Effect of dyeing repetition and color reinforcement materials on color formation of cloth by mixed fungi dyes

Suciatmih*

Research Center for Biology, Indonesian Institute of Sciences, Cibinong Science Center, Cibinong-Bogor 16911, Indonesia

*Email: suciatmih2008@yahoo.com

Abstract. Colors variation and aging on cloth can be obtained through dyeing repetition and the application of color reinforcement materials. In the present study, cloth was dyed with dyes from the mixed fungi of Aspergillus and Paecilomyces using three different dyeing repetitions (3, 6, and 9 times), three different mordants (CaCO$_3$, FeSO$_4$·7H$_2$O, and KAl (SO$_4$)$_2$·12H$_2$O), and three different other color reinforcement materials (salt, soda ash, and vinegar). The mixed fungi were grown on mineral salt glucose medium in stationary cultures in dark conditions for 4 weeks. By using the RHS color chart, the range of colors developed on dyed materials was measured. The result showed that different dyeing repetitions and the combination of those with color reinforcement materials had a great effect on the color formation of cloth by the mixed fungi dyes. The optimum condition of cloth dyeing by the fungal dyes depends on color reinforcement materials used. The combination of dyeing repetition and color reinforcement materials on the color formation of cloth by the fungal dyes generated various colors, adding a color variation on textile dyeing.

1. Introduction
The textile coloring process initially uses natural dyes. Along with the development of the era, however, synthetic dyes are widely used for coloring textiles because synthetic dyes are easy to obtain, cheap in price, simple in their use, and have varying colors. The use of synthetic dyes, however, is toxic and can cause environmental pollution. This is caused by the rest of the dyeing process of synthetic compounds which are difficult to degrade and will be persistent in nature so that it can adversely affect humans. The use of natural dyes then gets a place back in the textile coloring process.

Fungal dyes are alternative natural dyes that need to be developed. Youssef et al. [1] informed that dyes from fungi show non-toxic and biodegradability. Sharma et al. [2] reported that dyes from many fungi were stable, such as anthraquinone. Previous research reported that dyes produced by mixed fungi of Aspergillus and Paecilomyces successfully dye cotton cloths [3]. However, the effect of dyeing repetition, mordant, and other color reinforcement materials on cotton cloth color by the fungal dyes is unknown.

Dyeing repetition is a component of factors that can influence the direction and color of the cloth produced [4]. Littlegreendot [5] informed that dyeing repetition intends to obtain darker color than the previous dyeing and the color resistance to the material is better so that it does not fade easily. Further reported that to obtain darker colors, the cloth would be submerged up to 2-3 times, while Expats [6] reported that dyeing can be done 8-10 times a day. The final hue depended on how long the cloth was soaked in the dye bath and how often it was dipped.
Mordant also reported as a component of factors that influence the direction and color of the cloth produced [7]. Various colors and color levels produced on the cloths when a single dye added with different mordants [7; 8]. Some mordants that are ecologically safe and environmentally friendly are alum, ferrous sulfate, and limestone [9].

Some additives such as alkali, acid, and salts; or others are also often added to the dyes to get the desired color. Burch [10] informed that vinegar is used to lower the pH of a dye bath, while soda ash is to increase the pH of a dye bath. Anonymous [11] reported that alkaline dyes used to dye cellulose fibers, such as cotton, while acid dyes used to dye protein fibers, such as silk and wool. Chairat et al. [12] informed that salt aids in the dyeing process by helping to drive the dye into the fiber.

The study aimed to evaluate the effect of dying repetition and the combination of those with color reinforcement materials on cotton cloth color dyed with the dyes of mixed Aspergillus and Paecilomyces.

2. Materials and Methods
The chemicals used in this study are alum (KAl(SO₄)₂·12H₂O), CaCl₂·2H₂O, CuSO₄·5H₂O, ferrous sulfate (FeSO₄·7H₂O), glucose, H₃BO₃, KCl, lime (CaCO₃), MgSO₄·7H₂O, MnSO₄·H₂O, NaH₂PO₄, Na₂MoO₄·2H₂O, NaNO₃, Potato Dextrose Agar (PDA), salt (NaCl), soda ash (Na₂CO₃), vinegar, and ZnSO₄·7H₂O, while the other ingredients used in the research are cup glass, cotton cloth, detergent, Erlenmeyer, measuring cup, muslin cloth, Petri dish, stove, and test tube.

2.1. Inoculation process
The method of Suciatmih et al. [3] was used for the mixed fungi consisting of Aspergillus and Paecilomyces inoculation process, while the production medium of dyes used was a medium of mineral salt glucose [13]. After one month of incubation, the culture was passed through five layers of cheesecloth, and the filtrate was centrifugated at 8500 rpm for 20 min as performed previously [14]. The optical density of the filtrate was determined by spectrophotometre (Shimadzu) at 530 nm for quantifying the dyes [14]. The dyes' yield was calculated as OD units (UA530).

2.2. Dyeing
Cloth (4 cm × 4 cm or 0.24 g) without color reinforcement materials or control was dipped in the fungal dyes with a ratio of 1: 30 w/v (material: coloring) at 90°C for 15 minutes, lifted, squeezed, and dried at room temperature. According to the treatment, the colored cloth dyed again in the dyes at the same temperature and time. Furthermore, the colored cloth lifted, squeezed, soaked in 1% detergent for 10 minutes while stirring, rinsed with water, and dried at room temperature. There were three treatments for dyeing repetition, namely 1) Three times repeated dyeing; 2) Six times repeated dyeing; and 3) Nine times repeated dyeing.

Cloth added with color reinforcement materials using a meta or simultaneous-mordanting technique. The ratio used for meta-mordanting was 1 ml of each 2% mordants or other color reinforcement materials mixed with 30 ml of the dyes and 1 g of cloth dipped therein at 90°C for 15 minutes. The colored cloth then lifted, squeezed, soaked in 1% detergent for 10 minutes while stirring, rinsed with water, and dried at room temperature. Different dyeing repetitions (3, 6, and 9 times) combined with different mordants (alum, ferrous sulfate, and lime) or other color reinforcement materials (salt, soda ash, and vinegar) or combination between mordants and other color reinforcement materials were analyzed. The color of cloth after dyeing from each treatment was determined by the RHS color chart [15]. Each treatment of the study repeated twice.

3. Results and Discussion
The mixed fungi of Aspergillus and Paecilomyces grew on mineral salt glucose medium produced a greyed-purple 187A dye with an absorbance of 4.67 UA/L. The result is in line with Suciatmih et al. [3] that the same mixed fungi produced the same color. The fungal dyes are included in the group of...
substantive dyes because the dyes can directly stain textile fibers or will give good color when used alone [16].

The cloth color dyed with the fungal dyes on various dyeing repetitions (3, 6, and 9 times) without the addition of mordant or other color reinforcement materials (control) is presented in tables 1, 2, 3, 4, and 5. The dyeing repetition by the dyes without the addition of mordant or other color reinforcement materials produced varied colors on the cloths. This means that there is still the ability of cloth fibers to absorb the dyes. The dyeing repetition 3 times by the dyes on the control cloths produced a lighter color (187D greyed-purple) than the dyeing repetitions 6 and 9 times, each of which produced the same color, namely 187A greyed-purple. The results indicated that at the dyeing repetitions 6 and 9 times produced darker or older colors on the control cloths. Pujilestari [4] informed that when the dyeing process enters the maximum into the dyed material, it produced the color aging of textile materials. The more repetitions of dyeing, the more dyes were absorbed on the cloths. The cloth fibers began to saturate with the dyes in the dyeing repetition 6 times, so that the next dyeing (9 times) of cloth fibers did not have ability or ineffective to absorb the dyes. The cloth dyeing repetitions 6 and 9 times each produced the same color, namely 187A gray-purple. In other words, the optimum condition for the control cloth dyeing without the addition of mordant or other color reinforcement materials with the dye was 6 times.

The cloth color dyed by the dyes added with different dyeing repetitions (3, 6, and 9 times) and mordants (alum, ferrous sulfate, and lime) is presented in table 1. Cloth dyeing repeated as much as 3 and 6 times with the dyes was added with lime each produced the same lighter color (187D greyed-purple) than 9 times (187A greyed-purple). At 3 times, the cloth dyeing repetition with the dyes added with alum, it was obtained a lighter color (187C greyed-purple) than at the dyeing repetitions 6 and 9 times, each of which produced the same color (187A greyed-purple). Ferrous sulfate applied to the dyed cloth with the dyes as much as 3 times produced a lighter color (197A greyed-green) than at the dyeing repetitions 6 and 9 times, each produced the same color (202A black). The results indicated that the optimum condition for the dyeing of cloths with the dyes, each used alum and ferrous sulfate were carried out 6 times, while lime had to be done 9 times.

Depending on the metal character of mordants that play very important role in imparting color to the cloth, the complex formation not only strengthens dye fixation on the fibre but also modifies the final dye color [17]. Alum and lime each applied to the dyes combined with dyeing repetition did not change the cloth color or produced the same color with the control (greyed-purple respectively), while ferrous sulfate changed the cloth color or produced different colors with the control (greyed-green and black) (table 1). The addition of ferrous sulfate to the dyes gave a darker cloth color than alum and lime. The same results reported that ferrous sulfate produced dark colors on silk and wool fabric by *Eucalyptus* leaf dyes [18]; cotton cloth and polyester wool by *Ficus cunia* dyes [19]; and cotton cloth by fungal dyes [7]. Wikipedia [16] informed that iron mordant (ferrous sulfate) produces ‘sadden’ color, while alum mordant performs brighter color.

**Table 1.** Color formation on cloth by the fungal dyes with different dyeing repetitions and mordants

| Dyeing repetition/mordant | Alum | Ferrous sulfate | Lime | Control |
|---------------------------|------|----------------|------|---------|
| 3                         | 187C Greyed-purple | 197A Greyed-green | 187D Greyed-purple | 187D Greyed-purple |
| 6                         | 187C Greyed-purple | 197A Greyed-green | 187D Greyed-purple | 187D Greyed-purple |
The combination of different dyeing repetitions (3, 6, and 9 times) and other color reinforcement materials (salt, soda ash, and vinegar) on the cloth color dyed by the dyes is presented in Table 2. Cloth dyeing repeated 3 times added with vinegar by the dyes produced a lighter color (187C greyed-purple) than 6 and 9 times, each of which obtained the same color, namely 200A brown. The addition of salt to the cloth dyeing repetitions 3, 6, and 9 times by the dyes, each produced the same color (187A greyed-purple). The cloth dyeing repetitions 3 and 6 times added with soda ash by the dyes yielded the same cloth brighter colors (201C grey) than at 9 times (201A grey). The results showed that the optimum condition for dyeing repetition on the cloth by the dyes using vinegar, salt, and soda ash were 6, 3 and 9 times, respectively. It means the optimum condition for the cloth dyeing repetition by the dyes using salt was better than vinegar and soda ash. Chowdhury [20] reported that the addition of salt (as an electrolyte) to the dye solution is to assist the exhaustion of dye. This electrolyte neutralize the negative charge formed in the fiber surface and put extra energy to increase dye absorption. Chairat et al. [12] informed that the amount of dye adsorbed per gram of cotton (mg/g cotton) at equilibrium time (qe) was found to be approximately 18 and 10 mg/g cotton in the presence and absence of salt respectively.

Table 2. Color formation on cloth by the fungal dyes with different dyeing repetitions and other color reinforcement materials

| Dyeing repetition/other color reinforcement material | Salt            | Soda ash        | Vinegar         | Control         |
|-----------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| 3                                                   | 187A Greyed-purple | 201C Grey       | 187C Greyed-purple | 187D Greyed-purple |
| 6                                                   | 187A Greyed-purple | 201C Grey       | 200A Brown      | 187A Greyed-purple |
| 9                                                   | 87A Greyed-purple | 201A Grey       | 200A Brown      | 187A Greyed-purple |

Color reinforcement materials combined with dyeing repetition produced an unequal response in binding the dyes so that influenced the direction of color. Salt (at all of the dyeing repetitions) and vinegar (at the dyeing repetition 3 times) each applied to the dyes did not change the cloth color or
produced the same color with the control (greyed-purple respectively), while vinegar (at the dyeing repetitions 6 and 9 times) (each brown) and soda ash (at all of the dyeing repetitions) (each grey) changed the cloth color or produced different colors with the control (greyed-purple) (table 2). Burch [10] reported that vinegar added to the dyes causes the pH of the dye to be acidic, while soda ash to be alkaline. Our previous study [14] obtained that a single dye source (the same mixed fungi dyes) added with different dyeing pH (3, 7, and 9) produced different colors and tones on the cloth. It could be attributed to the changes in the dyes in the dyeing process. The dyes under strong acidic conditions (pH 3) are violet reddish, while if the pH rises above 3, the dyes gradually change from red-violet to violet. At the pH above 5, the dyes are dark violet, while with increasing pH, the color turns to bright violet.

Table 3. Color formation on cloth by the fungal dyes with different dyeing repetitions and mordants combined with vinegar

| Dyeing repetition/combination between mordant and vinegar | Dyed cloth color |
|----------------------------------------------------------|------------------|
|                                                          | Alum x Vinegar   | Ferrous sulfate x Vinegar | Lime x Vinegar | Control |
| 3                                                        | 187C Greyed-purple | 197A Greyed-green       | 187D Greyed-purple | 187D Greyed-purple |
| 6                                                        | 187A Greyed-purple | 202A Black               | 200A Brown       | 187A Greyed-purple |
| 9                                                        | 187A Greyed-purple | 202A Black               | 200A Brown       | 187A Greyed-purple |

The cloth color dyed by the dyes added with dyeing repetitions (3, 6, and 9 times) and mordants (alum, ferrous sulfate, and lime) combined with vinegar is presented in table 3. The same darker colors appeared on the dyed cloth as much as 6 and 9 times by the dyes using the mixture of lime and vinegar (each 200A brown), alum and vinegar (each 187A greyed-purple), and ferrous sulfate and vinegar (each 202A black). The results indicated that the optimum conditions of the cloth dyeing by the dyes added with the combination of lime and vinegar, alum and vinegar, and ferrous sulfate and vinegar were 6 times, respectively.

Different dyeing repetitions and mordants combined with vinegar influenced the brightness and direction of color. The same cloth color was obtained when the dyes treated with the combination of the dyeing repetitions, alum, and vinegar (187C, 187A & 187A greyed-purple); and the dyeing repetitions and alum (187C, 187A & 187A greyed-purple); the combination of the dyeing repetitions, ferrous sulfate, and vinegar (197A greyed-green, 202A & 202A black); and the dyeing repetitions and ferrous sulfate (197A greyed-green, 202A & 202A black); and the combination of the dyeing repetition 3 times, lime, and vinegar (187D greyed-purple); and the dyeing repetition 3 times and lime (187D greyed-purple); while different cloth colors each were produced by the combination of the dyeing repetitions 6 and 9 times, lime, and vinegar (each 200A brown); and the dyeing repetitions 6
and 9 times and lime (187D & 187A greyed-purple) (tables 1 & 3). The studies indicated that the addition of vinegar to the combination of the dyeing repetition and alum or ferrous sulfate was not necessary because it produced the same cloth color. Otherwise, the addition of vinegar to the combination of the dyeing repetition and lime was necessary because it produced different cloth colors.

The cloth color dyed by the dyes added with dyeing repetitions (3, 6, and 9 times) and mordants (alum, ferrous sulfate, and lime) combined with salt is presented in Table 4. The dyed cloth 6 and 9 times by the dyes, each was added with the mixture of lime and salt (each 187C greyed-purple), alum and salt (each 187C greyed-purple), and ferrous sulfate and salt (each 202A black) produced darker colors than the replication of dyeing as much as 3 times (187D greyed-purple; 187D greyed-purple; and 197A greyed-green respectively). The results indicated that the optimum condition of the cloth dyeing by the dyes added with the mixture of mordant (alum, ferrous sulfate, and lime) and salt were enough performed 6 times.

Different dyeing repetitions and mordants combined with salt influenced the brightness and direction of color. The same cloth color was obtained when the dyes each added with the combination of the dyeing repetitions, ferrous sulfate and salt (197A greyed-green, 202A black & 202A black); and dyeing repetition and ferrous sulfate (197A greyed-green, 202A black & 202A black); and the combination of the dyeing repetition 3 times, lime, and salt (187D greyed-purple); and the dyeing repetition and lime (187D greyed-purple); while the combination of the dyeing repetitions 6 and 9 times, lime, and salt (187C greyed-purple); and the dyeing repetitions 6 and 9 times and lime (187D & 187A greyed-purple); and the combination of the dyeing repetitions, alum, and salt (187D, 187C & 187C greyed-purple), and the dyeing repetitions and alum (187C, 187A & 187A greyed-purple) each produced different cloth colors (tables 1 & 4).

**Table 4.** Color formation on cloth by the fungal dyes with different dyeing repetitions and mordants combined with salt

| Dyeing repetition/combo. between mordant and salt | Dyed cloth color |
|-----------------------------------------------|-----------------|
|                                               | Alum x Salt | Ferrous sulfate x Salt | Lime x Salt | Control |
| 3                                             | 187D Greyed-purple | 197A Greyed-green | 187D Greyed-purple | 187D Greyed-purple |
| 6                                             | 187C Greyed-purple | 202A Black | 187C Greyed-purple | 187A Greyed-purple |
| 9                                             | 187C Greyed-purple | 202A Black | 187C Greyed-purple | 187A Greyed-purple |

The studies showed that the addition of salt to the combination of the dyeing repetition and ferrous sulfate was not necessary because it produced the same color, while to the combination of the dyeing repetition and lime or alum was necessary because it produced different cloth colors. The cloth color dyed by the dyes with the combination between dyeing repetitions (3, 6, and 9 times) and mordants (alum, ferrous sulfate, and lime) combined with soda ash is presented in Table 5. The colors of 201A
grey and 187A greyed-purple appeared on the cloths with the dyeing repetition as much as 6 and 9 times by the dyes when were added with each the mixture of lime and soda ash; and alum and soda ash. The colors were stronger or darker than the colors produced by the dyeing repetition 3 times, which were 187D greyed-purple respectively. The same color (201B grey) was obtained on the cloth dyed by the dyes added with the mixture of ferrous sulfate and soda ash repeated as much as 3, 6, and 9 times. The results indicated that the optimum condition of the cloth dyeing by the dyes using the mixture of lime and soda ash, alum and soda ash, as well as ferrous sulfate and soda ash were performed 6, 6, and 3 times respectively. Different dyeing repetitions and mordants combined with soda ash influenced the brightness and direction of color. The same cloth color (each 187A greyed-purple) was obtained when the dyes each added with the combination of the dyeing repetitions 6 and 9 times, alum, and soda ash; and the dyeing repetitions 6 and 9 times and alum; and the same cloth color (187D greyed-purple) was also produced when the dyes each added with the combination of the dyeing repetition 3 times, lime, and soda ash; and the dyeing repetition 3 times and lime. While the combination of the dyeing repetitions 6 and 9 times, lime, and soda ash (each 201A grey), and the dyeing repetitions 6 and 9 times and lime (187D & 187A greyed-purple); the combination of the dyeing repetitions, ferrous sulfate, and soda ash (each 201B grey); and the dyeing repetitions and ferrous sulfate (197A greyed-green, 202A black and 202A black); and the combination of the dyeing repetition 3 times, alum and soda ash (187D greyed-purple); and the dyeing repetition 3 times and alum (187C greyed-purple) each produced different cloth colors (tables 1 & 5). The studies indicated that except for the dyeing repetition 3 times, the addition of soda ash to the combination of the dyeing repetitions 6 and 9 times and alum was not necessary because it produced the same cloth color, while to the combination of the dyeing repetition and lime or ferrous sulfate was necessary because it produced different cloth colors.

**Table 5.** Color formation on cloth by the fungal dyes with different dyeing repetitions and mordants combined with soda ash

| Dyeing repetition/ combination between mordant and soda ash | Dyed cloth color |
|-------------------------------------------------------------|------------------|
|                                                             | Alum x Soda ash | Ferrous sulfate x Soda ash | Lime x Soda ash | Control |
| 3                                                           | 187D Greyed-purple | 201B Grey | 187D Greyed-purple | 187D Greyed-purple |
| 6                                                           | 187A Greyed-purple | 201B Grey | 201A Grey | 187A Greyed-purple |
| 9                                                           | 187A Greyed-purple | 201B Grey | 201A Grey | 187A Greyed-purple |

4. Conclusion
For this study, a mixed *Aspergillus* and *Paecilomyces* grown on the medium of Backer and Tatum (1998) produced a potential dyes that can be used in the textile industry. The application of color
reinforcement materials and dyeing repetition on color formation of cloth with mixed fungi dyes generated various colors, adding a color variation on textile dyeing. The optimum condition of the cloth dyeing by the fungal dyes added with salt was enough done 3 times, with lime and soda ash each was 9 times, while with alum, ferrous sulfate, and vinegar each was 6 times. Furthermore, except for the mixture of ferrous sulfate and soda ash (3 times), the optimum condition of the cloth dyeing by the dyes added with different mordants combined with different other color reinforcement materials each was enough done 6 times. Ferrous sulfate, soda ash, and vinegar (6 and 9 times) each added to dyeing repetition produced different cloth colors with the control, while other reinforcement materials did not. To get various cloth colors, salt, soda ash, and vinegar each should be added to the combination of the dyeing repetition and lime; soda ash to the combination of the dyeing repetition and ferrous sulfate; and salt to the combination of the dyeing repetition and alum.

Acknowledgment
The authors are grateful to the Research Center for Biology, Indonesian Institute of Sciences (LIPI) for providing the laboratory facilities; and Ety Suryati and Nurma Nurjanah (the technicians of Microbiology Division, Research Center for Biology – LIPI) for assisting in the study.

5. References
[1] Youssef MS, El- Maghraby OMO and Ibrahim YM 2008 Production of textile reddish brown dyes by fungi International Journal of Botany 4: 349-360
[2] Sharma D, Gupta C, Aggarwal S and Nagpal N 2012 Pigment extraction from fungus for textile dyeing. Indian Journal of Fibre and Textile Research 37: 68-73
[3] Suciatmih, Nurfianti and Magfirani SV 2018 Coloring properties assessment of dyes produced by mixed Aspergillus and Paecilomyces IOP Conf. Ser.: Earth and Environ. Sci 166(1): 20-23
[4] Puji lestari T 2017 Optimasi pencelupan kain batik katun dengan pewarna alam tingi (Ceriops tagal) dan Indigofera sp. Dinamika Kerajinan dan Batik 34(1): 53-62
[5] Littlegreen dot How to dye fabric with natural dyes http://www.littlegreen dot.com [Accessed on May 14, 2020]
[6] Expats…..for Expats Batik, the traditional fabric of Indonesia - Living in Indonesia http://www.exp at.or.id [Accessed on May 14, 2020]
[7] Suciatmih and Hidayat I 2017 Effect of different mordants on cotton cloth dyed with Aspergillus and Penicillium dyes. Aceh International Journal of Science and Technology 6(1):19-28
[8] Velmurugan P, Kim MJ, Park JS, Karthikeyan K, Lakshmanaperumalsamy P, Lee KJ, Park YJ and Oh BT 2010 Dyeing of cotton yarn with five water soluble fungal pigments obtained from five fungi Fibers and Polymers 11: 598-605
[9] Failisnur F, Sofyan S, Kasim A and Angraini T 2018 Study of cotton fabric dyeing process with some mordant methods by using gambier (Uncaria gambir Roxb) extract International Journal on Advanced Science Engineering Information Technology 8(4): 1098-1104
[10] Burch P 2016 All about hand dyeing www.pburch.net [Accessed on May 14, 2020]
[11] Anonymous 2011 What is the effect of pH in dyeing? What is the optimal pH? [Online] http://www.pburch.net/dyeing/FAQ/ph.shtml [Accessed on April 2nd, 2017]
[12] Chairat M, Bremmer JB, Samosorn S, Sajomsang W, Chongkraijak W and Saisara A 2015 Effects of additives on the dyeing of cotton yarn with the aqueous extract of Combretum latifolium Blume stems Coloration Technology 131(4): 310-315
[13] Baker RA and Tatum JH 1998 Novel anthraquinones from stationary cultures of Fusarium oxysporum Journal of Fermentation and Bioengineering 85(4): 359-361
[14] Suciatmih 2020 Combination of culture and dyeing conditions on cloth color dyed with mixed fungi dyes Journal of Biological Researches 25(2): 18-26
[15] The Royal Horticultural Society 1966 R.H.S. Colour Chart (London: The Royal Horticultural Society)
[16] Wikipedia Natural dye http://en.m.wikipedia.org [Accessed on May 14, 2020]
[17] Uddin MG 2014 Effects of different mordants on silk fabric dyed with onion outer skin extracts Journal of Textiles article ID 405626, pp. 1-8 http://dx.doi.org/10.1155/2014/405626
[18] Mongkolrattanasit R, Kryštůfek J, Wiener J and Viková M 2011 Dyeing, fastness, and UV protection properties of silk and wool fabrics dyed with Eucalyptus leaf extract by the exhaustion process Fibres and Textiles in Eastern Europe 19(3): 94-99
[19] Kundal J, Singh SV and Purohit MC 2016 Extraction of natural dye from Ficus cunia and dyeing of polyester cotton and wool fabric using different mordants, with evaluation of colour fastness properties Natural Products Chemistry and Research 4: 214
[20] Chowdhury TA 2014 Concentration of soda ash: An imperative factor for rubbing fastness of reactive dyed knit fabric Research Journal of Social Science and Management 4(2): 15-19