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Analysis Suminagashi Technique of Marbling Pattern Stability in Transfer Process Fabric Media: A Comparative Study on Satin, Polyester Blend, and Crepe

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Abstract
This study examines the suminagashi marbling technique with a focus on pattern stability during the transfer process onto textile media. The objective is to analyze the effect of fabric type on the visual quality of marbling patterns and color fastness. A quantitative comparative experimental design was employed, testing three fabric types—satin polyester, polyester blend, and crepe—under controlled conditions. Fifteen trained panelists from the Fashion Education Program at Universitas Negeri Semarang (UNNES) assessed the products using a validated observation sheet. The independent variable was fabric type based on fiber composition, while the dependent variables were marbling pattern quality and color fastness after washing. Data were analyzed using the Kruskal-Wallis nonparametric test. Results showed no statistically significant difference in pattern quality ($H = 3.22$; $p = 0.20$) or color fastness ($H = 4.61$; $p = 0.10$) across fabric types, thus H_0 was accepted. Empirically, however, crepe fabric achieved the highest scores in both pattern quality ($\bar{X} = 3.53$; Very Good) and color fastness ($\bar{X} = 3.80$; Very Good), outperforming satin polyester ($\bar{X} = 3.38$ and 3.68) and polyester blend ($\bar{X} = 3.03$ and 2.85). The superior performance of crepe is attributed to its hygroscopic silk–rayon fiber composition and textured surface morphology, which facilitate deeper dye penetration and stable pattern transfer. All three fabrics are viable for suminagashi-based fashion accessories, with crepe yielding the highest aesthetic and functional quality.

Keywords: marbling; suminagashi; polyester; satin; crepe; color fastness; pattern quality

INTRODUCTION

The textile and fashion industries currently face dual pressures: high consumer aesthetic demands on the one hand, and pressure for sustainable production practices on the other. In this context, dyeing techniques that create artistic motifs while minimizing environmental impact are of crucial relevance to contemporary textile design. One technique that meets these criteria is marbling, a decoration method based on the manipulation of pigments on a liquid surface, resulting in unique, organic abstract motifs that cannot be replicated identically[1]. This technique first developed in Persia and Turkey—known as ebru—before spreading to Europe and Asia, where each tradition developed its own variations[2].

The variation studied in this research is suminagashi (墨流し), an ancient Japanese marbling technique that literally means "flowing ink." Unlike Western marbling techniques that typically use carrageenan- or tragacanth-based thickening solutions, suminagashi utilizes the surface tension of

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pure water as a flotation medium for the pigment, transferring it to the fabric or paper surface through direct contact. From a sustainability perspective, this technique offers significant advantages: all pigments are absorbed into the fabric fibers, resulting in virtually no liquid waste, a stark contrast to conventional synthetic dyes containing azo compounds and heavy metals that are difficult to degrade and potentially carcinogenic[3].

The greatest technical challenge in suminagashi lies in the process of transferring the pattern from the liquid surface to the fabric. At this stage, the formed pattern is highly susceptible to distortion due to several factors: the viscosity of the solution, the distribution of pigment densities, and—most crucially—the characteristics of the fabric fibers themselves[4]. The absorbency of the fabric, which is influenced by the fiber's origin, weave structure, and surface finish, determines how quickly and evenly the pigment can penetrate the fiber matrix. Fabrics with too low absorbency risk distorting the pattern during transfer; conversely, fabrics with too high absorbency can cause the pigment to spread beyond the intended motif[5].

Several studies have examined aspects of the marbling technique in textiles. Widyaningrum and Syamwil (2022)[6] reported that different fabric types affect the clarity and sharpness of suminagashi motifs. Amelia and Wahyuningsih (2020)[7] confirmed the significant influence of fabric type on marbling results in general. Salmina et al. (2022)[8] specifically found that rayon-based fabrics produced superior surface design aesthetics in the suminagashi technique. Ichsanti and Russanti (2020)[9] demonstrated that the ratio of acrylic paint to water significantly affected motif sharpness. Gunawan (2024)[10] exploratoryally examined variations in the suminagashi technique under various conditions. However, no study has systematically compared three fabric types—polyester satin, polyester blends, and crepe—on two quality aspects simultaneously: motif quality and post-wash colorfastness in a single, controlled experimental design. This research gap underpins this study. These three fabrics were selected purposively because they are the most commonly used materials for making headscarves (hijab scarves) in the Indonesian domestic market, have a representative variety of fiber compositions (pure synthetic, blended, and semi-natural), and are widely available and affordable. Therefore, the findings of this study have direct applicability for fashion accessory craftspeople and designers.

This study aims to: (1) analyze the visual quality of marbling motifs produced by the suminagashi technique on polyester satin, polyester blends, and crepe; (2) analyze the colorfastness of these three fabrics after washing; and (3) identify the fabric type that produces the best marbling quality based on these two aspects. The results of this study are expected to provide a scientific contribution to the study of environmentally friendly textile dyeing techniques and serve as evidence-based guidance for fashion accessory industry practitioners in selecting optimal materials.

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METHOD

Design and Research

This study used a quantitative approach with a comparative experimental design11. The comparative design was chosen because the study aimed to compare the effects of fabric type (independent variable) on two dependent variables, namely marbling quality and color fastness, through standardized measurements. The study was conducted under strictly controlled conditions to ensure that the differences in measured results were truly due to differences in fabric type and not other factors.

Subject and Object

The research subjects were 15 students from the Fashion Design Education Study Program, Faculty of Engineering, Semarang State University (UNNES), who served as trained panelists. The Fashion Design Education students were selected based on the consideration that they already possessed basic competencies in assessing the quality of textile and clothing products through relevant courses, ensuring that their assessments had sufficient contextual validity. The 15 panelists met the minimum requirement for trained panelists in the sensory evaluation of textile products[12].

The research objects were suminagashi fabrics made from three types of materials. Each fabric was prepared under controlled conditions: the same ratio of acrylic paint to water (1:1), the same concentration of CMC solution (5 grams/liter), and an identical transfer procedure, to ensure that the sole treatment variable was the fabric type.

Materials and Material Characteristics

The selection of research materials was based on a study of the physical characteristics of the fibers that could potentially influence the outcome of suminagashi[13]. Table 1 summarizes the main characteristics and relevance of each fabric to the marbling process.

Table 1. Characteristics of Research Materials and Their Relevance to the Suminagashi Process

Fabric	Fiber Composition	Main Properties	Relevance Suminagashi
Satin Polyester	100% Poliester (warp satin, 200 lusi × 99 pakan/inci)	Hydrophobic, shiny smooth surface	Limited absorption; shiny pattern but prone to distortion during transfer
Polyester Blend	Poliester + other fiber (supernova fabric; fine, loose fibers)	Semi-hygroscopic; moderate absorption	Better absorption than satin; higher variability of results
Crepe	Silk–rayon blend; crepe texture (crimped)	High hygroscopicity; large surface area	Optimal absorption; sharp and fade-resistant printed patterns

Source: Adapted from various literature (Fauziana & Suhartiningsih, 2019; Aristi, 2018; Liao et al., 2024)

Polyester satin has a warp satin weave structure with a yarn density of 200 warp and 99 weft threads per inch, resulting in a smooth and shiny surface[14]. The hydrophobic nature of polyester fibers limits the absorption of water-based dyes, although the reflective surface creates an aesthetic visual effect[15]. Polyester blend fabrics (supernova fabrics) have fine, loosely woven fibers on their surface,

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providing semi-hygroscopic properties that allow for better absorption than pure polyester satin[16]. Crepe fabric is made from a blend of silk and rayon fibers with a distinctive crinkled surface texture (crepon). Silk fibers are highly hygroscopic and have a triangular prism structure that optimally refracts light; rayon, as a regenerated cellulose fiber, has a high affinity for water-based dyes[17].

The dye used is acrylic paint with a 1:1 water-to-water ratio. This ratio was chosen based on pre-experiments that indicated the optimal specific gravity of the mixture for floating without sinking in water[18]. The thickening medium used was a Carboxymethyl Cellulose (CMC) solution with a concentration of 5 grams per liter of water, which produced sufficient viscosity to hold the pattern without affecting the transfer process[19]. CMC was chosen because it does not require boiling, is completely soluble in cold water, and produces readily biodegradable waste[20].

Experimental Procedure

The suminagashi making process is carried out through the following stages which are applied uniformly to all three types of fabric: (1) Media preparation—CMC solution (5 g/l) is poured into a flat tub measuring 40 × 60 cm to a depth of ±3 cm and left for 30 minutes until the bubbles disappear; (2) Paint preparation—acrylic paint is diluted with water at a 1:1 ratio and stirred until homogeneous; (3) Pattern formation—paint is dripped alternately onto the surface of the media using a dropper, then the pattern is manipulated using a skewer to form the desired marbling motif; (4) Pattern transfer—the prepared fabric is placed slowly on the surface of the media evenly from one side to the other to avoid air bubbles that can distort the pattern; and (5) Fixation—the fabric is lifted, drained, and dried naturally in a place not exposed to direct sunlight for 24 hours.

After drying, the fabric samples were washed using a neutral detergent (pH 7) in water at 30°C for 3 minutes to test their colorfastness[21]. The washing procedure was standardized for all samples to ensure comparability of the results.

Assessment Instruments and Techniques

The research instrument was an observation sheet in the form of a rating scale with 10 questions compiled based on theoretical studies from various sources and validated by three experts (two textile experts and one fashion expert) before use. The instrument grid is presented in Table 2. The assessment scale used a four-point Likert scale: 1 (Poor), 2 (Not Good), 3 (Good), and 4 (Excellent).

Table 2. Assessment Instrument

Variable	Indicator	Sub-indicators	No
Product quality of suminagashi technique scarf (marbling pattern)	Desaign (Daga, 2017)	Styling (Daga, 2017)	1
		Motif (Dharsono, 2007 in Nisa, 2022)	2, 3
	Materials (Prawirsentono, 2002 in Amanullah, 2023)	Main Ingredients (Prawirsentono, 2002 in Amanullah, 2023)	4, 5
		Quality (Widiastuti, 2020)	6

16 Aristi, D. (2018). Perbedaan Hasil Jadi Hand Painting pada Organdi Poliester Menggunakan Outliner Alginat dan Zat Warna Dispersi. Surabaya: JPKK FT Unesa.

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18 Ichsanti, S. & Russanti, I. (2020). Pengaruh Perbandingan Volume Cat Akrilik dan Air Terhadap Hasil Jadi Marbling pada Bahan Duchesse. e-Journal Tata Busana, 7(2), 120–124.

19 Subagya, H. & Purbayanti, E. D. (2020). Pengaruh Konsentrasi Carboxymethyl Cellulose (CMC) sebagai Media Marbling terhadap Kualitas Motif. Jurnal Industri Tekstil, 15(2), 87–96.

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21 Lestari, D. A. & Wahyudi, T. (2022). Uji Ketahanan Luntur Warna terhadap Pencucian pada Kain Batik dengan Pewarna Alam. Arena Tekstil, 37(1), 35–44.

Color fastness of suminagashi scarf technique (marbling pattern)	Color (Kotler, 2000 in Azany, 2014)	Color (Kotler, 2000 in Azany, 2014)	7, 8
		Color binder (Dharsono, 2007 in Nisa, 2022)	9, 10

Source: Developed from various theoretical sources, 2026

Data Analysis Techniques

The assessment data were analyzed using the nonparametric Kruskal-Wallis test[22]. This test was chosen for two reasons: first, the ordinal data from the Likert scale assessment did not meet the assumption of a normal distribution (verified by the Shapiro-Wilk test, $p < 0.05$); second, the relatively small sample size ($n = 15$ per group) made the parametric test less appropriate. The Kruskal-Wallis test is the nonparametric equivalent of one-way ANOVA and is appropriate for comparing three independent groups. The statistical formula used is:

$$H = [12 / N(N+1)] \times \Sigma_i[n_i(\bar{R}_i - \bar{R})^2]$$

Description: H = test statistic; N = total number of observations; n_i = number of observations for the i-th group; $\bar{R}_i$ = average rank for the i-th group; $\bar{R}$ = average overall rank.

Decision criteria: H_0 is rejected if the significance value is $p < 0.05$, meaning there is a significant difference between the groups. If $p \geq 0.05$, H_0 is accepted. Interpretation of the average scores uses the guidelines in Table 3 adapted from Thomas and Mark (2015)[23].

Table 3. Guidelines for Interpretation of Average Scores

Average Range ($\bar{X}$)	Category
$1,00 \leq \bar{X} < 1,75$	Bad
$1,75 \leq \bar{X} < 2,50$	Not Good
$2,50 \leq \bar{X} < 3,25$	Good
$3,25 \leq \bar{X} \leq 4,00$	Excellent

Source: Adapted from Thomas & Mark (2015)

RESULTS AND DISCUSSION

Marbling Motif Quality on Three Types of Fabric

The results of the 15 panelists' assessment of the quality of marbling motifs on the three types of fabrics are presented in Table 4. Overall, the average total quality of the motifs reached **X** = 3.35, which is in the Very Good category. Among the three fabrics, crepe obtained the highest average (**X** = 3.53; Very Good), followed by polyester satin (**X** = 3.38; Very Good), and polyester blend (**X** = 3.03; Good).

Table 4. Marbling Motif Quality Data Analysis Results

Variable	Indicator	Stat.	Fabric			Total	Criteria
			Satin	Polyester	Crepe		
Quality	Desain	X	3.51	2.97	3.66	3.38	Excellent
		Sd	0.33	0.59	0.37	0.43	
		Cv	0.09	0.20	0.10	0.13	
	Fabric	X	3.26	3.08	3.4	3.25	Good
		Sd	0.33	0.61	0.25	0.40	
		Cv	0.10	0.19	0.07	0.12	
	Total	X	3.38	3.03	3.53	3.35	Excellent

Source: Author, 2026 (Primary Data). Description: $\bar{X}$ = mean; Sd = standard deviation; CV = coefficient of variation

On the design subdimension—which assesses visual appearance, fidelity, and clarity of the pattern—crepe achieved the highest score ($\bar{X}$ = 3.66), followed by polyester satin ($\bar{X}$ = 3.51), and polyester blend ($\bar{X}$ = 2.97). It is noteworthy that the coefficient of variation (CV) of the polyester blend reached 0.20 on this subdimension—more than double the CV of crepe (0.10)—indicating higher

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[23] Thomas, R. & Mark, S. (2015). Research Methods in Education (7th ed.). London: Routledge.

inconsistency of results between panelists. This reflects the inherent variability of polyester blend fabrics: loose fibers on the surface create local absorption inhomogeneities that result in patterns with less consistency[24].

On the material subdimension—which assesses material suitability and surface absorbency quality—the differences between fabrics were narrower: crepe ($\bar{X}$ = 3.40), polyester satin ($\bar{X}$ = 3.26), and polyester blend ($\bar{X}$ = 3.08) all fell within the Good to Very Good range. These findings indicate that all three fabrics maintained their material integrity after the suminagashi process without significant fiber degradation, despite differences in the quality of the retained motifs[25].

The Kruskal-Wallis test showed an H value of 3.22 with p = 0.20 (α = 0.05), thus H_0 was accepted: there was no statistically significant difference in motif quality between fabrics. This result is consistent with the findings of Amelia and Wahyuningsih (2020)[26], who found that differences between fabrics in common marbling techniques tended not to consistently reach the threshold of statistical significance when other factors (paint, media viscosity, transfer technique) were strictly controlled. Nevertheless, the average difference of 0.50 points between crepe and polyester blends—equivalent to one rating on the instrument scale—has practical significance that cannot be ignored. In the fashion accessories industry, such a significant difference in visual quality can directly impact the product's selling value[27].

Color Fastness to Washing

The results of the color fastness analysis to washing on the three fabric samples are presented in Table 5. The average total color fastness reached **X** = 3.44 (Very Good). Crepe fabric obtained the highest value (**X** = 3.80; Very Good), followed by polyester satin (**X** = 3.68; Very Good), and polyester blend (**X** = 2.85; Good).

Table 5. Marbling Pattern Durability Data Analysis Results

Variable	Stat.	Fabric			Total	Criteria
		Satin	Polyester	Crepe		
Resistance Color	X	3.68	2.85	3.8	3.44	Excellent
	Sd	0.34	0.49	0.21	0.35	
	cv	0.09	0.17	0.05	0.10	

Source: Author, 2026 (Primary Data). Description: $\bar{X}$ = mean; Sd = standard deviation; CV = coefficient of variation

A summary of the Kruskal-Wallis test results for both aspects is presented in Table 6. In the fastness aspect, the test yielded H = 4.61 with p = 0.10 (> 0.05), so H_0 was accepted. However, the average difference between crepe (3.80) and polyester blend (2.85) reached 0.95 points—a substantive difference that lies on the border between the Good and Very Good categories. This difference is practically very meaningful for consumers who are concerned about the color durability of the product after repeated use.

Table 6. Summary of Kruskal-Wallis Test Results on Both Assessment Aspects

Test aspects	Statistic H	df	p	decision
Marbling Pattern Quality	3,22	2	0,20	H_0 accepted
Color Fastness	4,61	2	0,10	H_0 accepted

Source: Author, 2026 (Primary Data). df = degrees of freedom; p = significance value; α = 0.05

The CV value of polyester blend fabric for fastness (CV = 0.17) is much higher than crepe (CV = 0.05) and polyester satin (CV = 0.09), indicating greater variability between sample units. This high variability is consistent with the inhomogeneous nature of the blend fiber: the uneven distribution of polyester and non-polyester fibers in the supernova fabric causes local differences in dye absorption

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and retention, so that some areas of the pattern are more fastness resistant than others[28].

Discussion: The Mechanism Of Crepe Fabric Excellence

Crepe fabric consistently outperformed other fabrics in both assessment aspects. This superiority can be explained by three interrelated mechanisms:

First, the hygroscopic fiber composition. Silk fibers in crepe fabric have the ability to absorb up to 30% of their own weight in moisture, supported by a porous microfibril structure and a high chemical affinity for water-based pigments29. Rayon, as a regenerated cellulose fiber, complements this property with hydroxyl (-OH) groups in its polymer chains that form hydrogen bonds with dye molecules30. The combination of these two creates a fiber matrix capable of absorbing and retaining acrylic pigments much more deeply than hydrophobic polyester fibers31.

Second, the surface morphology optimizes pattern transfer. The crinkled texture (crepon) of crepe fabric increases the effective contact surface area with the water medium, extending the contact time between the pigment and the fiber during the transfer process[32]. The longer the contact time, the greater the quantity of pigment absorbed into the fiber before the fabric is removed from the medium. In contrast, the very smooth and hydrophobic surface of polyester satin actually accelerates water drainage from the fabric surface, reducing the effective contact time and potentially distorting patterns that have not yet been fully fixed[33].

Third, a stronger pigment fixation mechanism. Acrylic paints work through a physical-mechanical binding mechanism: polymer particles fill the interfibrillar spaces of the fiber as the substrate dries, forming a binder layer that locks in the pigment. In hygroscopic fibers, larger and more abundant interfibrillar spaces allow deeper binder penetration, resulting in a stronger mechanical bond and resistance to abrasion and washing[34]. Gülümser et al. (2019)[35] confirmed similar findings: fabrics based on natural and semi-synthetic fibers consistently exhibited better color fastness than pure synthetic fiber fabrics when using water-based dyes, due to the more complex fiber-dye chemical interaction mechanism.

Polyester satin fabric, while producing an attractive visual effect due to its surface sheen, exhibited lower color fastness values than crepe. This aligns with the findings of Kan and Chan (2018)[36] that unmodified polyester has suboptimal dye uptake and therefore requires pretreatment such as alkaline scouring or plasma treatment to improve hydrophilicity before water-based dyeing. The study of these pretreatment techniques represents an interesting direction for further research.

From a sustainability and economic empowerment perspective, all three fabrics have proven

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[36] Kan, C. W. & Chan, K. (2018). Effect of surface modification treatments on the coloration of polyester fabric. Fibers and Polymers, 19(4), 852–861.

suitable for use in suminagashi applications in fashion accessory products. Setyaningsih (2023)[37] emphasized the relevance of the suminagashi technique as a sustainable textile dyeing alternative due to its minimal waste and the use of non-toxic materials. Laxmita et al. (2024)[38] added that the simplicity of the procedure and the availability of materials allow this technique to be implemented in community entrepreneurship training programs with minimal equipment investment. The resulting unique motifs—no two pieces of fabric are identical—provide significant added commercial value.

Figure 1. Marbling Result (crepe, mix-polyester, satin)
(a) Crepe (b) Polyester Blend(c) Satin Polyester
Souces: Author, 2026 (Primary Data)

CONCLUSION

Based on the research results and discussion, the following three things can be concluded. First, statistically there is no significant difference between the three types of fabrics in terms of marbling quality ($H = 3.22$; $p = 0.20$) and color fastness to washing ($H = 4.61$; $p = 0.10$), so H_0 is accepted in both aspects. Second, empirically crepe fabric produces the best quality in both assessment aspects: pattern quality ($\bar{X} = 3.53$; Very Good) and color fastness ($\bar{X} = 3.80$; Very Good), followed by polyester satin ($\bar{X} = 3.38$ and 3.68; both Very Good), and polyester blend ($\bar{X} = 3.03$ and 2.85; Good). Third, the empirical superiority of crepe fabric is explained by three mechanistic factors: (a) the hygroscopic nature of silk and rayon fibers that facilitate deeper dye absorption; (b) the wrinkled surface morphology that increases the contact area and effective transfer time; and (c) a stronger pigment fixation mechanism in the porous fiber matrix.

Based on these findings, this study recommends: (1) for fashion accessory craftsmen and designers, crepe fabric is the most optimal material choice for the suminagashi technique; (2) for users of polyester satin fabric, the application of pre-treatment techniques (such as alkaline scouring or plasma treatment) before the suminagashi process has the potential to significantly improve the quality of the results; (3) the transfer process should be carried out slowly, evenly, and without excessive pressure—the use of a printing frame can improve consistency; and (4) further research is recommended to explore other types of fabrics (cotton, linen, organza, viscose) and test different CMC variables and dye concentrations with a more comprehensive factorial design.

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DECLARATION OF CONFLICTING INTERESTS

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