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

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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 rami 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 for 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 rami fabrics is environmentally friendly beside time and energy-saving.

Keywords: Microwave irradiation; Rami 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 spin 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’s yeast enzyme, different concentration of Brewer’s 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_{26}H_{32}N_{14}Na_{5}O_{26}S_6, molecular weight 1,774.19 g/mol

![Figure 1. Chemical structure of Reactive Red HE7B dye.](image)

Chemicals: Sodium hydroxide (NaOH), acetic acid (CH_{3}COOH), 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 ºC) 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-finished 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 (40-50-60-70ºC) for different intervals of time (0-15-30-45-60 min). After bio treatment time, the temperature was raised to 80ºC 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 102ºC for 15 min

| Components            | Weight/gm |
|-----------------------|-----------|
| Reactive dye          | 30        |
| Urea                  | 100       |
| Sodium alginate       | 30        |
| Sodium carbonate      | 30        |
| Resist salt           | 10        |

Table 1. Formulation of the printing paste.

2.2.5. Fixation
The resist printed fabrics were fixed via steam fixation at 102ºC for 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 Kubelka–Munk equation:

\[ \frac{K}{S} = \frac{(1 - R)^2}{2R} \ldots \ldots (1) \]

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]:

\[ \text{Penetration\%} = \frac{(K/S)_b}{0.5 ((K/S)_f + (K/S)_b)} \times 100 \ldots \ldots (2) \]

Where: \((K/S)_f\) and \((K/S)_b\) are the K/S values of the face and back of the printed square samples respectively.

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

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

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:

\[ F\% = \frac{K/S \text{ after soaping}}{K/S \text{ before soaping}} \times 100 \ldots \ldots (4) \]
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 ºC 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 20 = 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+).

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 (H2O: 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 yeasts transfer from treated solution onto the fabrics under study was enhanced with increasing the amount of Brewer’s yeasts in treatment bath, and thus apparent shades depth also increased.

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 32°C 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].

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 molecules 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).

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

cellulose and any small chain oligomers produced by

exocellulbiohydrolase 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  | Color strength (K/S) |
| ml/gm | 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         |

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 60°C 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.

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 60°C. 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 field, 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.

From all the above data we can conclude that, an initial

yeast concentration of 0 ml (H_2O):50g yeast, temperature 60°C, at

pH 4 for 20 min used as optimized condition for determining

modified characteristics of raw as well as semi-finished rami

fabric.

3.3.1. 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

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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 ramie fabric in a treatment bath at 500 W powers were carried out at yeast concentration of 0 ml (H₂O):50 g (yeast), temperature 60°C, pH 4 for 20 min. The crystallinity of the untreated ramie 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 ramie fabrics is calculated using the following equation [25,26].

\[
CI\% = (I_{22} - I_{15})/I_{22} \times 100
\]

Where \( I_{22} \) is the intensity at \( 2\theta = 22^\circ \) and \( I_{15} \) at \( 2\theta = 15^\circ \)

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 Ramí 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-finished fabric. |
|---|---|---|---|
| Fabric type | \( I_{15} \) | \( I_{22} \) | \( F\% \) |
| Raw | 22.64 | 100.00 | 77.36 |
| Treated | 34.59 | 100.00 | 65.41 |
| Semi-finished | 27.72 | 100.00 | 72.28 |
| Treated | 35.38 | 100.00 | 64.62 |

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...
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 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].

![Image](https://via.placeholder.com/150)

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 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.

![Image](https://via.placeholder.com/150)

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 peak 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      | E. coli 1 washing cycles | E. coli 10 washing cycles | S. aureus 1 washing cycles | S. aureus 10 washing cycles |
|-------------|-------------------------|---------------------------|-----------------------------|-----------------------------|
| 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 ramie 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 ramie 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.

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