

Dyeing Properties of Pomegranate Peel Dye to Bamboo Pulp Fiber Fabric

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To understand the use of pomegranate peel, the extraction and dyeing properties of pomegranate pigment from the rind of *punica granatum* L were investigated. Natural pigment was extracted from pomegranate husk directly using boiling water in this paper, and then the bamboo pulp fiber fabrics were dyed by single-factor experiment with direct dyeing methods. The dyeing rate, color fastness, and single tensile properties were also been tested. Finally, the optimum dyeing technological condition of the bamboo pulp fiber fabric was determined. The optimum technical parameters of pomegranate peel dye were obtained: 1:50 of dye liquor ratio, 60°C of dyeing temperature, 60min of dyeing time, and 9 of pH. The dyed bamboo pulp fiber fabrics with pomegranate peel dye had good color fastness properties to soaping, rubbing and perspiration.

1. Introduction

Pomegranate rind is the peel of the plant of *punicaceae*. The shape of pomegranate rind is irregular flake or gourd ladle, and the thickness is between 1.5mm and 3 mm. The color of outside surface is red-brown, yellow brown or dark red, slightly shiny, with brown point and most verrucous small bumps (Lu et al, 2008; Shalini et al, 2014; Mustafa and Necattin, 2013). Pomegranate planted area in China is wide, loved by people, has become one of the focus on the development of fruit. However, pomegranate resources have many active components which have not been fully utilized, almost all abandoned, which caused great waste of resources (Zhu, 2009).

Pomegranate rind is a commonly used traditional Chinese medicine, and has the effect of antidiarrhea with astringent, stop bleeding and expelling parasite. The main composition of pomegranate rind is ellagic acid, with polyphenols ester structure, and shows the acidic (Li et al, 2002; Kong et al, 2008; Xu et al, 2014). Pomegranate peel contains yellow pigment, and folk has the records about using the boiled water of pomegranate peel dyeing the white cloth. The main components of natural pigment are pomegranate polyphenols. It has obvious inhibitory effect on chemical induced carcinogenesis and cancer, and can be used as exogenous antioxidants, antibacterial effect of antibacterial. Pomegranate peel is a good natural vegetable dye. Textile fabrics dyed by *granatum* dyestuff had been reported (Chen et al, 2012; Asim et al, 2014; Ali et al, 2014; Chalaya et al, 2007).

Bamboo pulp fiber is a native cellulose fiber developed by our country, which adopts the bamboo material and owns environmental protection and native antibiosis, deodorization, anti-ultraviolet radiation and good gas permeability, and has the same advantages as the viscose rayon like wonderful hygroscopicity, soft touch, dyeing easy and drooping appearance, so it will have bright prospect (Zhu, 2012; Zheng and Zhu, 2011; Guo and Deng, 2011; Liu and Ye, 2013).

In this paper natural pigment was extracted from pomegranate husk directly using boiling water, and then the bamboo pulp fiber fabrics were dyed by single-factor experiment with direct dyeing methods. The dyeing rate, color fastness, and single tensile properties were also been tested.

2. Experimental

Experimental materials: bamboo pulp woven fabric (Dynasty Textile Co. Ltd, Jiangsu)

Experimental Drugs: pomegranate peel (the traditional Chinese medicine itinerant) ; sodium hydrate; potassii; acetic acidacid; ferrisulfas (The above are the analysis of pure); salt; color fixing agent Y; nautral soap (Purchase of goods).

Experimental instruments: TU-1800 ultraviolet-visible spectrophotometer; WT2102T textile electronic balance; YG(B) 631color fastness to perspiration tester; SW-12A II color fastness to washing tester; Y(B)571—II color fastness to rubbing tester; Instron5565 universal strength tester; Thermostatic water bath; Thermometer; Timekeeper; pH test paper; Standard grey scale; Test tube; Beaker, etc.

The extraction process of pomegranate peel dye was as follows: Using boiling water extraction method, first dry the pomegranate peel in an oven, and grind it into fine powder with a mortar, then weigh 50g pomegranate powder, add 1 L of distilled water, stir with a glass rod, and make the pomegranate peel powder fully wettability, in the 90 water bath pot for constant temperature heating 120 min, filter the dye solution, waste slag, put the dye solution into the transparent plastic bottle after it cool and preserve in the shade alternate.

The initial extraction of pomegranate peel dye was diluted. Spectrophotometric curves were tested by spectrophotometer. After measurement, $\lambda_{\max} = 370\text{nm}$.

The dyeing methods of pomegranate peel dye were as follows.

Bamboo fiber fabrics were employed soap boiling 15min before dyeing, to remove the impurities on the surface, then dry stand-by. The bamboo fiber fabric was dyed by dip method. Using single factor analysis, under the conditions of changing dyeing temperature, dyeing time, pH value and other process, the bamboo fiber fabrics were dyed by direct staining experiments.

Firstly, 60min of dyeing time, 7 of pH value, 40, 50, 60, 70 and 80°C of dyeing temperature were chosen in dyeing experiments. Through the analysis of the dyeing rate, the best dyeing temperature was determined; then the best dyeing temperature, 7 of pH value, 40, 50, 60, 70 and 80min of dyeing time were chosen in dyeing experiments. Through the analysis of the dyeing rate, the best dyeing time was determined; finally, the best dyeing temperature, the best dyeing time, 6, 7, 8, 9 and 10 pH value of were chosen in dyeing experiments. Through the analysis of the dyeing rate, the best pH value was determined.

The specific dyeing experiment scheme was shown in Table 1.

Table 1: Direct dyeing experiment scheme of pomegranate hush

No.	Dyeing temperature /°C	Dyeing time /min	pH value
1	40	60	7
2	50	60	7
3	60	60	7
4	70	60	7
5	80	60	7
6	The best temperature	40	7
7	The best temperature	50	7
8	The best temperature	60	7
9	The best temperature	70	7
10	The best temperature	80	7
11	The best temperature	The best time	6
12	The best temperature	The best time	7
13	The best temperature	The best time	8
14	The best temperature	The best time	9
15	The best temperature	The best time	10

Note: 1:50 of dyeing bath ratio, namely, the ratio of fabric weight and dyeing liquid weight, can obtain 25 g of dyeing liquid, 0.5 g of bamboo pulp fabrics, 1:40 of fixing agent Y bath ratio, 20 g of fixing agent, 0.5 g of bamboo pulp fabrics.

Direct dyeing process: Dyeing (dyeing bath ratio 1:50, accelerating agent salt 10g/L, dyeing temperature 40-80°C, pH 7-10, dyeing time 40-80 min) - washing - fixation (bath ratio 1:40, fixation time 30 min), washing and drying.

The residual liquid colorimetric method was adopted to test dye uptake. Absorbance of dyeing liquid was tested by TU-1800 ultraviolet-visible spectrophotometer. According to the following formula to calculate the dye uptake:

$$\text{Dye uptake (\%)} = \frac{A_0 - A_1}{A_0} \times 100 \quad (1)$$

Type: A_0 and A_1 were absorbance of dyeing liquor before and after dyeing.

Soaping fastness, rubbing fastness, perspiration fastness were tested respectively according to GB/T 3921-2008 "textile color fastness test the fastness to soaping", GB/T 3920-2008 "textile color fastness test rubbing fastness" and GB/T 3922-2008 "textile color fastness test the color fastness to perspiration".

Single tensile properties of bamboo pulp fiber fabrics before and after dyeing were tested by instron 5565 universal intensive machine.

Test parameters: 200cN of pre-tension, 200 mm of clamp distance, 100mm/min of tensile speed. The latitude and longitude of fabrics were respectively tested 5 times, finally take the average.

Express index: Breaking strength, N. Elongation at break, %.

3. Results and discussion

Bamboo pulp fiber fabrics were dyed under the conditions that 1:50 of dye liquor ratio, 7 of pH value, 60 min of dyeing time, 40°C, 50°C, 60°C, 70°C and 80°C of dyeing temperature, and dyeing uptake under different dyeing temperature was tested. The results were shown in figure 1.

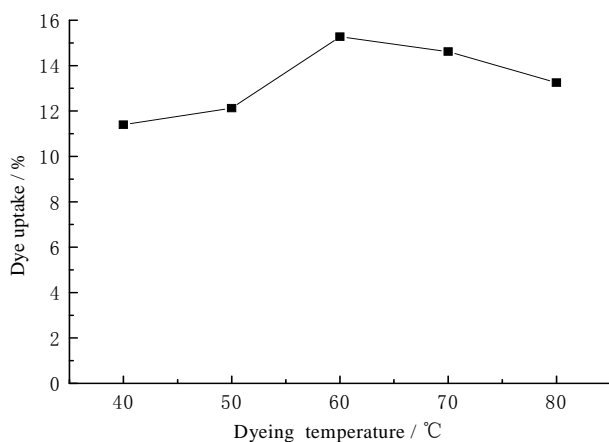


Figure 1: The influence of dyeing temperature on dye uptake

From Fig.1, it can be seen that the dye uptake rose with the increased of temperature. The dye uptake reached the maximum value when the temperate was around 60°C, and the dye uptake decreased with the increased of temperature when the temperate exceeded 60°C. The reason may be that with increasing of dyeing temperature, expansion of fiber increased, the pomegranate peel pigment concentration decreased, and kinetic energy of dye molecular increased at the same time, and the adsorption rate diffusion of dye molecular increased. When the adsorption diffusion rate increased to a certain degree of saturation, the adsorption value would decreased as continue to dyeing. Therefore, the best dyeing temperature of bamboo pulp fabrics dyed by pomegranate peel dye was 60°C.

Bamboo pulp fiber fabrics were dyed under the conditions that 1:50 of dye liquor ratio, 7 of pH value, 60°C of dyeing temperature, 40min, 50min, 60 min, 70min and 80min of dyeing time, and dyeing uptake under different dyeing time was tested. The results were shown in figure 2.

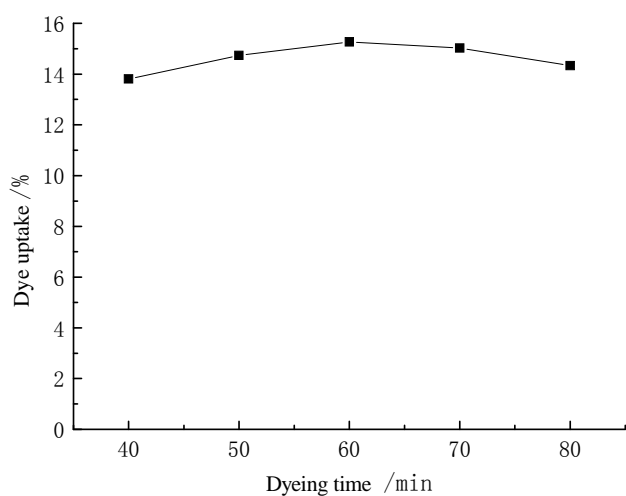


Figure 2: The influence of dyeing time on dye uptake

Fig.2 showed that the dye uptake increased with the increased of dyeing time. The dye uptake reached the maximum value when the time was 60min. The reason may be that the absorption of bamboo pulp fabrics to plant dyestuff was limited, and could not infinite dyeing, otherwise it would make the surface to produce too much floating color, and color fastness to rubbing of fabrics decreased. So, the best dyeing time of bamboo pulp fabrics dyed by pomegranate peel dye was 60 min.

Bamboo pulp fiber fabrics were dyed under the conditions that 1:50 of dye liquor ratio, 60°C of dyeing temperature, 6, 7, 8, 9 and 10 of pH value, and dyeing uptake under different pH value was tested. The results were shown in figure 3.

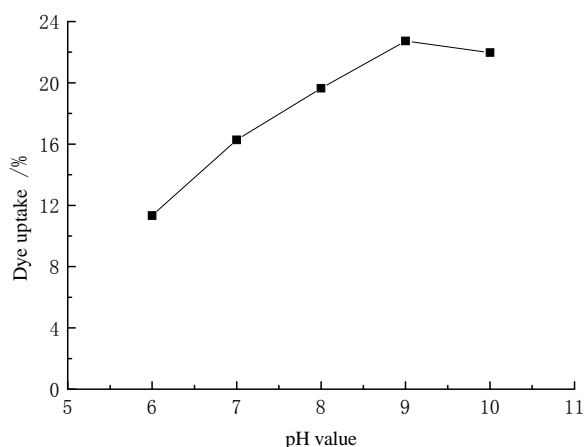


Figure 3: The influence of pH value on dye uptake

It can be seen from the Fig.3, the dye uptake increased with the increased of dye solution pH value. The solubility of pomegranate peel pigment would change under the condition of pH was bigger. Namely under the alkaline condition, the solubility of pomegranate peel pigment increased, and made the concentration of pomegranate peel pigment increase. Thus, the best pH value of bamboo pulp fabrics dyed by pomegranate peel dye was 9.

Table 2 shows the color fastness results of bamboo pulp fiber fabrics dyed in the optimal process.

Table 2: The test results of color fastness

Color fastness to rubbing / level	Dry friction	Discoloring fastness	4
		Staining fastness with cotton	4
	Wet friction	Discoloring fastness	3-4
		Staining fastness with cotton	3-4
Color fastness to soaping / level		Discoloring fastness	3
		Staining fastness with cotton	3
Color fastness to perspiration / level	Acidity	Discoloring fastness	3
		Staining fastness with cotton	4
	Alkalinity	Discoloring fastness	3-4
		Staining fastness with cotton	3-4

As can be seen from table 2, the grades of color fastness to soaping, color fastness to rubbing and color fastness to perspiration of bamboo pulp fiber fabrics dyed by pomegranate peel are 3 level or above. The color fastness to rubbing is relatively good, and the dry rubbing fastness is greater than the wet rubbing fastness. The color fastness to soaping is relatively poor, and at 3 level. In a word, bamboo pulp fiber fabrics dyed by pomegranate peel have good color fastness, meet the requirements.

Single tensile fracture properties of bamboo pulp fiber fabrics without dyeing and with dyeing under the best dyeing process conditions were tested, and the results were shown in table 3.

Table 3: Single tensile fracture properties test results of bamboo pulp fiber fabrics

Samples	Breaking strength /N		Elongation at break /%	
	Warp	Weft	Warp	Weft
Fabrics with dyeing	857.17	417.24	11.62	25.64
Fabrics without dyeing	962.16	447.28	12.63	26.42

It can be seen from table 3, the tensile properties of bamboo pulp fiber fabric before and after dyeing had changed, breaking strength of the samples after dyeing decreased, and the elongation at break also decreased, but the overall change is not very big, can satisfy the use requirement.

4. Conclusions

The optimal process of bamboo pulp fiber fabrics dyed by pomegranate pigment were 1:50 of dye liquor ratio, 60°C of dyeing temperature, 60min of dyeing time and 9 of pH.

The bamboo pulp fiber fabrics dyed by pomegranate pigment have good fastness to soaping, and the grade of color fastness is 3 – 4 level, and the staining fastness is greater than the discoloring fastness.

The tensile properties of bamboo pulp fiber fabric before and after dyeing had changed. Breaking strength and the elongation at break of the samples after dyeing all decreased.

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