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WASHFASTNESS PROPERTIES OF DYED PINEAPPLE LEAF FIBRE USING DIFFERENT DYEING TECHNIQUES

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Abstract

Pineapple leaf is categorised as natural fibre resources hence creating an initiative to reduce usage of synthetic fibre. Pineapple fruits commercially have high demand in the industry causing the leaves discarded as agricultural waste. As an alternative to reduce the waste, fibres from pineapple leaf were extracted and dyed to improve the aesthetic value of pineapple leaf fibre by adding dyeing substrates using low energy consumption approach. This research is the first step towards more profound understanding on the nature of colourfastness properties pineapple leaf dyed fibre in addition on the improvement of dyeing behaviour properties. This method could further be refined by considering the production of textile materials, which can provide alternative on the usage of highly expensive silk fibres in the *songket* making industry. Two different methods of dyeing were used to analyse the colourfastness properties of pineapple leaf fibres. Pineapple leaf fibre was extracted using mechanical extraction. The fibres were manually extracted by water retting process and dried at room temperature prior to dyeing. Red reactive dye was applied to the pineapple leaf fibres using infrared dyeing machine and exhaustion dyeing machine. Both dyeing techniques displayed interesting colour findings, where infrared dyeing with golden shade and exhaustion dyeing with a reddish shade. Both dyeing techniques gave excellent colourfastness to washing with the moderate performance of change in colour.

Keywords: pineapple leaf fibre, infrared dyeing, exhaustion dyeing, colourfastness properties, washing

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Introduction

Sustainable natural fibres have significant characteristics and value in the textile industry. Manufacturers in the textile field begin to implement their production lines and material sources in greener ways due to the raising awareness among costumers on environmental issues. Leaf fibre was classified as natural fibres commonly marketed by mankind for thousands years (Balakrishnan et al., 2019). In Malaysia, the agricultural industry focuses on finding suitable land nationwide to meet vast demands for the fruits. It was reported that the Deputy Minister of Agriculture and Food Industries said Malaysia's pineapple industry was booming rapidly with RM491 million for last year pineapple-based product exportation (Shah, 2020). Usually after harvesting season, the pineapple leaf can be found abundantly in the waste area. Hence, the pineapple leaf waste was increased along with the demand from its fruits. This is a well-recognized issue which necessitates a better approach.

Pineapple, also called pina is a fibre produced from the leaves, which is categorized as perennial bromeliad crop. Pineapple leaf fibre is white, smooth and glossy as silk. It has good blending properties with other natural and synthetic fibre. This distinction is further exemplified in studies that stated fibre from pineapple plant poses preferable properties for blending with jute, ramie and cotton fibres along with synthetic fibres (Banika et al., 2011). Additionally, the fibre sources obtained from the pineapple leaves plant can be processed into variable value-added products such as cloth, textile products, sport equipment and paper products (Asim et al., 2015). Pineapple leaf fibre is also used as potential reinforcement in the variety of thermoset, thermo-plastic, biodegradable polymer composites and rubber (Salleh, 2015). The fibre contained in pineapple leaf lies in the range of ~2.5 – 3.5%, covered by a hydrophobic layer that persists below the waxy surface (Banika et al., 2011).

Across the different country, it makes its own uses. Pineapple leaf fibre is utilised for making garments and sometimes incorporate with silk or polyester to create textile materials. Lower cost extraction of natural lignocellulosic fibres, suchlike pineapple leaf fibre in tropical regions, bring a new chance to discover their practical use as reduced-cost of raw resources (Mat Nayan et al., 2014). Pineapple fibre easily retains dyes. Hence, a proper approach to increase the aesthetic properties of pineapple leaf fibre must come to a realisation. Dyeing pineapple leaf fibre could enhance the pineapple properties to place it in a large market.

Dyes can be categorised as substances that, when applied to a substrate, produce colour shade through a process which alters the crystal structure of the coloured substances, at least temporarily (Bafana et al., 2011). Reactive dyeing reacts with fibre molecules to form a chemical compound. Reactive dyes are the most popular type for cellulose-based material (Chen et al., 2013). It comprises a reactive system which involves one or more electrophilic groups enabling the dyes to form a covalent bond with nucleophilic hydroxyl groups in the cellulosic substrate (Burkinshaw & Salihu, 2019).

Technically, there are various methods of dyeing. Exhaustion dyeing includes two processes, which are exhaustion and fixation (Chattopadhyay, 2011). The whole process primarily explains by immersing the textile substrate in dye-bath, applying several parameters i.e. time, dyeing temperature profile and chemical to drive into the textiles. Infrared (IR) dyeing is a technique of dyeing textile substrates using thermal infrared heating. The performance is said to be stable and reliable, energy-saving and environmentally friendly (Lux et al., 2019), no fumes, no glycerine for heat conduction, no use of water for cooling, energy saving and cost effective (Kappe & Dallinger, 2009). The objective of this research work is to analyse the colourfastness properties of pineapple leaf fibre using infrared dyeing technique in comparison with exhaustion dyeing technique. Pineapple leaf fibre was extracted through mechanical extraction. The extracting method involves water retting to soften the fibre and scraping the waxy layer of pineapple leaf to remove the fibre. Red reactive dyes were applied to pineapple leaf fibre using both techniques. In addition, colourfastness to washing in term of colour change and staining evaluation were carried out for both techniques to examine the colourfastness properties of pineapple leaf fibres.

Methods

Preparation of pineapple leaf fibre

Pineapple leaves were collected at Seri Menanti Farm Valley, Negeri Sembilan as shown in Figure 1. The leaves gained were cleaned and retted to soften the fibres and the inner part of the fibres were removed. The pineapple leaves were soaked in a water-filled container for 24 hours and extracted fibres were dried in the oven at 70ºC.

Figure 1. Seri Menanti Valley Farm

The extraction process was conducted using a mechanical extraction method to remove the waxy layer as shown in Figure 2. Rubber mallet was used for crushing the waxy layer on pineapple leaves. Then, scrapping tool was used to completely scratched the waxy layer leaving its fibres exposed beneath the pineapple leaf. Combing was performed after the oven-drying process to separate the fibres into single fibre.

Figure 2. Extraction process of pineapple leaf fibres

Dyeing techniques

There are two dyeing processes involve in this research which are exhaustion dyeing and infrared dyeing technique.

A. Exhaustion dyeing

The dyeing liquor ratio was 1:20 (fibre ratio to dye liquor). Approximately 5g of pineapple leaf fibres (PALF) were dyed with MX Basic Red 310N 11b Procion MX reactive dyes in red colour with 1.0% concentration. The dyeing process was performed at 90ºC for 60 mins by using exhaustion dyeing machine (Figure 3). The dyed PALF sample was immersed in the dye solution containing sodium hydroxide (60 g/L) and sodium carbonate (20 g/L) as a mordanting agent. Next, the dyed PALF was rinsed with tap water and air-dried. The colourfastness properties to washing of dyed PALF was evaluated in accordance with ISO 105 C10:2006 standard method.

Figure 3. Exhaustion dyeing machine

B. Infrared (IR) dyeing

Approximately 5g of pineapple leaf fibres were soaked in a dye pot containing 1:20 (fibre ratio to dye liquor) stock solution ratio. MX Basic Red 310N 11b Procion MX reactive dye in red colour was used to dye the fibres. The dyeing process was carried out using a laboratory infrared dyeing machine (Figure 4). Sodium hydroxide (60 g/L) and sodium carbonate (20 g/L) were also added as part of the dyeing mixture. The temperature of dyebath was steadily increased up to 90^{O}C for 60 mins throughout the process. The temperature was constant in 90^{o}C while the dye pot was rotated at 45 rpm for the designated shade depth. The dyeing concentration was constantly observed at 1.0% shade depth. Finally, the samples were air-dried and assessed for colourfastness properties to washing.

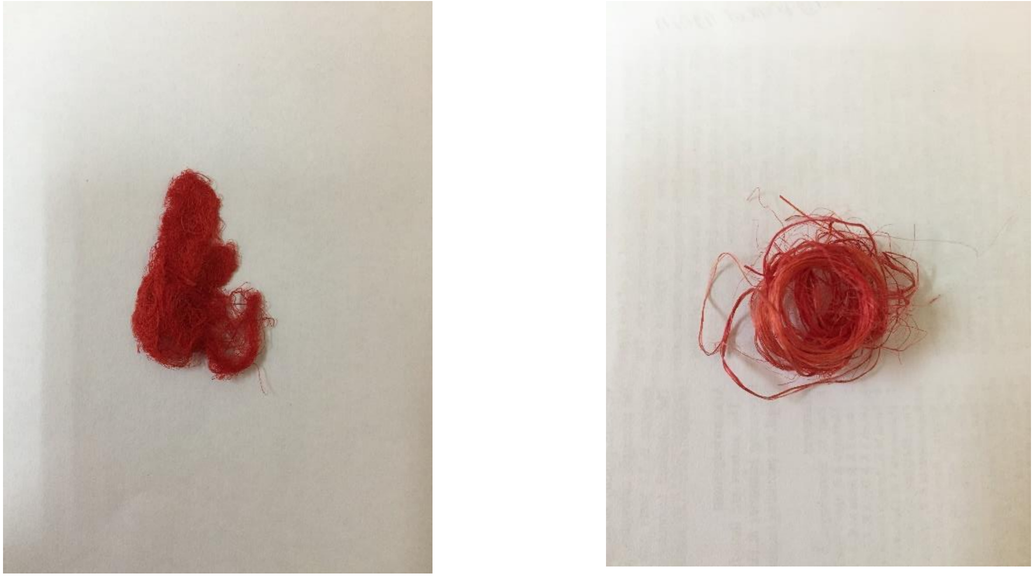
Figure 4. Infrared dyeing machine

Analysis of colourfastness to washing

Process of colourfastness to washing was conducted according to ISO 105 C10:2006 (ISO, 2006) standard method by Gyrowash, a washfastness testing machine. The dyed PALF in contact with cotton and silk as adjacent fabrics was agitated in 30 minutes at 40$\pm$2^{o}C in standard soap and sodium carbonate solution. Staining evaluation was performed according to ISO 105-A03:2019 (ISO, 2019). Colour changing assessment was evaluated according to ISO 105-A02:1993 (ISO, 1993).

Result and Discussion

Figure 5 has shown the colour shade depth of dyed pineapple leaf fibre samples at 1.0% concentration by two different method of dyeing. The figure indicates pineapple leaf fibres dyed with IR dyeing machine in the Figure 5(A) and pineapple leaf fibre dyed with exhaustion dyeing in the Figure 5(B). It was visually observed that IR dyeing method has more effect in colour shade depth as compared to exhaustion dyeing method despite similar dyeing concentration used. Moreover, stronger and darker colour shade obtained using IR dyeing method. The colour of the dyed PALFs were different to each other due to different dyeing techniques approached.



(a) (b)

Figure 5. The colour shade depth of dyed pineapple leaf fibres for (a) infrared dyeing (1.0%) and (b) exhaustion dyeing (1.0%)

Fibre dyed using exhaustion dyeing yields reddish shade, while golden shade for infrared (IR) dyeing after washing as shown in Figure 6. Different shade in IR dyeing after washing process probably due to the infrared wave used although the dye is red in colour beforehand. This result gives unique colour hue of selected dye.

(a) (b)

Figure 6. Colour change of pineapple leaf fibres for a) Infrared dyeing machine and b) Exhaustion dyeing machine

The overall evaluations of the colourfastness to washing results are depicted in Table 1. Both exhaustion and IR dyeing techniques showed moderate resistance to colour change due to washing. Pineapple leaf fibres dyed with exhaustion dyeing showed very good to excellent resistance to staining on cotton and silk adjacent fabrics. Hence, the result showed good fixation of dye towards the pineapple leaf fibre for both dyeing techniques. Meanwhile, pineapple leaf fibres dyed with IR dyeing showed excellent resistance to staining on both cotton and silk composite fabric. This may be caused by more dye molecules were diffused and fixed in the fibre molecules, making the colour retained.

Table 1. Colourfastness to washing of the PALF dyed with reactive dye

Dyeing conditions		Colour change (rating)	Staining		PALF
Method	**Concentration (%)**		**Silk**	**Cotton**	
Exhaustion dyeing	1.0	3 (moderate)	4/5 (excellent)	4 (very good)	
Infrared (IR) dyeing	1.0	3 (moderate)	4/5 (excellent)	4/5 (excellent)	

Conclusion

Pineapple leaf fibres were dyed with reactive dye to generate commercialised and coloured textile materials. This research has indirectly showed that pineapple leaf fibre can be dyed using reactive dyes through both dyeing methods. The pineapple leaf fibre significantly showed moderate colour yield from both dyeing techniques. However, dyeing pineapple leaf fibre using infrared dyeing techniques resulted in more variation (golden shade) of colour produced compared to exhaustion, which could only produce certain shade of colour. Silky, soft and lustrous pineapple leaf fibres have high potential to be used in textile and clothing industries. Therefore, dyeing pineapple leaf fibre are essential as it enhance the usage of this fibre. Different dyeing techniques used gives additional options to dyeing industry to have more options in dyeing technique and also colour yield. Despite reduction in cost, water and electricity consumption, the different colour hue yielded using infrared dyeing confirmed the benefit of IR dyeing, where golden shades can be obtained using reactive red dye. Excellent colourfastness to washing also allow the dyed fibre to be converted to a good dyed yarn, fabric and garment.

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References

Asim, M., Abdan, K., Jawaid, M., Nasir, M., Dashtizadeh, Z., Ishak, M. R., & Hoque, M. E. (2015). A Review on Pineapple Leaves Fibre and Its Composites. *International Journal of Polymer Science, 2015*, 1-16. doi: 10.1155/2015/950567

Bafana, A., Devi, S. S., & Chakrabarti, T. (2011). Azo dyes: past, present and the future. *Environmental Review, 19* ((NA)), 350-371. doi: https://doi.org/10.1139/a11-018

Balakrishnan, S., Wickramasinghe, G. L. D., & Wijayapala, U. G. S. (2019). Study on dyeing behavior of banana fiber with reactive dyes. *Journal of Engineered Fibers and Fabrics, 14*, 155892501988447. doi: 10.1177/1558925019884478

Banika, S., Nag, D., & Debnath, S. (2011). Utilization of pineapple leaf agro-waste for extraction of fibre and the residual biomass for vermicomposting. *Indian Journal of Fibre & Textile Research 36*, 172-177.

Burkinshaw, S. M., & Salihu, G. (2019). The role of auxiliaries in the immersion dyeing of textile fibres: Part 9 practical aspects of the role of inorganic electrolytes in dyeing cellulosic fibres with pure reactive dyes. *Dyes and Pigments*, *161*, 628-641. doi: 10.1016/j.dyepig.2017.10.014

Chattopadhyay, D. P. (2011). Chemistry of dyeing. *In Handbook of textile and industrial dyeing*. Woodhead Publishing. pp. 150-183.

Chen, Q., Zhao, T., Wang, M., & Wang, J. (2013). Studies of the fibre structure and dyeing properties of Calotropis gigantea, kapok and cotton fibres. *Coloration Technology, 129*(6), 448-453. doi: 10.1111/cote.12051

Kappe, C. O., & Dallinger, D. (2009). Controlled microwave heating in modern organic synthesis: highlights from the 2004-2008 literature. *Mol Divers, 13*(2), 71-193. doi: 10.1007/s11030-009-9138-8

International Organization for Standardisation. (1993). Tests for coloured textiles and colorants – *Requirements with guidance for use* (ISO Standard No. 105-A02:1993). https://www.iso.org/standard/3785.html.

International Organization for Standardisation. (2006). Tests for coloured textiles and colorants – *Requirements with guidance for use* (ISO Standard No. 105-C10:2006). https://www.iso.org/standard/31775.html.

International Organization for Standardisation. (2019). Tests for coloured textiles and colorants – *Requirements with guidance for use* (ISO Standard No. 105-A03:2019). https://www.iso.org/standard/75985.html.

Lux, C., Lubio, A., Ruediger, A., Robert, S., & Muehlethaler, C. (2019). Optimizing the analysis of dyes by Surface-Enhanced Raman Spectroscopy (SERS) using a conventional-microwave silver nanoparticles synthesis. *Forensic Chemistry, 16*, 100186. doi: 10.1016/j.forc.2019.100186

Mat Nayan, N. H., Abd Razak, S. I., & Wan Abdul Rahman, W. A. (2014). Biopulping by Ceriporiopsis subvermispora towards Pineapple Leaf Fiber (PALF) Paper Properties. *Advanced Materials Research, 1043*, 180-183. doi: 10.4028/www.scientific.net/AMR.1043.180

Salleh, J., Yusoh, M.K., & Ruznan, W. S. (2015). Tensile Strength of Some Natural-Fibre Composites. *Pertanika Journal of Tropical Sciences, 38*(4), 575-582.

Shah, M., F. (2020). Govt to Expand Pineapple Cultivation with Booming Global Demand. The Stars. https://www.thestar.com.my/news/nation/2020/06/12/govt-to-expand-pineapple-cultivation-with-booming-global-demand. [Access online 30 October 2020].