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Research Article

Study of Sun Protection Factor (SPF) Batik Textile Fabric on Solar Radiation in Pekalongan

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Abstract

The amount of sunscreen ability is determined through the value of a person's Sun Protection Factor (SPF) when under the sun without experiencing sunburn. This study aims to measure the intensity of sunlight received by batik textile fabrics and SPF measurements to determine the ability of these fabrics to protect sunlight radiation. The research was conducted at the Sorogenen area in Pekalongan, Central Java. The intensity data collection is done during the sunny weather with 30^{0}C - 32^{0}C temperature. The SPF value is calculated by comparing the intensity of sunlight without and with a protective batik cloth. Between 10:00 a.m. and 2:00 p.m. (GMT +7), the average intensity is 85.160 lux to 113.400 lux. The results obtained by fabric with a thickness of 2 mm have an SPF greater than fabric with a thickness of 1 mm. Cotton fabric has the ability to protect against sunlight better than satin and Mori fabric. A blue cotton cloth owns the most significant SPF value with a thickness of 2 mm of 36.06. In comparison, the smallest SPF value is owned by yellow Mori fabric with a thickness of 1 mm of 5.24.

Keywords: *Sun Protection Factor; intensity; batik textile fabrics*

Kajian Sun Protection Factor (SPF) Kain Tekstil Batik Terhadap Radiasi Matahari di Pekalongan

Abstrak

Besarnya kemampuan tabir surya ditentukan melalui nilai Sun Protection Factor (SPF) kulit seseorang ketika berada dibawah sinar matahari tanpa mengalami sengatan surya. Penelitian ini bertujuan untuk mengukur intensitas sinar matahari yang diterima kain tekstil batik dan pengukuran SPF untuk mengetahui kemampuan kain tersebut dalam memproteksi radiasi sinar matahari. Penelitian ini dilakukan di Lapangan Sorogenen Kota Pekalongan. Pengambilan data intensitas dilakukan pada saat cuaca cerah dengan suhu 30^{0}C – 32^{0}C dari pukul 10.00 hingga pukul 14.00 WIB. Nilai SPF dapat dihitung dengan membandingkan intensitas sinar matahari tanpa pelindung kain batik dengan intensitas sinar matahari dengan pelindung kain. Intensitas rata - rata pada rentang pukul 10.00 hingga pukul 14.00 WIB sebesar 85,60 lux hingga 113,400 lux. Hasil yang diperoleh kain dengan ketebalan 2 mm memiliki SPF lebih besar dibandingan kain dengan ketebalan 1 mm. Kain katun memiliki kemampuan *proteksi terhadap sinar matahari lebih baik dibandingkan kain satin dan kain mori. Nilai SPF paling besar dimiliki oleh kain katun berwarna biru dengan ketebalan 2 mm sebesar 36,06. Sedangkan nilai SPF paling kecil dimiliki kain mori kuning dengan ketebalan 1 mm sebesar 5,24.*

Kata Kunci: *Sun Protection Factor; Intesitas; kain tekstil batik*

PACS: 01.40.-d; 07.89.+b; 42.88.+h

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I. INTRODUCTION

Indonesia is positioned on the equator, which results in quite strong sun radiation levels. Thus, throughout the course of a year, solar radiation exposure reaches 6 to 8 hours every day [1]. The sun emits an electromagnetic spectrum of energy. The wavelengths of various types of energy, or radiation, are categorized. These emissions are classified according to their wavelength, which is measured in nanometers. (1 nm = 10^{-9} m). The radiations with shorter wavelengths are more energetic. Sunlight that reaches the earth is composed of 66 % of infrared light, 32 % visible light, and 2 % ultraviolet light [2].

Ultraviolet light is a source of energy from the sun that can penetrate the atmosphere to the earth's surface [3]. Ultraviolet light radiation cannot be seen and felt directly by humans. Ultraviolet light from the sun has good benefits, one of which is for the formation of cholecalciferol (Vitamin D). Cholecalciferol plays a role in the metabolism of bone formation and also in defense of the body's immune system [4]. Excessive radiation can cause adverse effects in humans such as sunburn, skin cancer, eye damage, photosensitivity, and others [5].

In 1989, a consensus was reached in the United States to reduce the risk of UV radiation exposure through the use of appropriate clothing, the use of physical and chemical sunscreens, increasing the behavior of avoiding solar exposure, being cautious with photosensitive treatments, and being aware of the adverse effects of exposure [6]. In line with this consensus, many other countries, including Indonesia, set a program to reduce the risk of solar exposure, namely by avoiding solar exposure when UV radiation is highest, between 10.00 to 16.00, covering the body with appropriate clothing wearing sunscreen [7]. Still, sunscreen use sometimes gives disorders to some people, such as skin allergies, discomfort, and health problems [8].

Clothing can protect the skin against sun exposure, even seen as the simplest step in reducing the harmful effects of sunlight on the skin [9]. In line with research conducted by Sayed et al. [10], clothing can protect the skin from solar radiation because the fabric can reflect, absorb, and spread the wavelength of the sun [11]. The need and effectiveness of clothing protection against UV radiation depend on the fabric's type and color [12].

Pekalongan City is one of the UNESCO creative city networks in the category of crafts & folk art in December 2014. It has the city branding city of “The World's City of Batik,” one of the largest batik industry centers in Indonesia [13]. Batik Pekalongan has different characteristics or characters from batik from other coastal areas. Batik Pekalongan is rich in colors and motifs that continue to develop [14]. Batik Pekalongan textile fabric raw materials generally use various fabrics such as cotton, mori, satin, *paris* (cotton-like but thinner), silk, and pineapple fiber fabrics [15].

The purpose of this research is to determine the following: (1) the intensity of sunlight in the city of Pekalongan; (2) the SPF value of Pekalongan batik textile fabric (cotton cloth, mori cloth, and satin fabric) in various colors in order to determine the most effective fabric in protecting against solar radiation.

II. METHOD

This research was conducted from September 24, 2019, to October 5, 2019. The stages of this study were measured in Sorogenen Area East, Pekalongan City. They used the Luxmeter HS1010 equipment to assess the amount of solar radiation that can be transmitted to batik cloth in order to protect it from sun exposure.

The batik cloth used in this study consisted of three types of fabric, namely: cotton, mori, and satin. Each color variation is done to determine the effect of color factors in protection from UV radiation exposure including red, dark blue, green, brown and yellow. In addition to variations in color and type of fabric, in this study variations in thickness of 1 mm and 2 mm were also carried out to analyze the effect of fabric thickness on solar radiation protection.

The efficacy of a sunscreen product has been recognized as an important public health issue. It is usually expressed by the sun protection factor (SPF), which is defined as the UV energy required to produce a minimal erythema dose (MED) on protected skin, divided by the UV energy required to produce a MED on unprotected skin. The minimal erythemal dose (MED) is defined as the shortest time interval or lowest dose of UV light irradiation necessary to produce a minimal amount of perceptible erythema on unprotected skin. The higher the SPF, the more effective the product is in preventing sunburn [16]. The dose that results in minimal erythema extending to the borders of irradiation is then used to determine the SPF of the fabric as equation (1) [17]:

$$SPF = \frac{MED_0}{MED} \qquad (1)$$

With, SPF is the value of Sun Protection Factor, MED_O: the dose of sun radiation received by the skin without a protective cloth (lux) and MED: the dose of sun radiation received by the skin with a protective cloth (lux).

Measurement of the intensity of sunlight radiation is carried out between 10:00 a.m. and 2:00 p.m. (GMT +7); data is gathered every hour, up to four times. Based on the time span data, the average intensity of sunlight without a protective cloth is calculated, and the average intensity using a protective cloth to obtain the most effective SPF value based on fabric type, color, and thickness.

III. RESULTS AND DISCUSSION

The average intensity of sunlight in the Sorogenen area of Pekalongan City was measured without protective fabric, the graph shows the data in Figure 1.

Figure 1 shows the highest average intensity of sunlight without protective cloth is in the range of 12:00 - 13:00 (GMT +7) at 113,400 lux, while the lowest average intensity is at 10:00 - 11:00 (GMT +7) with 85,160 lux intensity.

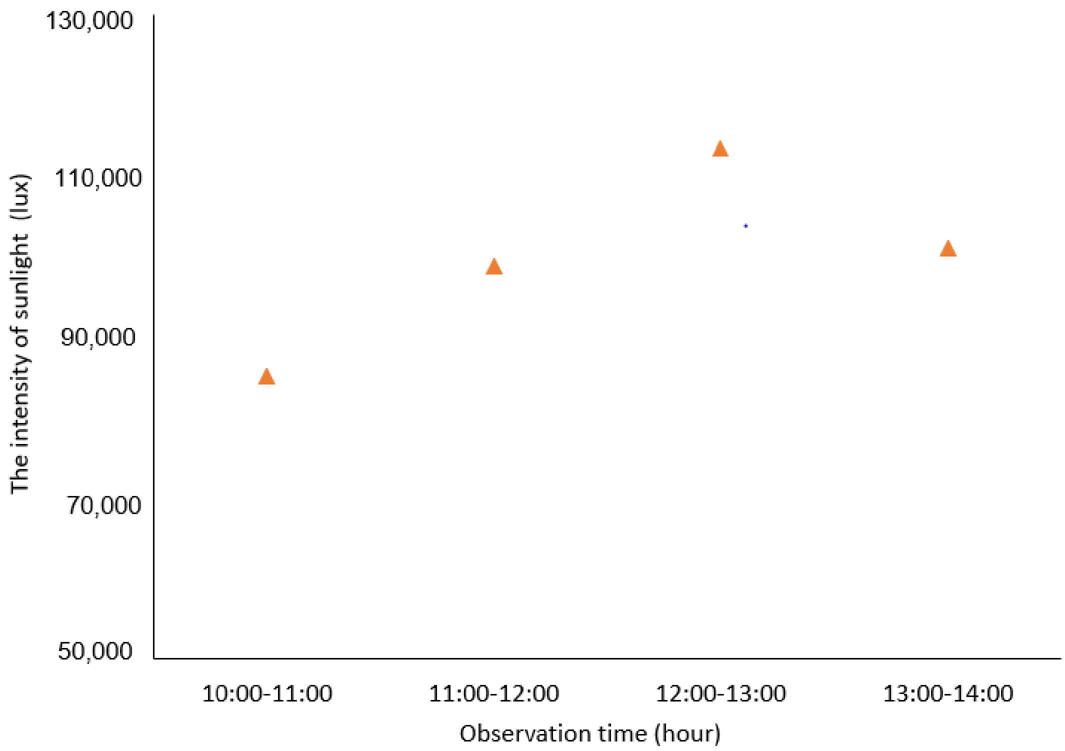

Figure 1. Average Intensity of Sunlight without Protective Cloth

These results are the same as previous studies conducted by [5] on Kuta Beach in Bali that the highest average intensity of sunlight without protective cloth occurs at 12:00 – 13:00 (GMT +8). Wong et al. [18] have also conducted studies on the intensity of sunlight without protective cloth which produces the highest average intensity at 12:00 – 14:00.

Data on the average intensity of sunlight with a protective cloth is measured in the same timeframe, from 10:00 - 11:00 (GMT +7) to 13:00 – 14:00 (GMT +7) in Pekalongan City, which can be presented in the graphical form Figure 2a and 2b.

It is shown in Figure 2a, and Figure 2b that the highest average intensity of sunlight occurs between 12:00 and 1:00 p.m. (GMT +7) for yellow cloth with a thickness of 1 mm at 21,078 lux, and the lowest average intensity of sunlight occurs at 10:00 – 11:00 (GMT +7) for blue cotton fabric with a thickness of 2 mm at 1,580 lux.

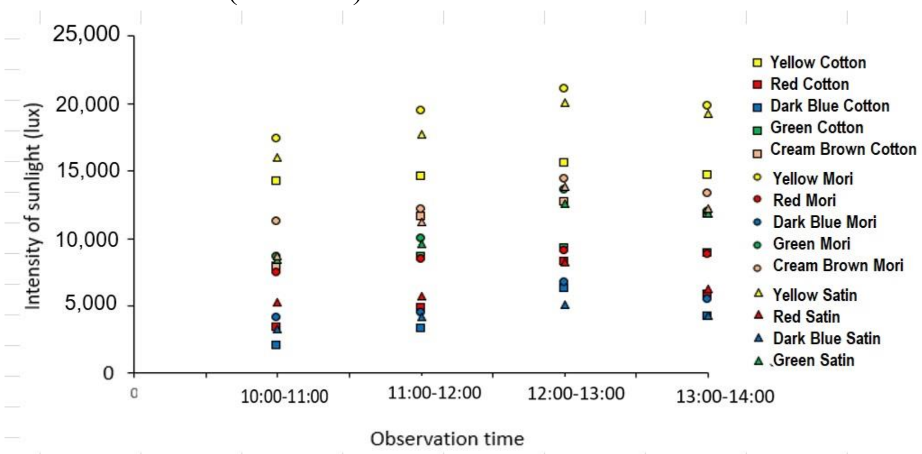

Figure 2a. Average Intensity Chart of Sunlight with 1 mm Thick Protective Cloth

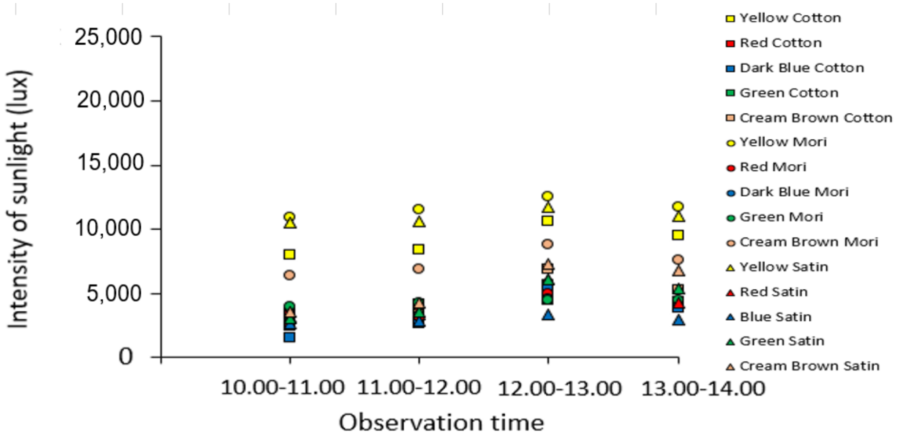

Figure 2b. Average Intensity Chart of Sunlight with 2 mm Thick Protective Cloth

At 1:00 and 2:00 p.m. (GMT +7), solar radiation's intensity decreases because the sun's exposure begins to dim. Allen et al.[19] measuring the intensity of sunlight using a few pieces of shirt fabric and the whole shirt fabric also obtained the result that the highest intensity occurred at 12:00 – 13:00 that is equal to 183,000 lux for t-shirt fabric.

Another study conducted by Singh, et al. [20] to compare ultraviolet protection with fabric techniques between warp and woven yarn fabric produced that the highest intensity of sun exposure occurred at 11:00 – 13:00 amounted to 23,743 lux for warp woven fabric. Veramika et al. [11] conducted a study to determine the SPF value of sunlight using cotton, rayon, and polyester fabrics at Kuta Beach, Bali, resulting in intensity levels in the 10-11 hours to 16-17 hours range ranging from 59,760 lux to 138,660 lux.

The SPF value tells a person how much longer he/she can remain in the sun wearing the fabric to receive the same dose of erythemogenic UV on the fabricprotected portion of the skin as on unprotected skin. The higher the SPF value, the better the fabric's ability to protect against sunburn [21]

Ghane, et al [22] invested UPF on six cotton/polyester samples, nylon yarn as warp yarn, and aluminum or copper yarn when weft was produced which was composed of weft yarns using spectrophotometer techniques. It was concluded that the absorption ability of nylon fabrics was higher than that of cotton/ polyester samples of 2.8557. Tantari [23] added that the clothes' protective nature depends on its fibre's struvture, color, waterproof properties, and refine processes. Personal protection towards Ultraviolet radiation can be further supported by wearing a big cap, using an umbrella, being under a shade, using appropriate protective clothing, and avoiding the sunlight between 10:00 am – 04:00 pm.

The SPF value of each batik textile fabric is calculated by comparing the intensity of sunlight without a protective cloth to the intensity of sunlight using a protective cloth using Equation (1). The average SPF can be presented in Figure 3b.

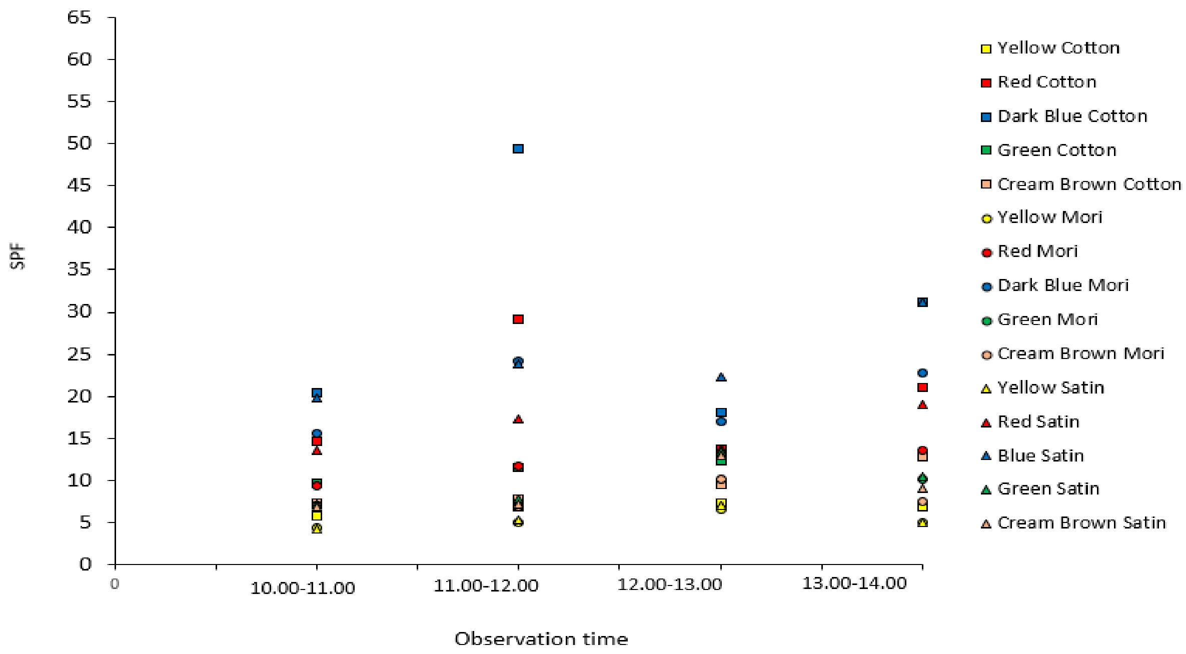

Figure 3a. SPF Value Chart of Batik Fabric with a Thickness of 1 mm Against Time

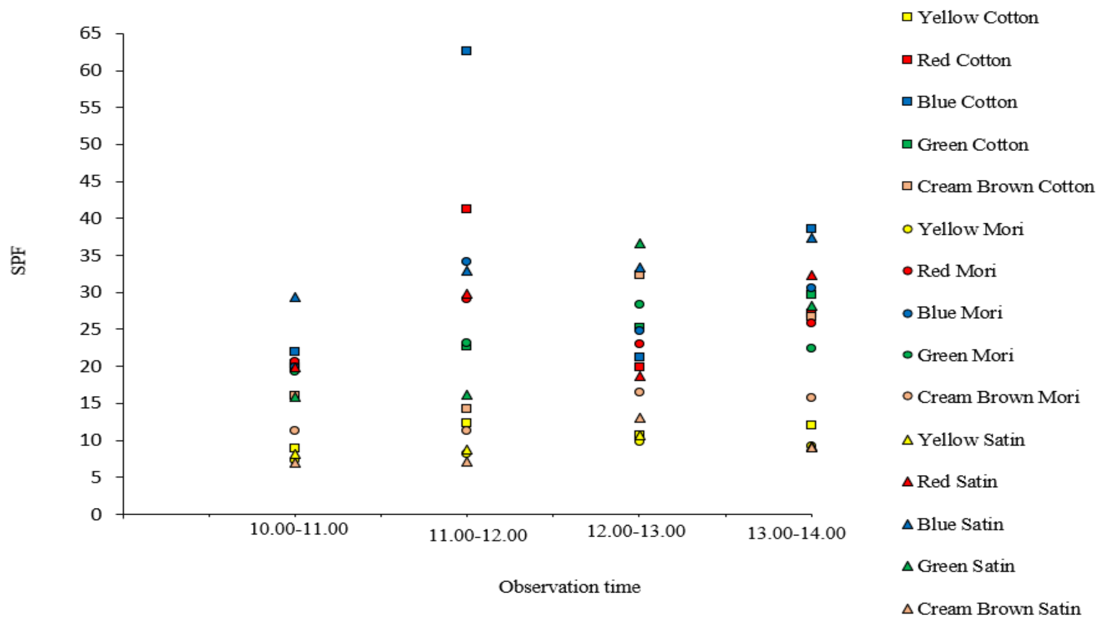

Figure 3b. SPF Value Chart of Batik Fabric with a Thickness of 2 mm Against Time

In Figure 3a and 3b, the average SPF is calculated from 10:00 – 11:00 a.m. to 1:00 – 2:00 p.m. (GMT +7). The greatest SPF value is 62,59 for blue cotton fabric with a thickness of 2 mm between 11:00 a.m. and 12:00 p.m. (GMT +7), while the lowest SPF value is 4,32 for yellow cloth with a thickness of 1 mm between 10:00 a.m. and 11:00 a.m. (GMT +7).

The difference in SPF values between fabrics is related to each fabric's capacity to retain the sunlight that reaches its surface. [24]. The type of fabric and fabric color affect the protection from the sun [25]. In the same type of fabric, different colors can protect different rays of the sun. Dark-colored materials such as black, blue, and red offer the best sun protection since pigments absorb the sun's radiation [26].

Grifoni, et al. [27] investigates the properties of UV protection in fabrics made of vegetable fibers (cotton, flax, hemp, and ramie), with different construction parameters (drapery and apparel fabrics), colored with some of the most common natural dyes. The results revealed that thick and dense (cover factor, CF > 94 %) drapery fabrics made of vegetable fibers showed good UV protection even if it is not colored [28].

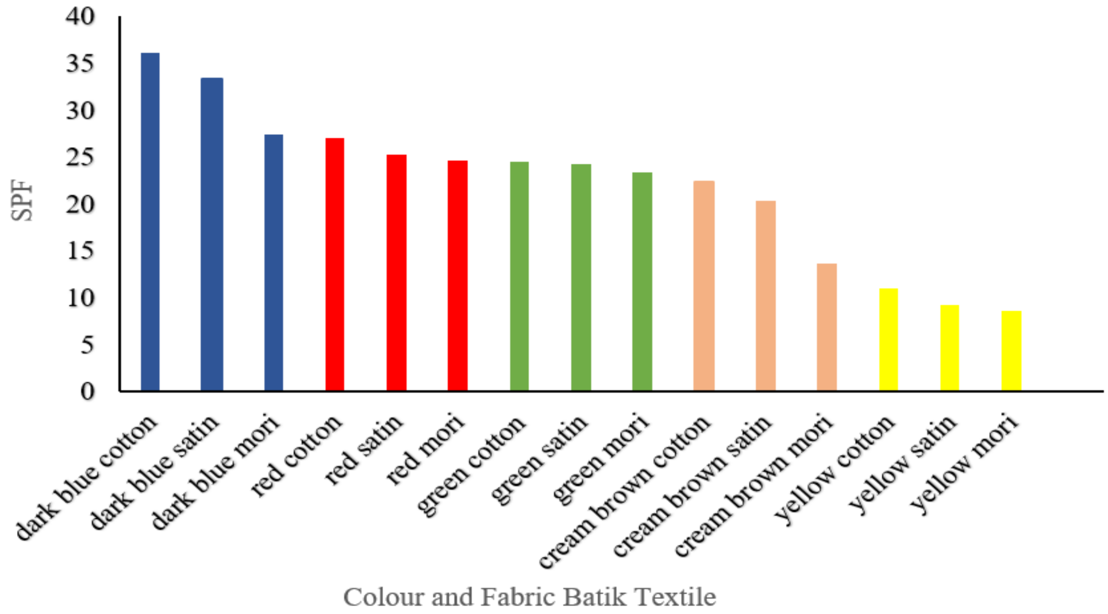

Figure 4b. SPF Value of Batik Fabric with a Thickness of 2 mm

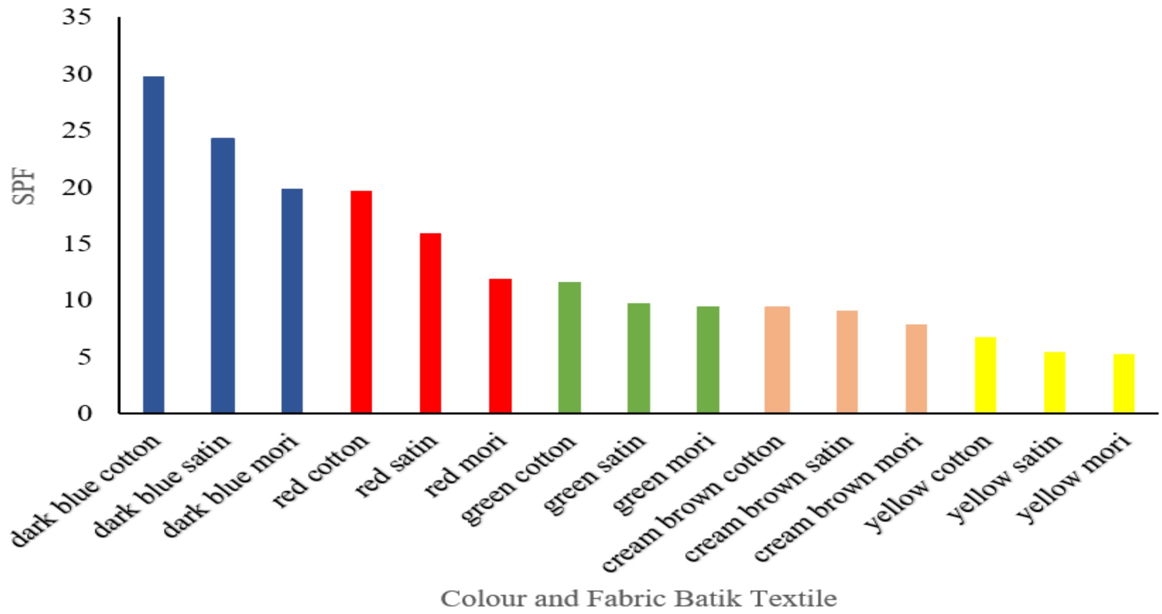

Figure 4a. SPF Value of Batik Fabric with a Thickness of 1 mm

Figure 4a and Figure 4b show the SPF value of various types of batik textile fabrics such as cotton fabrics, Mori fabrics, and satin fabrics. The optimum average SPF value is influenced by fabric thickness. SPF value for 2 mm fabric thickness is greater than 1 mm fabric thickness, thicker fabric transmits less UV radiation, so it has better sun protection capability. Dyes used to dye batik textiles can affect the UV protection of the fabric, depending on the position and intensity of the UV wavelength absorption band of the dye and the concentration of the dye in the textile. The absorption of UV radiation can affect substrate, attributes, including fluorescence, update information on test methods and standards for determining the UV protection of apparel textiles and on factors affecting UV protective.

In this study, blue cotton fabric with a thickness of 2 mm has the highest average SPF value 29.78, and yellow cloth with a thickness of 1 mm has the lowest average SPF value of 5.45. The average SPF value of each batik cloth can be displayed in Figure 4a and Figure 4b. Photodegradation, and UV protection [29]. In general, dark colors provide better UV protection because of increased UV absorption. However, certain hue dyes can vary greatly in the level of UV protection due to individual transmission and absorption characteristics.

Brightly colored fabrics reflect sunlight around them or can be thought of as objects with vivid colors that absorb fewer photons. According to the findings of this study, the blue cotton fabric had the highest SPF value, while the yellow cloth had the lowest. According to Hoffmann, et al. [28], SPF parameters for textile fabrics are as follows:

Table 1. Different SPF Ranges and UVR Protection Category

SPF Range	UVR Protection Cateory
15 – 24	Good protection
25 – 39	Very good protection
40 – 50	Excellent protection

The SPF value of Pekalongan batik textile fabric that can protect against sunlight is a dark blue cotton cloth, and the dark blue satin fabric has very good protection against sun radiation. Dark blue Mori cloth, red cotton cloth, and red satin fabric have good protection against sunlight radiation. Green satin batik textile fabric green Mori fabric, brown cotton fabric, brown satin fabric, brown Mori fabric, yellow cotton fabric, yellow satin fabric, and yellow Mori fabric are included in the category insufficient protection.

Batik textile fabric, in its function as clothing, has long been used as part of efforts to protect against sun exposure. Even some experts declare clothing as the main but simple mode of protection against sunlight. Batik textile fabrics, including UV absorbers of various types. When increasing UV protection, it is critical to select materials with a low risk for irritation and sensitivity. In addition, strict requirements for design must be obeyed for clothing assigned to sun protection clothing. Clothing also plays an important role in the prevention of skin cancer and dermatosistive photosensi. As a result, further educational efforts are needed to change people's solar behavior and raise awareness for the use of adequate sun-protective clothing. Whether there will be a market for labeled UV protective clothing is highly dependent on consumer acceptance and investigation.

IV. CONCLUSION

Based on this study, it was concluded that the intensity of sunlight from 10:00 to 14:00 WIB. Fabrics with a thickness of 2 mm have an SPF more significant than a thickness of 1 mm. The most significant SPF value is the blue cotton cloth, while the smallest SPF value is owned by yellow Mori fabric. Dark colors on the fabric will protect against solar radiation that is higher than bright colors. The type of fabric also influences protection against sun exposure. Cotton fabric is more resistant to sunlight than satin and cloth.

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