. Microwave irradiation had no obvious damaging effect of treated fabric compared to the untreated one. It was also found that treatment with Brewery's yeast enzyme coupled with microwave irradiation also affected the fine structure of raw and semi-finished rami fabrics. The crystallinity of the treated fabric in treatment bath under microwave irradiation decreased by 18.27%, while it decreased by 11.85% in semi-finished one. The printed ramie fabrics were exhibited excellent antibacterial activities even after 10 washing. The techniques used here provide the industrial product with low cost, applicable for medical purposes, as well as it can be accomplished for other fabrics. The applicatory potential of this technique for natural and synthetic fabrics are under investigation in ongoing research by our research team.

5. REFERENCES

1. Binita, B.; Kalita, Nabaneeta, G.; Sanghamitra, K. Properties of ramie and its blends. *International Journal of Engineering Research and General Science* **2013**, *1*.
2. Pandey, S.N. Ramie fibre: part I. Chemical composition and chemical properties. A critical review of recent developments. *Textile Progress* **2007,** *39*, 1-66, https://doi.org/10.1080/00405160701580055.
3. Mohanty, A.K.; Misra, M.A.; Hinrichsen, G.I. Biofibres, biodegradable polymers and biocomposites: An overview. *Macromolecular materials and Engineering* **2000**, *276*, 1-24, https://doi.org/10.1002/(SICI)1439-2054(20000301)276:1<1::AID-MAME1>3.0.CO;2-W.
4. El-Shemy, N.; Karima, H.; Elham, El-K.; Hosam, El-S. Synthesis and Applications of Nano Binder Based on Plant Oils. *Journal of Natural Fibers* **2017**, *14*, 10-25, https://doi.org/10.1080/15440478.2015.1133364.
5. Leslie, W.C. *Textile printing (2nd edn.) Society of dyers and colorists.* Perkin House, UK, 2003.
6. Araujo, R.; Casal, M.; Cavaco, A.P. Application of enzyme for textile fibres processing. *BiocatBiotrans* **2008**, *26,* 332-349, https://doi.org/10.1080/10242420802390457
7. Mari, M.M.; Abd El-Hamid, M.F.; El-Khatib, H.S.; El-Gamal, A.R. 1st International conference of textile research Division NRC, Cairo, Egypt, 2004, https://doi.org/10.1080/10242420802390457
8. Nam, S.; Netravali, A.N. Green composites. I. Physical properties of ramie fibers for environment-friendly green composites. *Fibers and Polymers* **2006,** *7*, 372-379, https://doi.org/10.1007/BF02875769.
9. Zhuang, L.; Zheng, C.; Sun, J.; Yuan, A.; Wang, G. Performances of ramie fiber pretreated with dicationic imidazolium ionic liquid. *Fibers and Polymers* **2014**, *15*, 226-233, https://doi.org/10.1007/s12221-014-0226-8.
10. Elshemy, N.S.; Elshakankery, M.H.; Shahien, S.M.; Haggag, K.; El-Sayed, H. Kinetic Investigations on Dyeing of Different Polyester Fabrics Using Microwave Irradiation. In: *Conference Issue (The 8th International Conference of The Textile Research Division (ICTRD 2017).* National Research Centre, Cairo 12622, Egypt), Volume 60, 2017; https://doi.org/10.21608/ejchem.2017.1604.1131.
11. Haggag, K.; Elshemy, N.S.; Niazy, W. Recycling of Waste PET into Useful Alkyd Resin Synthesis by Microwave Irradiation and Applied in Textile Printing. *Research Journal of Textile and Apparel* **2014,** *18*, 80-88, https://doi.org/10.1108/RJTA-18-01-2014-B010.
12. Elshemy, N.S. Unconventional natural dyeing using microwave heating with cochineal as natural dyes. *Research Journal of Textile and Apparel* **2011**, *15*, 26-36, https://doi.org/10.1108/RJTA-15-04-2011-B004
13. Elshemy, N.S.; Hassabo, A.G.; Mahmoud, Z.M.; Haggag, K. Novel Synthesis of Nano-emulsion Butyl Methacrylate /Acrylic acid Via Micro-emulsion polymerization and Ultrasonic Waves. *J. of Textile and Apparel, Technology and Management* **2016**, *10*.
14. Judd, D.B.; Wyszin, K.G. *Colorin Business Science and Industry*. 3rd edn., Wiley-Blackwell, Anybook Ltd, Lincoln, UK, 1975.
15. Wang, L.; Liu, B.; Yang, Q.; Lu, D. Rheological studies of mixed printing pastes from sodium alginate and modified 241 xanthan and their application in the reactive printing of cotton. *Coloration Technology* **2014,** *130,* 273-279, https://doi.org/10.1111/cote.12089.
16. AATCC Technical Manual Test method 39, 1971.
17. ASTM Standard C33 (ASTM D1682-64 e1), 1975.
18. Baliarsingh, S.; Behera, P.C.; Jena, J.; Das, T.; Das, N.B. UV reflectance attributed direct correlation to colour strength and absorbance of natural dyed yarn with respect to mordant use and their potential antimicrobial efficacy. *Journal of Cleaner Production* **2015**, *102*, 485-492, https://doi.org/10.1016/j.jclepro.2015.04.112
19. AATCC Technical Manual, Method 8, (1989), 68, 23, (1993).
20. AATCC Technical Manual, Method 36, (1972), 68, 23, (1993).
21. AATCC Technical Manual, Method 15, (1989), 68, 30, (1993).
22. AATCC Technical Manual, Method 16A, 1989), Color fastness to light: carbon – Arc lamb continuous light 68, 33, (1993).
23. El-Shemy, N.S.; El-Hawary, N.S.; El-Sayed, H. Basic and Reactive-Dyeable Polyester Fabrics Using Lipase Enzymes. *J Chem Eng Process Technol* **2016,** *7*, 271, https://doi.org/10.4172/2157-7048.1000271.
24. El-Hennawi, H.M.; Shahin, A.A.; Rekaby, M.; Ragheb, A.A. Ink jet printing of bio-treated linen, polyester fabrics and their blend. *Carbohydrate polymers* **2015**, *118*, 235-241, https://doi.org/10.1016/j.carbpol.2014.10.067.
25. Segal, L. An empirical method for estimating the degree of crystallinity of native cellulose using the X-ray diffract meter. *Textile Research Journal* **1959**; *29*, 786-794, https://doi.org/10.1177/004051755902901003.
26. Younis, G.; Awad, A.; Dawod, R.E.; Yousef, N.E. Antimicrobial activity of yeasts against some pathogenic bacteria. *Veterinary world* **2017,** *10*, 979, https://doi.org/10.14202/vetworld.2017.979-983.

27. Kalia, S.; Thakur, K.; Celli, A.; Kiechel, M.A.; Schauer, C.L. Surface modification of plant fibers using environment friendly methods for their application in polymer composites, textile industry and antimicrobial activities: A review. *Journal of Environmental Chemical Engineering* **2013**, *1*, 97-112, https://doi.org/10.1016/j.jece.2013.04.009.

6. ACKNOWLEDGEMENTS

The authors also gratefully grateful acknowledge to National Research Centre (NRC) for facilities provided.