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Medicinal Plants in East Sumba that Potential as Natural Dyes for Ikat Weaving

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Abstract

The revival of the natural dyes comes from an awareness of maintaining health and preserving the environment. Medicinal plants can be used as a source of the natural dyes. This study aimed to determine the medicinal plants in East Sumba Regency potentially exploited as a natural dye for ikat weaving. Plant data was obtained from Tana Tuku village and Mbatakapidu village in East Sumba Regency. A total 13 species of plants were extracted to dye cotton fabric and mordant by $FeSO_4$ (ferrous sulphate), $Al_2(SO_4)_3$ (alum) dan $CaCO_3$ (lime). The intensity of color L*, a*, b* were analyzed by Kruskal Wallis test and Duncan post hoc test. The fastness of washing test analyzed by a gray color change scale and staining scale standard. The results showed that the ferrous sulphate mordant produced dark color and the alum mordant produced bright color. The intensity of red color was shown by *Swietenia macropylla* King and *Leucaena leucocephala* when it was mordanting by lime. The intensity of yellow color was shown by *Woodfordia fruticosa* (L.) Kurz with alum and *Syzigium polyanthum* with lime. The color change was not significant at 40 ^oC of washing shown by *Tamarindus indica* and *Leucaena leucocephala* mordanting by ferrous sulphate, *Leucaena leucocephala*, *Bombax ceiba* and *Timonius timon* mordanting by alum, *Tamarindus indica*, *Leucaena leucocephala*, *Timonius timon* mordanting with lime. All natural dyes did not stain the upholsteries.

Keywords: medicinal plant, natural dye, mordant, cotton, color fastness.

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1. INTRODUCTION

Revival of the spirit back to nature which is currently carried out by the world community is influenced by awareness to maintain health and preserve the environment. In addition to consuming medicines made from herbs, utilizing materials from nature that are environmentally friendly is also being developed. One of them is using natural ingredients for textile dyes (Ado *et al*., 2014). The existence of Indonesia as one of the countries rich in biodiversity has the opportunity to explore various natural colors for textile products, for example in batik cloth and ikat. Medicinal plants are considered to be able to produce a variety of the color pigment so they can be used as natural dyes (Shakhatreh, 2013). Natural dyes are also considered environmentally friendly because they are renewable and safer for human health than synthetic dyes which can cause allergies, a toxic and carcinogenic. Besides derived from plants, natural dyes can also come from insects, animals and minerals (Sentikumar *et al*., 2015).

East sumba ikat weaving which is predominantly done by women in a hereditary still utilizes natural dyes in the manufacturing process. Ikat weaving as a home industry can support 30% of the household economy in East Sumba Regency (Babang, 2008). Woven cloth

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has important values for the people of Sumba such as marriage customs, death customs, social activities and government. East sumba ikat weaving is also preferred by consumers outside East Sumba Regency because coloring in ikat weaving gives a distinctive color and cannot be imitated by synthetic dyes (Ndima, 2007).

Parts of plant used as natural dyes of east sumba ikat weaving are roots, stems, leaves, twigs and seeds. Besides minerals like lime is needed as a fixation agent or mordanting. The raw material used is cotton yarn. Plants that are used by east sumba ikat weaving artisan are consists of dye plants, mordanting plants, softener plants and fabric preservatives. The dye plants that are widely known by weaving artisan are *Morinda citrifolia* L. which produces red, *Indigofera tinctoria* L. which produces blue, *Cudrania cochinchinensis* and *Curcuma domectica* which produces yellow. Plant of mordanting namely *Symplocos* sp. mixed with *M. citrifolia* L. to strengthen the red color. Fabric softener and preservative namely *Aleurites moluccana* L. Willd and *Erythrina* sp. used before cotton yarn is immersed in natural dyes.

The process of making east sumba ikat weaving takes about 5-8 months and even years. One of the reasons for the length of the process of making ikat is the dyeing plants that have not been cultivated consciously by artisan so that to get them, craftsmen take them from nature (Murniati and Takandjanji, 2016). In addition, the dyeing plants used only grow in certain seasons, the lack of knowledge and skills of the artisan to extract and utilize natural dye causes the artisan to switch to synthetic dyes.

East Sumba Regency has many medicinal plants which can be used as a source of natural dyes for ikat weaving. Medicinal plants are selected as plants that have the potential to produce natural dyes as ikat weaving because they are available and can be obtained in the yard or garden. This is to ensure the sustainability of the east sumba ikat weaving business based on natural dyes as cultural heritage and the widespread use of plants that are around the community that potentially as natural dyes weaving to support the household economy. Based on this, the aimed of this study is to determine medicinal plants in East Sumba that have the potential as natural dyes of ikat weaving.

2. MATERIALS AND METHODS

Study Area

The study area was conducted in two villages namely Tana Tuku Village, Nggaha Ori Angu sub-district and Mbatakapidu Village, Waingapu City sub-district, East Sumba Regency. In the two research villages, 60 respondents were selected purposively to be interviewed and inventoried of plants in their yards or gardens. Furthermore, medicinal plants suspected of having the potential to produce dyes were tested at the Textile Chemistry Physics Laboratory and Textile Chemistry Evaluation at the Sekolah Tinggi Teknologi Tekstil, Bandung. The time of the study was conducted from November 2017 to March 2018.

Equipments and Materials

The equipments used in this study are plant inventory tool such as the measuring tapes and tally sheets; respondent questionnaires, analytical scales, pH meters, a set of beaker, SS 6200 Spectrophotometer, Laundry-Ometer, standard of gray color change scale and gray staining scale.

The materials used were plastic clips for storing samples of dried plant parts (barks, leaves, twigs, seeds,), mordanting substances such as ferrous sulphate ($FeSO_4$), alum ($Al_2(SO_4)_3$) and lime ($CaCO_3$), cotton fabric, polyester fabric, ECE (European Color fastness Establishment) phosphate WOB (without optical brightening agent) and water.

Extraction Process

The amount part of plants the natural dye was extracted 600 grams in dried form. Part of plants was cut randomly and roughly to easier the boiling process (Wanyama *et al*., 2014). The comparison of plant parts with water was 1: 5 (w/v) for barks and seeds and 1: 8 (w/ v) for leaves and twigs. The comparison part of plants and water was made differently because the plant parts in the form of leaves and twigs that have been dried have more amounts than the bark and seeds to meet the same weight of 600 grams. The amount of water as a solvent for the natural dye portion of leaves and twigs was certainly needed more so that the extracted natural dye can submerge the cotton properly. Natural dye was extracted at 70 ^{o}C for 45 minutes. Natural dye solution extraction was carried out twice to meet the amount of solution needed. The results of the extraction of the first and second solutions were then concentrated at 70 ^{o}C for 15 minutes. After the solution has cooled, the pH was measured to determine the neutral pH produced by natural dye.

Dyeing Process

The ratio of cotton to the volume of natural dye solution was 1:20 (w/v). The cotton sample size of 30x20 cm was adjusted to the need for further testing. Dyeing was carried out at a temperature of 70 ^{o}C for 45 minutes. During the dyeing process, the material was stirred so that dye can be absorbed evenly into the cotton fibers. Before being dried, the dyed cotton material is rinsed with water. The rinsing process was carried out to obtain a clean cotton material from impurity material that is attached to the fabric surface.

Mordanting Process

The mordanting is a way to tie natural dyes with fabric fibers. It is the most important stage after the color dyeing process because it is a step to tie the dyes (Wijana *et al*., 2015). Mordanting after the test material is dipped in natural dye extraction is done so that it has good fastness. The selection of mordant ferrous sulphate, alum and lime is based on the nature of substances that are relatively harmless to the environment (Kwartiningsih *et al*., 2009). Ferrous sulphate, alum and lime are metal complex compounds that are useful for natural dye mordants (Amalia and Aktamimi, 2016).

In the process of mordanting, the ratio of mordant substances to water was 2 g / l. The color fabric test sample was dipped in a mordant solution at room temperature for 15 minutes then rinsed and dried it (Rosyida and Achadi, 2014). During the mordanting process, the cotton was stirred so that the fixation agent can be absorbed into the fiber.

Color Intensity Measurement

In the process of measuring color intensity, five different points were taken on a sample cloth dyed with natural dyes using a Spectophotometer, then the five points were searched for mean values. Values that are read on the Spectrophotometer are the value of the brightness level (Lightness = L *), the intensity of the red color (a *) and the intensity of the yellow color (b *). The color scale model of the Commission Internationale d'Eclairge (CIE) L *, a *, b * is used to evaluate the color of the dyeing results (Rym *et al*., 2015).

Washing Fastness Testing

The washing fastness testing carried out on cotton fabric at temperature 40 ^{o}C on the Laundry-Ometer machine followed the SNI ISO 105-C06: 2010 standard, then continued with the color change test using a gray change scale that followed the ISO 105-A02: 2010 standard and the stain change test using a gray stain scale that adhere to ISO 105-A03: 2010 standards. A gray scale is a paper refer to changes color from dark gray to white in a color rating order of 5 (excellent), 4/5 (good), 4 (good), 3/4 (enough), 3 (enough good), 2/3 (less), 2 (less), 1/2 (bad) and 1 (bad). The value of color changes and color stain was assessed visually. In the assessment of color change, if the washing sample had a color that was not conspicuous with the sample before washing when compared to the gray scale plate, it was good, whereas if there was a significant change in color after washing was categorized as bad. In the color stain assessment, fabric and upholstery samples (cotton representing natural fibers and polyester inherit synthetic fibers) were washed together, compared to the gray stain scale. If it did not leave a stain was good, if it leaves a striking stain was bad value.

Data Collection

Data collected were color intensity L*, a* and b*. The value L* or lightness has a value in the range 0-100, component a* consists of a + (red) and a- (green) in the range +127 to -128, component b* consists of b + (yellow) and b- (in blue) in the range +120 to -120 (Rym *et al.*, 2015; Vadwala and Kola, 2017). In addition, data from the results of washing fastness for washing 40 °C were collected following the SNI ISO 105-C06:2010a standard, then proceed with the color change test using the gray standard following the SNI ISO 105-A02: 2010b standard and the staining change test follows SNI ISO 105-A03: 2010c.

Data Analysis

Analysis of the results of the color intensity test (L * a *, b *) was performed using IBM SPSS 21 with a Multivariate Analysis of Variance (Manova) statistical test if the data obtained fulfilled the assumptions of normality and homogeneity. If it was not met, then Kruskal-Wallis non parametric test was performed to see the difference in color produced by the treatment of ferrous sulphate, alum and lime mordant substances on natural dyes absorbed on cotton fabric. If there are significant differences continued to Duncan's post hoc test. Descriptive analysis of the washing fastness was carried out by comparing the results of cotton fabric washed samples to the gray color change scale standart and gray stain scale standard which has a rating of 5 (excellent), 4/5 (good), 4 (good), 3/4 (enough), 3 (good enough), 2/3 (less), 2 (less), 1/2 (bad) and 1 (bad).

3. RESULTS AND DISCUSSION

Medicinal Plants Used by East Sumba People

Medicinal plants used by the community in East Sumba were acquired hereditary as well as from interactions with migrants or other tribes domiciled in the two research villages. Medicinal plants were used to treat humans and livestock. Utilization of medicinal plants was done by boiling then drinking or using water for bathing, mashed and used as an external medicine that was posted on the sick body part. Medicinal plants that have been hereditary known were *Lannea coromandelica* (Houtt) Merr, *Tamarindus indica* L., *Cassia fistula* L., *Leucaena leucocephala* (Lam) de Wit, *Woodfordia fruticosa* (L.) Kurz, *Grewia eriocarpa* Juss., Bombax ceiba L., *Ziziphus mauritiana* Lam., and *Timonius timon* Spreng. Merr. While medicinal plants obtained from interactions with migrants or other tribes were *Areca catechu* L., *Swietenia macropylla* King, *Azadirachta indica* A. Juss and *Syzigium polyanthum* (Waight) Walp.

The way to find out a plant can be used as natural coloring is by boiling it with water. If it produce color, it can be used as a source of natural dyes (Kumar, 2015). The medicinal plants mentioned in Table 1, when boiled, produce red, brownish red, brown and brownish yellow colors. Based on the colors produced in the east sumba ikat weaving namely red, yellow and brown, black, white and blue, the medicinal plants had the potential to be explored as alternatives to natural dyes weaving.

Medicinal plants which used as a source of natural dyes, are selected from one part of the plant to be extracted as dyes for ikat weaving. The selection of plant parts considered information obtained from respondents in the field (Table 2).

Table 1. Utilization of plant parts as medicine

Scientific Name/Local Name	Utilization of Plant Parts as Medicine
L. coromandelica (Houtt) Merr/kehi	Sap : trachoma; Leaves : anti-diabetes; Barks : blood booster
T. indica / kamaru	Leaves: refreshes the body after recovering from illness (boiled for bath water); Fruit flesh : abdominal pain
C. fistula L./kunjur	Leaves: relax the muscles in horse animals after a race or long trip
W. fruticosa (L.) Kurz/hayi	Leaves and twigs : bathing water for women after childbirth and in infants to deal with the rush (fever and rash on the skin)
L. leucocephala / lamtoro gung	Young fruit: treat deworming; Leaves : appetite enhancing medicine in pigs, cattle and goats
G. eriocarpa Juss/linu	Barks : blood booster, treat hepatitis
B. ceiba L./rongu	Barks : treat cough
Z. mauritiana Lam / kalangga	Leaves : recover broken bones (pounded and attached to the affected or broken part); Barks : medicine to strengthen teeth (boiled and rinsed with sap of palm)
Timonius timon/nggai	Barks: anti-inflammation on the body skin that was injured both in animals and humans
A. catechu *L.*/winnu	Seeds : treat abdominal pain (chewed and sprayed it to tummy, it used by Savu tribe)
S. macropylla King / mahoni	Leaves, seeds, barks : treat malaria, febrifuge
A. indica/mimba	Leaves : treat malaria, a natural pesticide to treat flies
S. polyanthum/lobung	Leaves : anti-diabetes dan anti-hypertension

Table 2. Parts of medicinal plants extracted as dyes for ikat weaving

Scientific Name	Extracted Part of Plants
L. coromandelica (Houtt) Merr	barks
T. indica L.	barks
C. fistula L.	barks
L. leucocephala (Lam.) de Wit	barks
W. fruticosa (L.) Kurz	leaves, twigs
G. eriocarpa Juss.	barks
A. ceiba L.	barks
Z. mauritiana Lam.	barks
T. timon Spreng Merr	barks
A. catechu L.	seeds
S. macropylla King	barks
A. indica A Juss	leaves
S. polyanthum (Wight) Walp.	barks

Color Intensity L*, a*, b*

Based on the results of normality and homogeneity tests of brightness (L*), red intensity (a*) and yellow intensity (b*) with $\alpha = 0.05$, the results did not meet the assumptions of normality and homogeneity so that the Kruskal-Wallis nonparametric test was performed. Kruskal Wallis test results on natural dye with mordanting treatment showed that there was a *p value* <0.05 (reject H0). In the brightness level test (L*), all mordanting substances showed a significant difference. This also happened to the intensity of red (a*) and the intensity of yellow (b*). Because it gave a significance difference, it was continued to Duncan's post hoc test to find out which natural dye groups were different.

In Figure 1., showed the reaction between celloluse in cotton fibers and tannins derived from plants (Prabu and Bhute, 2012).

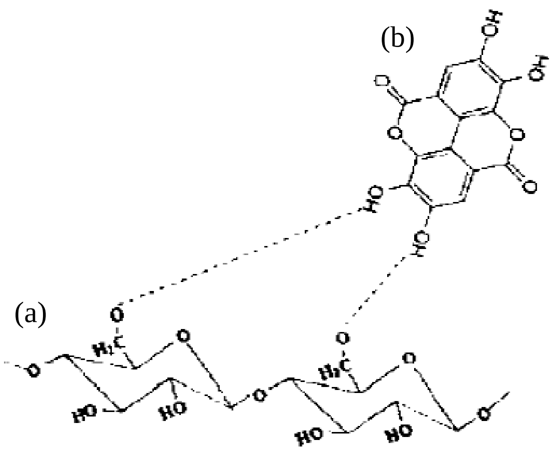

Figure 1. Cellulose (a) and tannins (b) reaction

The chemical reaction between cellulose, tannins and mordanting substances can be seen at equation below.

Ferros sulphate:

$$(C_6H_{10}O_5)_n + C_{76}H_{52}O_{46} + FeSO_4 \rightleftarrows (C_6H_{10}O_5)_n\text{-}C_{76}H_{52}O_{46}\text{-}Fe^{2+} + SO_4^{2-}$$

Alum:

$$(C_6H_{10}O_5)_n + C_{76}H_{52}O_{46} + Al_2(SO_4)_3 \rightleftarrows (C_6H_{10}O_5)_n\text{-}C_{76}H_{52}O_{46}\text{-}Al^{3+} + SO_4^{2-}$$

Lime:

$$(C_6H_{10}O_5)_n + C_{76}H_{52}O_{46} + CaCO_3 \rightleftarrows (C_6H_{10}O_5)_n\text{-}C_{76}H_{52}O_{46}\text{-}Ca^{2+} + CO_3^{2-}$$

Brightness Intensity (L*)

L* states the level of brightness of the dark light in the range 0-100 (Rym *et al.*, 2015). The number 0 indicates the color direction is very dark or black while the number 100 indicates the color is bright or white. In the treatment without mordant (Table 3), *S. macropylla* had the smallest value or displays the darkest color whereas *A. indica* showed the largest or brightest value. When it used ferrous sulphate mordant, all natural dyes values were smaller or darker and the darkest was *S. polyanthum* while the brighter was *T. indica*. In alum mordant, natural dye tended to be bright and the highest value was shown by *S. macropylla*. The lime mordant showed a smaller value than the treatment without mordant but not darker than the ferrous sulphate.

Table 3. Brightness level (L*) of natural dyes affected by mordanting treatment

Natural Dyes	Mordanting			
	No Mordant	**Ferrous Sulphate**	**Alum**	**Lime**
S. macropylla	60.36 h	47.78 g	80.42 a	55.81 f
L. coromandelica	64.29 g	43.83 h	62.33 j	56.06 f
L. leucocephala	64.63 g	48.21 g	62.09 j	57.52 f
S. polyanthum	65. 99 f	32.97 i	65.49 i	60.43 e
A. catechu	70.99 e	43.91 h	70.50 h	56.71 f
G. eriocarpa	71.09 e	48.07 g	71.82 g	60.00 e
C. fistula	73.85 d	51.23 f	73.67 f	69.46cd
T. timon	73.98 d	55.03 e	74.83 e	68.16 d
B. ceiba	74.67 c	61.69 c	76.66 d	72.70 b
Z. mauritiana	78.12 b	57.79 d	77.32 c	70.61 bc
W. fruticosa	78.24 b	47.86 g	77.12 cd	69.14 cd
T. indica	78.47 b	69.78 a	65.10 i	77.62 a
A. indica	79.83 a	66.76 b	79.64 b	78.05 a

[a]number in the same column followed by the same letter is not significantly different at the 5% level (Duncan's test)

The mordanting process in addition to fixing colors can also be affected the brightness level (L *) of natural dyes. The ferrous sulphate tends to steer natural dye in the dark. The alum tends to direct natural dye in the sunny direction. Alum is a chemical compound that is colorless so it only serves to strengthen the dye (Rosyida and Achadi, 2014). According to Kristijanto and Soetjipto, 2013; Wijana *et al*., 2015, alum tend to be brighter when compared to lime and ferrous sulphate because there are Al^{3+} ions that react with tannins, while lime with Ca^{2+} ions when reacting with tannins (hydroxyl groups) produce yellow precipitate which in large amounts can causes the dye of cotton to be darker.

Red Intensity (a*)

The value of a* represents the red-green coordinates consisting of a + (colored red) and a- (colored green) in the range +127 to -128 (Vadwala and Kola, 2017). In Table 4 seen natural dye without mordant treatment which tends to produce red color was *C. fistula*, while those that tend towards green color were *A. indica* but not significantly different from *W. fruticosa*, *S. polyanthum*, *Z. mauritiana*, *G. eriocarpa*, *T. indica*, *T. timon*, *A. catechu*, *B. ceiba*, *L. leucocephala*, *L. coromandelica* and *S. macropylla*.

Natural dye when treated with a mordanting, the direction of the color produced varies. In the treatment of ferrous sulphate, all natural dyes change color to smaller or tend towards green. $FeSO_4$ which was reacted with natural dyes containing tannins would give a dark color or draw out shades of green (Singh & Singh, 2018). The most oppurtunity of natural dyes were producing green because it had the lowest a* value, namely *W. fruticosa* while the red color was *L. leucocephala*. In interaction with alum, *W. fruticosa* had the ability to produce green color while *T. indica* produces red but not significantly different from *L. coromandelica*. In the treatment of lime, tends to produce natural dye towards the red color, this was evident from the value of a* which tends to increase. The ability of dyes to bind to cotton fabrics was due to the presence of OH^- groups from cellulose contained in the fabric fibers forming covalent bonds with calcium metal in lime (Prabawa, 2015). Natural dye of *S. macropylla* produces the highest red color but was not significantly different from *L. leucocephala*. Acidic and neutral solutions on natural dye that have bonded with cotton fibers when treated with Ca^{2+} ions produce an orange or yellowish red color. Calcium in lime mordant will bind strongly with dyes in an acidic condition (Puchtler *et al*., 1968).

Table 4. Red intensity (a *) ZPA affected by mordanting treatment

Natural dyes	Mordanting			
	No mordant	Ferrous sulphate	Alum	Lime
A. indica	3.20 b	1.13 g	1.74 j	5.21 h
W. fruticosa	4.20 b	0.14 i	1.11 k	7.27 g
S. polyanthum	7.33 b	0.88 h	6.29 h	10.39 e
Z. mauritiana	7.58 b	1.79 f	5.53 i	7.99 fg
G. eriocarpa	8.03 b	2.80 d	9.17 c	15.85 c
T. indica	8.97 b	2.97 c	13.48 a	8.68 f
T. timon	10.44 b	1.89 f	8.74 d	11.93 d
A. catechu	10.96 b	1.93 f	8.08 e	15.19 c
B. ceiba	11.03 b	2.46 e	8.00 e	10.36 e
L. leucocephala	15.00 b	4.10 a	10.97 b	17.79 ab
L. coromandelica	16.23 b	3.71 b	13.08 a	17.34 b
S. macropylla	17.42 b	3.82 b	6.76 g	18.45 a
C. fistula	34.15 a	2.71 d	7.53 f	10.67 e

[a]numbers in the same column followed by the same letter are not significantly different at the 5% level (Duncan's test)

Yellow Intensity (b*)

The b* component consists of b+ (yellow) and b- (blue) in the range +120 to -120 (Vadwala and Kola, 2017). In the treatment without mordants, natural dyes which tended to produce yellow color was *S. macropylla*, while *T. indica* tended towards the blue color.

The mordanting treatment gave different results at the intensity of b* (Table 5). Alum can produce a bright yellow color while ferrous sulphate produces a brown color (Crew, 1982). In the treatment of ferrous sulphate, *L. leucocephala* showed the highest value or tends towards yellow but it was not different from *S. macropylla* and *Z. mauritiana*. While the smallest value was showed by *S. polyanthum*.

In the treatment of alum and lime tend to increase the value of b* towards the color yellow. Natural dyes which can produce yellow color when fixed with alum was *W. fruticosa* and reduces yellow color in *S. macropylla*. In the lime treatment, it was produced the highest b* *S. polyanthum* value in the direction of yellow.

Table 5. Yellow intensity (b*) natural dyes affected by mordanting treatment

Natural dyes	Mordanting			
	No mordant	Ferrous sulphate	Alum	Lime
T. indica	8.68 i	9.15 cd	23.01 b	10.49 i
Z. mauritiana	11.24 h	9.74 abc	10.56 i	15.78 f
A. indica	12.14 g	9.29 bcd	16.55 e	13.45 h
C. fistula	12.57 g	6.52 f	12.47 h	18.31 e
B. ceiba	12/71 g	8.56 d	13.51 h	14.64 g
A. catechu	15.16 f	7.74 e	13.51 g	22.54 b
T. timon	15.67 ef	6.90 f	13.56 g	16.43 f
L. coromandelica	16.05 e	5.73 g	16.90 e	17.59 e
W. fruticosa	17.11 d	5.15 g	25.90 a	20.50 d
L. leucocephala	17.90 c	10.21 a	14.88 f	21.36 c
G. eriocarpa	18.06 c	6.56 f	18.03 d	22.50 b
S. polyanthum	21.01 b	2.25 h	20.12 c	27.91 a
S. macropylla	28.32 a	10.02 ab	8.87 j	22.02 bc

[a] numbers in the same column followed by the same letter are not significantly different at the 5% level (Duncan's test)

Washing Fastness Testing

In the dyed process, cotton cloth can absorb natural dyes. This was showed that dyes in medicinal plants can enter the fiber and react cellulose. The bond formed between natural dyes and cotton fibers was a hydrogen bond, but with the addition of mordanting substances can fix the dyes such as tannin in cotton fibers so that they do not fade easily (Rosyida and Zulfiya, 2013).

The value of washing fastness 40 ^{o}C on a gray scale produced a color change of 4/5 until 2/3. Without mordanting treatment, three natural dyes namely *T. indica*, *T. timon* and *A. indica* showed a color change of 4 (good) which means that without mordant, natural dye can bind well and absorbed on cotton . The natural dye was capable to bind strongly with cotton fibers and mordanting substances can be used as substances that help produce the desired color variations (Kartikasari and Susiati, 2016). On the staining scale testing, all natural dye showed a value of 5 (excellent). This was means that in the washing process, the dye that comes out with soapy water when washed did not completely stain the upholstery of cotton and polyester. The natural dye fastness of washing can be seen in Table 6.

In the treatment of ferrous sulphate mordanting, the value of gray color change natural dye value was good (4/5 to 4) produced by *T. indica*, *L. Leucocephala*, *W. fruticosa*, *G. eriocarpa*. They changed color but did not flashy. The other natural dyes were showed good enough value. The staining scale value for stain color test was 5 (excellent), it means that in the washing process, all natural dyes did not stain the cotton and polyester upholsteries.

L. Leucocephala, *B. ceiba* and *T. timon* mordanting with alum showed 4/5 (good) while *C. fistula* and *S. macropylla* showed 4 (good). They showed color changes but didn't provide a striking color. *W. fruticosa* showed a value of 2/3 (less) meaning that there was a noticeable discoloration of the color. *W. fruticosa* could not bind to cotton fibers when fixed with alum. The value of staining scale alum mordant showed a scale of 5 (excellent) which means there is no stain on the upholsteries.

In the lime mordanting treatment, *T. indica* , *L. leucocephala*, *T. timon* showed gray color change scale values 4/5 (good) and *W. fruticosa*, *B. ceiba*, *Z. mauritiana*, *S. macropylla*, *A. indica* showed gray color change scale values were 4 (good). They bound well to cotton fibers when fixed with lime. Whereas *S. polyanthum* showed a value of 2/3 (less) which it means that when it was fixed with lime, lime substance was not able to bound to the cotton fibers so that it produced a striking color change when it washed. All natural dyes were mordanting with lime did not stain cotton and polyester upholsteries.

Table 6. Natural dye grouping based on fastness of washing

Mordanting	**Grey scale**					**Staining scale**	
						Cotton fabric	**Polyester fabric**
	4/5	**4**	**3/4**	**3**	**2/3**	**5**	**5**
No mordant	-	B I L	C G H J K	A D E F M	-	A B C D E F G H I J K L M	A B C D E F G H I J K L M
Ferrous sulphate	B D	E G	A C I J K L	F H M	-	A B C D E F G H I J K L M	A B C D E F G H I J K L M
Alum	D G I	C K	A H L M	B F J	E	A B C D E F G H I J K L M	A B C D E F G H I J K L M
Lime	B D I	E G H K L	A C F J	-	M	A B C D E F G H I J K L M	A B C D E F G H I J K L M

A = *L. coromandelica*, **B** = *T. indica*, **C** = *C. fistula*, **D** = *L. Leucocephala*
E = *W. fruticosa*, **F** = *G. eriocarpa*, **G** = *B. ceiba*, **H** = *Z. mauritiana*
I = *T. timon*, **J** = *A. catechu*, **K**= *S. macropylla*, **L** = *A. indica*, **M** = *S. polyanthum*
5 = excellent, 4/5 = good, 4 = good, 3/4 = enough, 3 = good enough, 2/3 = less

The color change of *W. fruticosa* with alum and *S. polyanthum* with lime on the gray color change scale showed value 3 (enough) in Table 6. When dyeing process, the dye did not optimally entered to the fiber and bound so that the lime substance was unable to lock the color on the cotton fabric. This causes lose the yellow dye attached to the surface of the cotton fabric during the washing process. Discoloration before and after washing for cotton dipped on natural dyes *W. fruticosa* and *S. polyanthum* can be seen in Figure 2 and Figure 3.

A1 A2

Figure 2. Comparison of color change before and after washing *W. fruticosa* with alum A1 : after washing, A2: before washing

A1 A2

Figure 3. Comparison of color change before and after washing *S. polyanthum* with lime A1 : after washing, A2: before washing

4. CONCLUSION

Natural dye extraction from 13 medicinal plants in East Sumba Regency can dye the cotton. Medicinal plants which have the potential as natural dyes based on the level of dark brightness were plants that are mordanting with ferrous sulphate ($FeSO_4$) while bright brightness levels were mordanting with alum ($Al_2(SO_4)_3$). Plants that have the potential to produce red color were those fixed with lime ($CaCO_3$) such as *S. macropylla*, and *L. leucocephala*. The potential of yellow color was obtained from natural dye fixed by alum, it was *W. fruticosa* and fixed with lime was *S. polyanthum*. Based on the results of the color change fastness test for washing, *T. indica* and *L. Leucocephala* treated of ferrous sulphate; *L. Leucocephala*, *B. ceiba*, *T. timon* treated of alum and *T. indica*, *L Leucocephala*, *T. timon* treated of lime did not significant color changes. All natural dye did not stain the upholsteries.

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REFERENCES

Ado A. Yahaya, Kwali AA, Abdulkadir RS. 2014. Dyeing of textile with eco-friendly natural dyes: a review. *International Journal of Environmental Monitoring and Protection*. 1(5):76-81.

Amalia R, Akhtamimi I. 2016. Studi pengaruh jenis dan konsentrasi zat fiksasi terhadap kualitas warna kain batik dengan pewarna alam limbah kulit buah rambutan (*Nephelium lappaceum*). *Dinamika Kerajinan dan Batik*. 33(2):85-92.

Babang KR. 2008. Penguatan kelompok pengrajin tenun ikat tradisional (studi kasus di desa Hambapraing, kecamatan Haharu, provinsi Nusa Tenggara Timur) [tesis]. Bogor: IPB.

Badan Standarisasi Nasional. 2010a. Tekstil-Cara uji tahan tahan luntur warna - Bagian 06: Tahan Luntur terhadap Pencucian Rumah Tangga dan Komersial. Jakarta: BSN.

Badan Standarisasi Nasional. 2010b. Tekstil-Cara uji tahan tahan luntur warna - Bagian A02: Skala Abu-Abu untuk Penilaian Perubahan Warna. Jakarta: BSN.

Badan Standarisasi Nasional. 2010c. Tekstil-Cara uji tahan tahan luntur warna - Bagian A03: Skala Abu-Abu untuk Penilaian Penodaan. Jakarta: BSN.

Crew PC. 1982. The influence of mordant on the lightfastness of yellow natural dyes. *Journal of the American Institute for Conservation*. 21:43-58.

Kartikasari E, Susanti YT. 2016. Pengaruh fiksator pada ekstrak daun manga dalam pewarnaan tekstil batik ditinjau dari ketahanan luntur terhadap keringat. Jurnal Sciencetech. 2(1):136-143.

Kristijanto AI, Soetjipto H. 2013. Pengaruh jenis fiksatif terhadap ketuaan dan ketahanan luntur kain mori batik hasil perwarnaan limbah teh hijau. Prosiding Seminar Sains dan Pendidikan Sains UKSW; Salatiga, Juni 15, 2013. 4(1) Pp. 386-394.

Kwartiningsih E, Setyawardhani DA, Wiyatno A, Triyono A. 2009. Zat pewarna alami dari kulit buah manggis. *Ekuilibrium*. 8(1):41-47.

Kumar BA. 2015. Some ethno-medicinal plants and eco-friendly natural colors yielding flowering plants of B.S.N. Govt. P.G. collage campus, Shajapur (M.P)- A survey report. *International Journal of Research-Granthaalayah*. 3(4):1-6.

Murniati,Takandjanji M. 2016. Analisis usaha tenun ikat berbasis pewarna alam di kabupaten sumba timur: kasus di kecamatan kambera dan umalulu. *Dinamika Kerajinan dan Batik*. 33 (1):67-84.

Ndima PP. 2007. Kajian budaya kain tenun ikat sumba timur. [Tesis]. Salatiga (ID): UKSW.

Prabawa IDGP. 2015. Ekstrak biji pinang sebagai pewarna alami pada kain sasirangan. *Jurnal Riset Industri Hasil Hutan*. 7:2 (31-38).

Prabu KH, Bhute AS. 2012. Plant based natural dyes and mordant: A review. *Journal of Natural Product and Plant Resource*. 2(6): 649-664.

Puctler H, Meloan SN, Terry MS. 1968. On history and mechanism of alizarin and alizarin red stain for calcium. *The Journal of Histochemistry & Cytochemistry*. 17(2):110-124.

Rosiya A, Zulfiya A. 2013. Pewarnaan bahan tekstil dengan menggunakan ekstrak kayu nangka dan teknik pewarnaannya untuk mendapatkan hasil yang optimal. *Jurnal Rekayasa Proses*. 7(2):52-58.

Sentikumar RP. Bhuvaneshwari V, Sathiyvimal S, Amseveni R. Kalaiselvi M, Malayaman V. 2015. Natural colour from dyeing plants for textiles. *International Journal Bioscience Nanoscience*. 2(7):160-174.

Shakhatreh SK. 2013. Does natural dyes from selected medicinal plants used in Jordan Suitable fpr Dyeing Different types of cloth after chemical treatment. *Environment and Natural Resources Research*. 3(1):1-7.

Singh S, Singh DR. 2018. Application of natural mordants on textile. *International Journal of Applied Home Science*. 5(1):252.260.

Rosyida A, Achadi D. 2014. Pemanfaatan daun jati muda untuk pewarnaan kain kapas pada suhu kamar. *Arena Tektil*. 29(2):115-124.

Rym M. Farouk M, Bechir EM. 2015. Dyeing propertied of cationized and non-cationized cotton fabric dyed with *Vitis vinifera* L. leaves exact. *The Journal of Textile Institute*. (4):1-5.

Vadwala Y, Kola N. 2017. Natural dyes extracted from bark of *Bombax ceiba* Linn. locally known as semal and its application on various fabrics pretreated with eco-friendly and non eco-friendly mordant. *International Journal of Trend in Scientific Research and Development*. 1(3):37-43.

Wijana S, Diyah BSD, Adam MM. 2015. Pengaruh bahan fiksasi terhadap ketahanan luntur dan intensitas warna kain mori batik hasil pewarnaan ekstrak kulit kayu mahoni (*Swietenia mahagoni (L*) Jacg.). *Prosiding Seminar Agroindustri dan Lokakarya Nasional FKPT-TPI*. Universitas Trunojoyo Madura: Bengkalan, September 2-3, 2015. Pp 202-210.

Wanyama PAG, Kiremire BT, Murumu JES. 2014. Extraction, characterization and application of natural dyes from selected plants in uganda for dyeing of cotton fabrics. *African Journal Plant Science*. 8(4):185-195.