ECO-PRINTING LEATHER QUALITY IN DIFFERENT MORDANT METHODS

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The leather coloring technique using the eco-printing method is carried out by transferring the colors and motifs of plants on the leather material by direct contact. This process requires mordant to maximize the color. The use of mordant is done in three ways, namely mordant is done at the beginning (pre-mordanting), mordant is done simultaneously (meta-mordanting), and mordant is done at the end (post-mordanting). This study aims to determine the quality of eco-printing leather with the implementation of different mordant methods. The research materials were 16 pieces of sheep's crust leather. The research treatment was using various mordant methods, namely pre-mordanting, meta-mordanting, and post-mordanting. Colorfastness, tensile strength, elongation, tear strength, flexibility, and fracture resistance were among the eco-printing leather qualities evaluated. The research was carried out in an experimental setting using a completely randomized design. To conclude, the best mordant method was carried out at the beginning of the eco-printing process on leather media (pre-mordanting), where the quality of eco-printing leather obtained of 5.44 ± 0.968 mm, crack resistance (distance) of 8.78 ± 0.97 mm, the tensile strength of 1743.64 ± 45.26 N/cm^2, leather elongation of 55.15 ± 10.26 %, tear strength of 268.24±132.49 N/cm, sewing strength of 1247.12 ± 649.91 N/cm, colorfastness of wet rubbing rated 4 (good), and dry rub of 4 (good).

Keywords: quality, eco-printing leather, crust leather

INTRODUCTION

Leather goods products are generally colored with synthetic materials. The advantages of synthetic coloring provide an attractive appearance, more varied colors, and is easy to work with. However, the use of synthetic dyes is not environmentally friendly because the waste from synthetic dyes can be dangerous, since some dyes can be degraded into carcinogenic and toxic compounds (Berhanu and Ratnapandian, 2017).

Therefore, the use of natural dyes for leather is increasingly in demand, for natural dyes have the advantage that they do not cause damage to the environment and do not have side effects on health. Furthermore, natural dyes are easier to find. Several studies of natural coloring on leather have been conducted using Henna leaf extract (*Lawsonia inermis*) (Musa *et al*., 2008), *Acacia catechu* extract (Pant and Gahlot, 2012), *Bixa orellana* seed extract (Selvi *et al*., 2016), *Tagetes erecta* L. flower extract (Marigold) (Pervaiz, 2017), and plant extract of *Osyris quadripartita* (Teklay and Kechi, 2017).

One of the natural colorings of leather can be done with the eco-printing method. This method is a natural coloring process that is different from what is commonly done by the community, because in addition to transferring color, it also produces natural forms that exist in plants (leaves and flowers), on the leather. The eco-printing method is used to decorate the surface of the skin with various shapes and colors (coloring) produced from natural materials (Izmal, 2016). Currently, eco-printing is widely used in textiles such as cotton, a combination of cotton and polyester, and a combination of cotton and Tencel (Izmal, 2016). Another study also compared the use of eco-printing on wool, silk, cotton, and flax (Rekabya *et al*., 2009).

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A study on eco-printing on leather media is still limited compared to cloth media. Ristiani and Isnaini (2019) reported that eco-printing can be done on sheep leather material, by steaming at a medium temperature of 80°C resulting in good average color rubbing resistance with a score of 4 and 4-5. Meanwhile, according to Pancapalaga *et al*. (2021), the use of aluminum potassium sulfate in the natural coloring of leather using the eco-printing will increase wet rubbing resistance, sweat resistance, and washing resistance and will not to reduce the color intensity of eco-printed leathers. Besides the type of mordant that determines the quality of the leather color, the eco-printing is also the mordant method.

Therefore, further study on the mordant methods needs to be done. Generally, there are three mordant methods used, pre-mordant (mordant at the beginning), meta mordant (mordant simultaneously), and post-mordant (mordant at the end). This study aims to determine the quality of eco-printed leathers by implementing different mordant methods and also to determine which mordant methods produce the best quality of eco-printed leathers.

EXPERIMENTAL

Materials

The main research material used was 16 pieces of sheep crust leathers. The crust materials were obtained from leather craftsmen in Yogyakarta. The mordant material was $Al_2(SO_4)_3$, while the natural dyes were obtained from castor bean leaves and mangrove bark.

Methods

The instruments used in this study included analytical scales, stainless steel knives, basins, measuring cups, pencils, scissors, thermometers, buckets, shoes, plastic, ropes, stoves, pans, and thermometers. It also had a crock meter to test wet and dry rubbing resistance. A universal testing machine was used for the tensile strength test. A strength tester was used for the elongation and tear strength of the leather. Softness tester 300 equipment was used to measure skin softness and lastometer was used to measure leather crack resistance.

Implementation of Eco-Printing Method Coloring

The eco-printed leather process used the method proposed by Pancapalaga *et al*. (2021). The crust leathers were soaked in water for 6 hours until the color became bluish. Then, the crust leathers were soaked at the beginning (T1) with a solution of mordant (aluminum potassium sulphate) with a ratio between water and mordant of 1: 1 for 12 hours. Meanwhile, leathers of the T2 treatment were soaked at the beginning and the end (meta-mordant). After soaking, the crust leathers were dried. After a bit dry, the crust leathers were spread out on the floor that had been given a plastic base. The surface of the crust leathers was given red (*Jatropha gossypiifolia)* leaves and covered with a cloth that had been colored naturally with mangrove trunk extracts (*Rhizophora mucronata*). Then, the leathers were rolled on a pipe and tied with a cloth, and steamed for 1 hour. After cooling, the leather bond was opened and the crust was soaked (post-mordant or T3) for 12 hours. Finally, the leathers were dried at room temperature followed by laboratory testing to determine the quality of the eco-printed leathers.

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Testing

The leather softness test was carried out according to ISO 17235 (2015). The eco-printing leather crack strength test was carried out according to ISO 3379 (2015). Tensile strength and leather elongation tests were carried out according to SNI. 06-1795-1990. The tear strength test was carried out based on SNI 06-1794-1990. The sewing strength test was carried out following SNI 06-1117-1989. The color fastness test due to dry and wet rubbing was carried out according to ISO 20433 (2012).

Data Analysis

The data of elasticity, crack resistance, tensile strength, elongation, tear strength, and sewing strength obtained were analyzed using ANOVA to determine the differences between each treatment. If the treatment has a significant effect, then Duncan's test was conducted as a follow-up. meanwhile, the color fastness to wet and dry rubbing was measured by assessing the color difference with the grayscale and rating it with marks from 1 to 5. The standard used was the standard issued by the International Standard Organization (ISO 20433:2012). The wet/dry rub fastness data obtained were tabulated and analyzed by the Kruskal Wallis test. To investigate the difference between treatments, it was continued by using the Mann-Whitney test.

RESULTS AND DISCUSSION

The leather color was transferred by direct contact of plant leaves and bark extract and steaming, with different mordant methods. The results of the influence of eco-printing processed leathers on physical and fastness resistances are presented below.

Table 1. The physical and fastness characteristics of eco-printed leathers

Mordant method	Softness (mm)	Crack resistance (distance) (mm)	Tensile strength (N/cm^2)	Elongation (%)	Tear strength (N/cm)	Sewing strength (N/cm)	Rubbing fastness	
							wet	dry
Pre-	5.44± 0.96^b	8.78± 0.97^a	1743.64± 745.26^a	55.15± 10.26^a	268.24± 132.49^b	1247.12± 249.91^a	4	4
Meta-	4.22± 0.33^a	8.76 ±0.57^a	1493.10± 603.98^a	59.64± 10.99^a	204.70± 55.10^{ab}	895.26± 148.96^b	3/4	3
Post-	4.30± 0.15^a	7.67 ±0.56^a	1137.65± 321.69^a	57.89± 10.44^a	144.48± 28.82^a	862.45± 157.70^b	3/4	3

Description: The notation followed by a different letter in one column indicates a significant difference ($P<0.05$).

Eco-Printed Leather Softness

Table 1 presents that the mordant method had a significant effect ($P<0.05$) on the eco-printing leather elasticity score. The highest eco-printing leather elasticity score produced by the mordant method was carried out by pre-mordant of 5.44 ± 0.96 mm while the lowest eco-printing leather elasticity was carried out by the meta-mordant method of 4.22 ± 0.33 mm. The high elasticity score in the pre-mordant method is because the leather soaked with the mordant before the dyeing process might provide an opportunity for the mordant to bind to the leather proteins. Thus, when the dye is applied, there is a maximum bond between the natural dye and the leather creating more elastic properties on the

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leather. According to Abu (2016), the pre-mordant process aims to increase the absorption of natural dyes on the media and produce good elasticity and color sharpness.

Eco-Printed Leather Crack Resistance

In contrast to eco-printing leather elasticity presented in Table 1, the mordant methods show no significant effect ($P>0.05$) on crack resistance (distance) for mordant methods did not change the leather skin structure and caused the skin density remains. Hasan *et al*. (2014) argue that the elasticity of tanned leather was influenced by water content, fat, fiber structure, and leather thickness. However, the data in Table 1 indicate that the highest eco-printing leather crack resistance value was produced by the pre-mordant of 8.78 ± 0.97 mm, while the lowest was produced by the post-mordant of 7.67 ± 0.56 mm. Mustakim *et al*. (2007) added that crack resistance of the leather is closely related to changes in the structure of leather collagen, changes in the structure of collagen bonds in the leather might cause the strength of the leather to increase. Thus, leather is not easy to crack due to the gelatinization process of leather fibers.

Tensile Strength and Elongation of Eco-Printed Leather

Similar to the crack resistance, the mordant method also showed no significant effect ($P>0.05$) on the tensile strength and elongation of the eco-printing leather due to the meta-mordant did not change the chemical composition of eco-printing leather. It indicates that the collagen fibers and the webbing corners are still intact during the immersion process with the mordant. In other words, the leather structure, especially the corium of the leather has been perfectly bonded during the tanning process. According to Triatmojo (2014), leather with high tensile strength generally has low elongation, while those with low tensile strength have high elongation.

This is evident in the tensile strength and elongation values of the eco-printing leather produced. The highest tensile strength value of the eco-printing leather produced by the pre-mordant method of 1743.64 ± 745.26 N/cm^2, while the lowest was by the post-mordant method of 1137.65 ± 321.69 N/cm^2. On the other hand, the lowest elongation score was in the pre-mordant method of 55.15 ± 10.26 (%), while the highest elongation was in the meta-mordant method of 59.64 ± 10.99 (%).

Eco-Printed Leather Tear Strength

The use of different mordant methods had a significant effect ($P<0.05$) on the tear strength of the eco-printing leather. The highest eco-printing leather tear strength score was found in the pre-mordant method treatment of 268.24 ± 132.49 N/cm. The high tear strength value was due to the perfect absorption of natural color into the leather’s collagen fiber cavities, thereby making the leather’s ability to withstand tearing loads better. However, at the post-mordant method, the value of the tear strength of the eco-printing leather decreased. This is presumably because the absorption of color by the leather has reached the maximum absorption limit. Hence, it causes a decrease in the value of the tear strength. Prabhu and Bhut (2012) suggest that the pre-mordant method with aluminum potassium sulphate showed the lowest color that came out after washing, indicating a very good complexing of aluminum with natural dyestuffs. It is also said that the basic chemical bond between natural dyes and mordant, of them, is the covalent bond between the hydroxyl oxygen and the Al^{3+} ions.

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Eco-Printed Leather Sewing Strength

In terms of the tear strength, the use of different mordant methods had a significant effect ($P<0.05$) on the sewing strength of eco-printing leather. This is probably due to the mordant method starting with the immersion of *aluminum potassium sulfate* causing an increase in acidity in the eco-printing leather. This increase in acidity changes the structure of the collagen protein in the eco-printed leather. Triatmojo (2014) stated that the factors that influence the sewing strength are the thickness of the leather, the content, and density of collagen protein, the angle of the braid of the collagen fibers, and the thickness of the corium. Moreover, the value of sewing strength is directly proportional to the tensile strength and tear strength, if the tensile strength and the tear strength are high, the sewing strength is also high.

Eco-Printed Leather Color to Wet and Dry Rubbing

Table 1 presents the mordant methods that affect the value of wet and dry rubbing resistance. The value of eco-printing leather color fastness due to wet and dry rubbing on average gave a score of 4 (good) compared to the meta- and post-mordant methods. The pre-mordant method has the highest value because it was carried out at the beginning with aluminum potassium sulfate Sulfate has the opportunity to bind to the skin tissue more perfectly. Thus, the value of colorfastness due to wet rubbing and dry rubbing is increasing, indicating that it does not fade easily. Mordant is a chemical substance that forms chemical bonds with natural dyes. The chemical bond between the mordant and the natural dye is formed first by soaking the leather first with the mordant and then dyeing it. This might help the absorption and fixation of natural dyes and also prevent color by rubbing. The color fading is assessed by light fastness tests as well as improve fastness (Boahin *et al*., 2011).

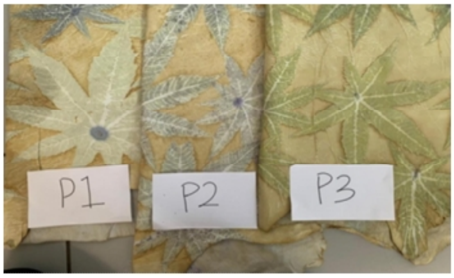

Figure 1. Eco-printed leather results with different mordant methods

Figure 1 visualizes the results of P1 and P3 colors clearer than P2. This indicates that the mordant method might affect the brightness of the color on the surface of the eco-printing leather. According to Ahmad and Hidayati (2018), the mordanting process functions as a color enhancer and changes natural dyes according to the type of metal as a binder. The surface of the leather is impregnated with mordant, then during the coloring process reacts with the mordant, forming a chemical bond and sticking firmly to the leather.

CONCLUSION

The best mordant method to be carried out is the pre-mordant method done at the beginning of the eco-printing process (before coloring) on leather material, with the

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quality of the eco-printing leather obtained of 5.44 ± 0.968 mm for softness, crack resistance (distance) of 8.78 ± 0.97 mm, the tensile strength of 1743.64 ± 45.26 N/cm^2, elongation of 55.15 ± 10.26 %, tear strength of 144.48 ± 28.82 N/cm, sewing strength of 1247.12 ± 649.91 N/cm, wet rub colorfastness of 4 (good), and dry rub of 4 (good).

The light fastness of eco-printed leathers will be evaluated in the next stage of the research and A method for textile dyeing was proved to be applicable for leather also and can be useful for the creative industry.

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