Extraction of Natural Dye from Red Spinach (*Amaranthus Dubius)*

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***Abstract*— The revival of manufacturing natural dye has been one of the options to counteract pollution caused by synthetic dye. The research was conducted to extract natural dye from red spinach (*Red amaranth)*. Component responsible for the red coloring in the red spinach is betacyanin. Solvent extraction method using ethanol was used to extract the natural dye. Ratios of 30:70, 40:60 and 50:50 of ethanol water was prepared as the solvent medium. The extracted dye was used to dye a white cotton fabric for fastness test. Fastness test was conducted to evaluate the capability of the dye to stick to the fabric without running off or fading. Three fastness test was performed which includes light, wash and rub. Three different shades of red were produced from the three different ratios. The darkest red shade was obtained from 50:50 ratio and the lightest red shade was obtained from 30:70 ratio. As for the fastness test, light and rub test showed good fastness whereas washing showed medium to poor fastness.**

***Keywords*— Red spinach, natural dye, solvent extraction method.**

I. INTRODUCTION

The art of natural dye has been long forgotten ever since the discovery of the synthetic dye in the nineteenth century. It used to be an ancient art practiced commonly in India, Egypt and Central Asia as the earth is rich in natural resources. Different colours of plants are used to extract the desired colours of natural dye. There are many parts of the plant that can be beneficial in producing natural dye such as the bark, stem, leaves, roots and flowers. However, since the knowledge on natural dye are not practised, there are no development in extracting and dyeing technique. Therefore, to satisfy the growing demand for dyes, the manufacturer chooses synthetic dyes. The advantages of producing synthetic dye includes simple process of production in large quantity with reasonable price. However, it was found out that, the usage of synthetic dye has been harmful to the environment. Based on the previous study, the mordant used in the synthetic dyes which is to enhance the colour of synthetic dye are cytotoxic and carcinogenic that can cause various diseases to living organisms and the environment [4,10]. This is because of the chemical substance known as potassium dichromate aaffects human in such organ damage, lesions on body parts, decrement of fertility rate and food intake capacity are caused by synthetic dyes [3]. The breaking news on synthetic dyes causes the textile industry to be greatly affected as it has triggered the balance of the ecosystem at an alarming rate.

Synthetic dyes are widely applied in the textile industry with the purpose of dyeing fabrics such as nylon, leather, silk, wool and cotton [3]. Invented by an English scientific expert, William Henry Pekin in the mid-nineteenth century, the practice of synthetic dyes began to conquer the food, cosmetic and textile industries [1]. This is because the synthetic dyes can be easily obtained at a cost-effective price with various shade of colors [2]. Even though synthetic dyes are cost-effective in terms of pricing with variety of shades, like any other product, it also has its downside. Manufacturing synthetic dyes requires knowledge because to produce a specific hue of colour, a detail and precise calculation and measurement should be made. Thus, it need skilled labour to match the right amount of colour for a specific shade because lack of the individual variety of various colour parts can cause the manufactured colour to be similar in shade. The other disadvantage of synthetic dye is that, synthetic dye fade quicker than natural dyes even though chemicals are added to prevent the dye from washing-off. However, since it can produce easily by proper measurement and calculation, the synthetic can easily be reproduce to enhance the faded colour.

Natural dyes were originated from the ancient art of China which was adapted in Europe during Bronze Age [2]. It was manufactured from plants, animals and minerals which are organic with hydroxyl group binded on their nucleus. During the manufacturing and application process of the natural dyes, no pollution is created. Besides keeping the ecosystem in balance, the natural dyes are ecofriendly, non-toxic and does not contain allergens [6]. The demand of natural dye continue to increase worldwide after the consciousness of the downside of synthetic dyes [1]. Since one of the reason for not choosing natural dye is that the lack of development in extracting process, researchers came up with various study regarding the extraction of natural dye. Advance technologies which are environmental friendly, durable and profitable technologies are applied to broaden the traditional ways of extracting natural dyes [11].

Red spinach (*Amaranthus dubius*) is an edible red coloured amaranth which is also known as the Chinese spinach. Belongs to the family of Amaranthaceae. *Amaranthus dubius* is the only tetraploid *Amaranthus* species. It is a weedy type of plant that can be found scattered especially in the humid low land tropics [7]. Red spinach, *Amaranthus dubius* is claimed to be the product of an invention from *Spinacia oleracea L.* with the aim of producing a spinach with more extensive red colouration than the existing spinach. During the research, it was discovered that the red colouration of the leaves of the spinach was caused by genetic determinant which exist in the epidermis cell of the spinach leaf located among the veins of upper and lower leaf. As a result, a beautiful and savoury red spinach plant was invented which are full of health benefits due to the presence of betacyanin.

Betacyanin, molecular structure shown in Figure 1, is known for its indication of outstanding antioxidant activity [9]. It was claimed to have an anticancer effects. Red colouration of the red spinach was caused by the betacyanin contents which is classified in the betalains group [8, 9]. Betalain on the other hand are grouped into betacyanins and betaxanthins. Betanin, isobetanin, probetanin, neobetanin, amaranthine, isoamaranthine, iresins (acylated amaranthine), celosianins (acylated amaranthine), gomphrenin I, isogomphrenin I, acelated gomphrenins are the examples of betacyanins. The betacyanins presence in the plant can be determined via sample solution in extraction buffer, absorbance

spectrum using quantifying the betacyanin absorbance peak. Other option are by using high-performance liquid chromatography (HPLC) which enables different types of betacyanins to be determine such as betanin, amaranthine and gompherin. By summing up the different types of betacyanin pigment present, the total betacyanin content may be determined [9].

The present motivation of this research is extracting natural dye from red spinach (Amaranthus Dubius) in order to study the fastness of the natural dye produced.

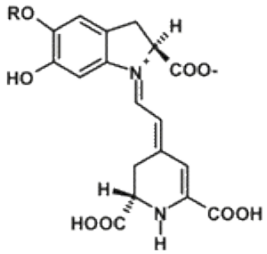


Figure 1: Molecular structure of betacyanin.

II. METHODOLOGY

A. Materials

Source: The red spinach in Figure 2 was freshly purchased from Pasar Besar Klang, Selangor.

Figure 2: Fresh red spinach used as source of material for the study.

B. Methods

Solvent extraction method was used to extract the natural dye from the red spinach.

i. Preparation of Red Spinach Leaves

The leaves of the freshly obtained sample was separated from the stalks before washing them with water thoroughly to remove any forms of impurities sticking to the leaves. After washing, the leaves were left to dry at room temperature to remove surface water from washing. Once dried, the leaves were cut into smaller pieces for the extraction process [16].

ii. Solvent Extraction of Natural Dye from Red Spinach Leaves

100 grams of sample was weighed and was taken into a round bottom flask of 500 ml. Ratio 0f 40:60 of solvent (ethanol: water) was added into the round bottom flask. Water bath was prepared at a temperature of 60°C and the round bottom flask was heated for 1 hour. Crude dyestuff was obtained by filtering the heated solution using cotton cloth filter [1].

iii. Purification of Red Spinach Dye from Extract by Using Vacuum Rotary Evaporator

Rotary vacuum evaporator was used to remove the solvent from the crude dyestuff at 78°C and then collected [16].

iv. Dyeing the Cotton Fabrics with the Extracted Natural Dye from Red Spinach

The white cotton fabric was cut into pieces of 4 cm^2 and was dyed via dip coating method [19]. The dyed fabrics was left to dry at room temperature before conducting fastness test.

v. Light, Wash and Rub Fastness Test on the Fabrics Dyed using Natural Dye from Red Spinach.

Fastness test was conducted on the fabrics dyed with the natural dye to study the capability of the dye to adhere to the fabrics without disappearing or fading. The original sample will be used to differentiate the loss of depth of the colour [20]. Light fastness was done by exposing the dyed fabrics directly to sunlight for 30 minutes, 60 minutes and 90 minutes. Wash fastness was conducted by washing the fabrics in 10 ml of water and 10 ml of water added with 0.1 grams of commercial detergent at room temperature for 15 minutes [19]. Rub fastness was performed by rubbing the fibers of the fabrics to observe if the colour of the fabrics faded [20].

vi. Characterization of Betacyanin Present in the Extracts

III. RESULTS AND DISCUSSION

A. The extracted natural dyes of red spinach

Natural dye were extracted from the leaves of the red spinach by using solvent extraction method where ethanol is used as the solvent. Extraction process was conducted at 60°C for an hour on a hot plate [1]. During the extraction process, it can be observed that the colour of the extract changes with time from purplish to reddish. The purplish colour of the extract can be seen after 30 minutes of heating and the reddish colour can be seen after 1 hour of heating. Colour changing of the extract may be the sign of betacyanin degradation. This is because betacyanin is altered with increasing temperature and time. Upon heating, isomerization, decarboxylation or cleavage may occur which eventually lead to gradual reduction of the colour of the extract [13]. The shades of red produced from the three ratios of solvent can be seen in figure 3.

Figure 3: Shades of red produced from 50:50, 40:60 and 30:70 ratios before solvent removal process.

From left to right, it can be seen that the shades of red changes from darkest to lightest.

Table 1: Shades of red produced from different solvent ratios.

Solvent Ratio	50:50	40:60	30:70
Shades of Red	Dark	Medium	Light

However, before the solvent removal, the colour of the dyes tend to change after keeping the extracts for 2 days under room temperature, the colour of the extract turned from reddish to brownish to greenish as a result of pigment degradation [12].

The extracted dye was then filtered and purified by using a vacuum rotary evaporator to remove the solvent used [16]. Figure 4 shows the extracted dye after the solvent (ethanol water solvent) was removed.

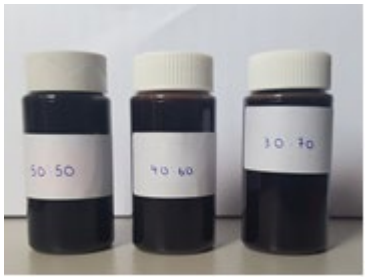


Figure 4: Natural dyes obtained after solvent removal process.

The natural dye was then used to dye a white cotton fabrics whereby dip coating method was used [19]. From figure 5, the shades of the natural dye can be seen clearly and was compared to an undyed fabrics.

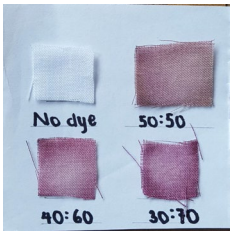


Figure 5: Dyed fabrics using natural dye from red spinach.

B. Fastness Test on the Cotton Fabrics Dyes with Natural Dye from Red Spinach

Three fastness test was conducted which includes light, wash and rub. Light fastness test conducted with a purpose of studying the effects of deterioration of the fabrics dyed with the natural dye upon exposure to sunlight. Different materials of fabrics will react differently to the light exposure [17]. The light fastness test will be affected by internal and external factors. Internal factors includes chemical and physical state of the dye, concentration of the dye, nature of the fibers in the fabrics and types of mordant used. External factors are the source and intensity of the light, temperature and the humidity of the surrounding and the atmospheric pollution present in the surrounding. Table 2 shows the result of the dyed fabrics after light test where the test was conducted from 30 minutes, 60 minutes to 90 minutes.

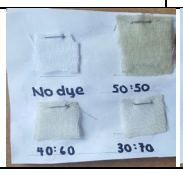
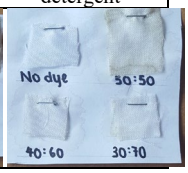
Table 2: Light fastness test at the duration of 30, 60 and 90 minutes.

Duration of Exposure (Minutes)	30	60	90
			

From the observation, no significant changes can be seen after exposing the dyed fabrics to sunlight. This is because when the light fastness is conducted under sunlight, external factors such as temperature and humidity may influence the rate of fading of the fabrics [18]. Therefore, very little effect that is almost undetectable can be observed in the result.

Wash fastness was divided into two test by using water and water added with commercial detergent. In this test, the dyed fabrics were washed in 10 ml of water and 10 ml of water with 0.1 grams of commercial detergent for 15 minutes at room temperature. The result of the test can be observed in Table 3.

Table 3: Comparison of wash fastness using water and water added with commercial detergent.

Wash Fastness	Water	Water and detergent
		

From the table 3, wash fastness with water shows medium fastness and water added with detergent shows poor fastness. Wash fastness is conducted to observe the rate of diffusion of the natural dye on the fabrics [19]. The nature of the fabrics can also effect the wash fastness [19]. Overall, the rate of diffusion of the dyed fabrics were high because no mordant are used.

Rub fastness was performed on the dyed fabrics by rubbing the fibres of the fabrics. When the dyed fabrics causes staining to the other surface, the fibres of the fabrics will be broken into smaller fibres called fibrils. This occurs because of the abrasion from rubbing Factors affecting the rub fastness includes the types of shade and dye, materials of the fabrics and method of dyeing. Fabrics with more long fibers tend to have better rub fastness than the fabrics with less short fibers [21].

The fading of the colour was the observed as seen in figure 5.

Figure 5: Rub Fastness on the dyed cotton fabrics.

Figure 5 shows the result of rubbing fastness of the dyed cotton fabrics. Good rub fastness were shown as there were no fading occurring in all the dyed fabrics. No transference of colour was observed during the rubbing.

Conclusion

Amaranthus Dubius can be obtained easily with affordable price. The study can be concluded that the shades of red in natural dye from red spinach changes with the ratio of the solvent (ethanol: water) used whereby the darkest is obtained from 50:50 ethanol: water and the lightest is obtained from 30:70 ethanol: water. Light and rub fastness of the dyed cotton fabrics were good. Wash fastness of the dyed cotton fabrics were ranged from medium to poor.

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