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| ARTICLE |

Mechanical Characteristics and Antibiosis of Sized Fabrics with *Bletilla striata*

Young Mee Baek
Korean Traditional Costume Research Institute in Pusan National University, Busan 609-735, Korea

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Abstract: *Bletilla striata* is an important herb that is used as a paste for texture processing, an ingredient in incense and an additive for preserving calligraphic works and paintings. This study evaluated *Bletilla striata*, which has been used to preserve and manage the textiles and paper. In particular, this study examined the viscosity of a paste made from *Bletilla striata,* as well as the mechanical characteristics and antibiotic properties of the fabrics treated with the herb. In terms of viscosity, *Bletilla striata* paste was less sticky than wheat flour paste, meaning that the former can be applied more evenly to sized fabrics. In addition, *Bletilla striata* paste has high transparence, ensuring little color difference between the fabrics treated and not treated with the paste. Regarding the mechanical characteristics of the fabrics processed using the KES-FB System, the sized fabrics treated with *Bletilla striata* paste showed a higher flexibility and recovery rate and than those treated with the wheat flour paste, indicating that the former paste can be more effective in making fabrics maintain their original form and shape. Finally, silk fabrics treated with *Bletilla striata* showed very high antibiosis. This suggests that the paste can be used to develop antibiotic substances that can preserve textiles.

Key words: *Bletilla striata*, Starching, Viscosity, KES-FB System, Mechanical characteristics, Antibiosis

1. INTRODUCTION

In modern times, most precedents for starching are no longer used due to material development and simple management of clothing. Nevertheless, starching is still commonly used as a simple method for the touching of cool summer clothes and bedding. From previous studies and customs, a range of starches, such as rice starch, wheat flour starch, fermented starch, potato starch and agar starch, have been used for the manufacture and management of clothing. In particular, in『Gyuhapchongseo(閨閤叢書, 1809)』, the statement, 'Daewampul can be used for silk clothing, and if there is no Daewampul, it can't be represent the original color in the handling of blue fabrics', means that Daewampul , that is, *Bletilla striata* has been used for starching high-quality silk clothing. *Bletilla striata* plays important roles as an additive ingredient in starch manufacturing for Jangwhang (Baek, 2009). In『Donguibogam(東醫寶鑑, 1610)』and『Jaejoongsinpheon (濟衆新篇, 1799)』, the materials can be used as the main ingredients for ceremonial incense, such as Buyongwhang and Chwiseonwhang.

Bletilla striata is the dried root of the perennation orchid that is used in oriental medicine for not only its effects on hemostasis in case of hemoptysis and hematemesis, but also as a remedy for skin disease, such as furunculus, burns and skin cracking. *Bletilla striata* contains essential oil, starch and sugar as the main components, and when immersed in water, bletilla-glucomannan (D-mannose:D-glucose=3:1), which has a significant inhibitory effect on Gram-positive bacteria and mycobacterium, is extracted (Park, 2007). In Lee *et al*.(2008)'s studies, starch containing *Bletilla striata* was reported to have antimicrobial effects on *Escherichia coli* and *Bacillus*. Recently, many studies have examined the effects of *Bletilla stratia* in the medical and skin care fields. Oh (2008) studied the anti-inflammatory activity from an extract of *Bletilla striata*, and Yoon *et al*. (2003) examined the inhibitive action of melanin pigment with B16 melanomatous cells. In addition, many patents on the whitening or cosmetic development of atopic skin have been granted. Therefore, many studies on the anti-microbial activity, anti-inflammatory activity and whitening have been performed but few have evaluated its practical uses on fabrics.

In the present study examined how the science from traditional costume culture can be applied to the modern textile industry by evaluating the mechanical properties and antimicrobial ability from extracts of *Bletilla striata*.

2. MATERIAL AND METHOD

2.1. Material

The mechanical characteristics of the starching samples were compared with wheat flour starch, which is mostly used in modern houses. *Bletilla striata* samples were purchased in a medicinal store

Corresponding author: Young Mee Baek
E-mail: paikym@pusan.ac.kr

Table 1. Properties of the fabrics.

Test	Fabric	Weave	Thickness[a] (mm)	Fabric count (thread/cm)	
				Warp	Weft
Color and mechanical characteristics	cotton	plain	0.68	17	15
	silk	plain	0.165	46	34
Antibiosis	cotton	plain	0.24	35	31
	silk	plain	0.15	51	37

Table 2. Mechanical characteristics.

Characteristics		Meaning
Bending property	B	Bending rigidity
	2HB	Hysteresis of bending moment
Tensile property	LT	Linearity of load-extension curve
	WT	Tensile energy
	RT	Tensile resilience
	EMT	Extension at maximum load
Shear property	G	Shear stiffness
	2HG	Hysteresis of shear force at 0.5deg. of angle
Compression property	LC	Linearity of compression thickness curve
	WC	Compression energy
	RC	Compression resilience
Surface property	MIU	Coefficient of friction
	MMU	Mean deviation of MIU
	SMU	Geometrical roughness

and wheat flour was used as manufactured flour in Korea. After washing, *Bletilla striata*. was poured into distilled water and left to stand at a constant temperature and humidity for 24 hours. Subsequently, it was then poured into 4 times the amount of boiled water, and filtered on a fine mesh. A comparable amount of wheat flour starch was weighted by measuring the weight concentrations of dried *Bletilla striata*. A water bath was then set up with the same concentrations of wheat flour followed by boiling. The flour was then used after these processes. In terms of the color difference and mechanical characteristics, the fabric samples were prepared as indigo-dyed traditional cotton by hand, and blue and red dyed silk. In the anti-microbial experiment, standard silk fabric was prepared according to the KS K ISO 105 standard. Table 1 lists the sample characteristics.

2.2. Method

2.2.1. Viscosity of starch

The viscosity of starch was measured at 26℃, spindle 3, 50 rpm using a BROOKFIELD viscosimeter.

2.2.2. Starching treatment

The starching treatment was conducted at a 1:50 proportion. The fabrics were immersed for 10 minutes and dried naturally.

2.2.3. Measurement of color difference

The optical characteristics of the treated fabrics were conducted using an optical colorimeter (Machbath Color Eye 3100, USA) under the condition of a D_{65} luminous source, 10^0. The L^*, a^* and b^* were measured as CIELAB, and the WI(Whiteness Index) was 10deg./D_{65}/Ganz, YI(Yellow Index) was 2deg./C/ASTM D1925 and BI(Brightness Index) was 2deg./C/TAPP1452/ISO2470.

$$\Delta E(L^* a^* b^*) = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

$$\Delta L^* = L^*_1 - L^*_2 \quad \Delta a^* = a^*_1 - a^*_2 \quad \Delta b^* = b^*_1 - b^*_2$$

2.2.4. Mechanical characteristics

The mechanical characteristics of the starching samples were assessed by measuring the bending property, tensile property, shear property, compression property and surface property using the KES-FB System(Kawabata Evaluation System. Kato Texh. Co. Ltd., Japan). Table 2 summarizes the meanings of the values.

2.2.5. Antibacterial characteristics

The antibacterial activity of the treated samples was measured in accordance with the modified KS K 0693: 2006 standards and

Table 3. Viscosity of the samples.

Material	*Bletilla striata*	Wheat flour
Viscosity	20cP	40cP

concentration : 3.18%, spindle 3, RPM 50, 26℃

Table 4. Color difference of the samples before and after treatment.

Material		*L**	*a**	*b**	*ΔE*	H	V/C
Silk (BLUE)	Non	31.444	1.129	-24.182	-	4.39PB	3.03/5.42
	Bletilla striata	30.772	0.194	-22.733	1.85	3.88PB	2.97/5.07
	Wheat flour	29.366	1.337	-21.907	3.09	4.62PB	2.83/4.86
Silk (RED)	Non	34.930	50.162	19.212	-	4.00R	3.36/11.32
	Bletilla striata	34.174	49.185	19.309	1.24	4.16R	3.30/11.05
	Wheat flour	36.596	47.327	17.137	3.89	3.60R	3.53/10.76
Cotton (BLUE)	Non	23.865	-0.459	-20.687	-	3.22PB	2.28/4.72
	Bletilla striata	24.032	-1.409	-20.851	0.98	2.60PB	2.30/4.79
	Wheat flour	26.336	-0.336	-18.764	3.13	3.53PB	2.53/4.21

measured in the Korea Apparel Testing Research Institute (KATRI) to improve the reliability of the experiment. The test species were gram-positive bacteria *Staphylococcus aureus* (ATCC 6538) and gram-negative bacteria *Klebsiella pneumoniae* (ATCC 4352), which are used to assess the antimicrobial activity experiment in the American Association for Textile Chemists and Colorists (AATCC). The concentration of *Staphylococcus aureus* and *Klebsiella pneumoniae* was 1.3×10^5CFU/㎖, and 0.05% non-ionic surfactant Tween 80 was added.

$$Bacteriostatic\ reduction\ rate(\%) = \frac{A-B}{B}\times 100$$

A: Colony after 18hrs culture with the untreated fabrics
B: Colony after 18hrs culture with the treated fabrics

3. RESULT AND CONSIDERATION

3.1. Viscosity of *Bletilla striata*

Viscosity indicates the resistance to fluid flow, and viscosity of starch affects the characteristics and shape of the fabrics. The viscosity of a 3.18% *Bletilla striata* solution in distilled water was 20cP, whereas that in case of wheat flour starch with the same concentration was 40cP. Therefore, *Bletilla striata* starch has a lower viscosity than wheat flour starch at the same concentration. This suggests that the viscous components in *Bletilla striata* are composed of glucose by hydrolysis, which would have good transparency. In contrast, in the case of wheat flour it contains a relatively larger starch like water-soluble protein component, such as gluten, resulting in a higher viscosity.

3.2. Characteristics of the starching fabrics with *Bletilla striata*

3.2.1. Color difference

According to「Dochimbup (擣砧法)」of『Gyuhapchongseo (閨閤叢書)』, records reveal the following: 'Daewampul can be used for silk clothing and if there is no Daewampul, it can't be represent the original color in the handling of blue fabrics.' and 'In the case of red silk, animal glue is added to *Bletilla striata* and stepped on without batting and then trimmed using a wooden roller to smooth the cloth after the fabrics are almost dried.' This means that *Bletilla striata* can be applied to colorful silk fabrics. With blue cotton, and blue and red silk, as shown Table 4, *ΔE* of the starching fabrics with *Bletilla striata* showed a difference of approximately 1 but there were differences of more than 3 in the case of wheat flour starch. Therefore, *Bletilla striata* shows lower *ΔE* values than wheat flour starch, making *Bletilla striata* starch a more suitable starch for maintaining the unique color of the fabrics.

3.2.2. Mechanical characteristics

Table 5 lists the mechanical characteristics by *Bletilla striata* starch and wheat flour starch according to the KES-FB System. First, *Bletilla striata* showed slightly larger bending rigidity (B) and bending hysteresis (2HB) than wheat flour starch, meaning that wheat flour starch is more flexible. The linear tensile properties (LT) and tensile energy (WT) of the wheat flour starch were higher than those of *Bletilla striata*, whereas the shear characteristics of *Bletilla striata* were lower than those of wheat starch. Therefore, the resistance against shear deformation was relatively lower, indicating effective shape stability. The compression

characteristics were similar, whereas the surface roughness of the fabrics treated with wheat flour starch was higher than those treated with *Bletilla striata*.

3.3. Antibacterial characteristics

Because *Bletilla striata* is used as a traditional medicinal ingredient to treat hemostasis or wounds and possesses anti-inflammatory and anti-microbial characteristics, it has been studied for potential use in pharmaceuticals, medicines and cosmetics in both Eastern and Western countries. The anti-microbial activity of *Bletilla striata* and wheat flour to *Staphylococcus aureus* and *Klebsiella pneumoniae* was measured. *Bletilla striata* showed 99.9% antimicrobial activity, as shown in Figure 1. Do (1994) reported the anti-microbial of an ethanol-extract of *Bletilla striata* against *Bacillus subtilis* and *Escherichia coli*, and Kovacs *et al*. (2008), showed that natural phenanthrenes exhibit biological activity against malaria and cancer. Other studies have reported the biological activity of phenanthrenes extracted from *Bletilla striata*. Yamaki *et al*. (1989) showed that of the components of *Bletilla striata*, bluestrarene B showed the strongest activity, and a Lee *et al*. (2008) suggested that *Bletilla*

Table 5. Mechanical characteristics of the samples.

Material		Bending		Tensile				Shear		Compression			Surface		
		B	2HB	LT	WT	RT	EMT	G	2HG	LC	WC	RC	MIU	MMD	SMD
Silk	non	0.0253	0.0075	0.876	5.42	73.21	2.67	0.25	0.04	0.823	0.086	72.09	0.1545	0.04135	5.715
	Bletilla striata	0.0699	0.0272	0.811	5.72	76.98	3.24	0.63	0.32	0.371	0.131	74.81	0.12	0.04415	5.825
	wheat flour	0.0502	0.0169	0.871	6.45	70.70	2.99	6.09	17.92	0.297	0.149	40.94	0.101	0.0424	6.73
Cotton	non	0.0100	0.0085	0.652	16.60	39.37	10.20	1.78	4.09	0.327	0.254	41.34	0.2355	0.03985	14.495
	Bletilla striata	0.1070	0.1552	0.9	6.67	64.74	2.71	9.17	17.09	0.498	0.173	23.12	0.184	0.04095	18.025
	wheat flour	0.2455	0.5182	0.996	7.35	58.34	2.96	27.82	71.62	0.865	0.243	45.27	0.1745	0.05035	11.975

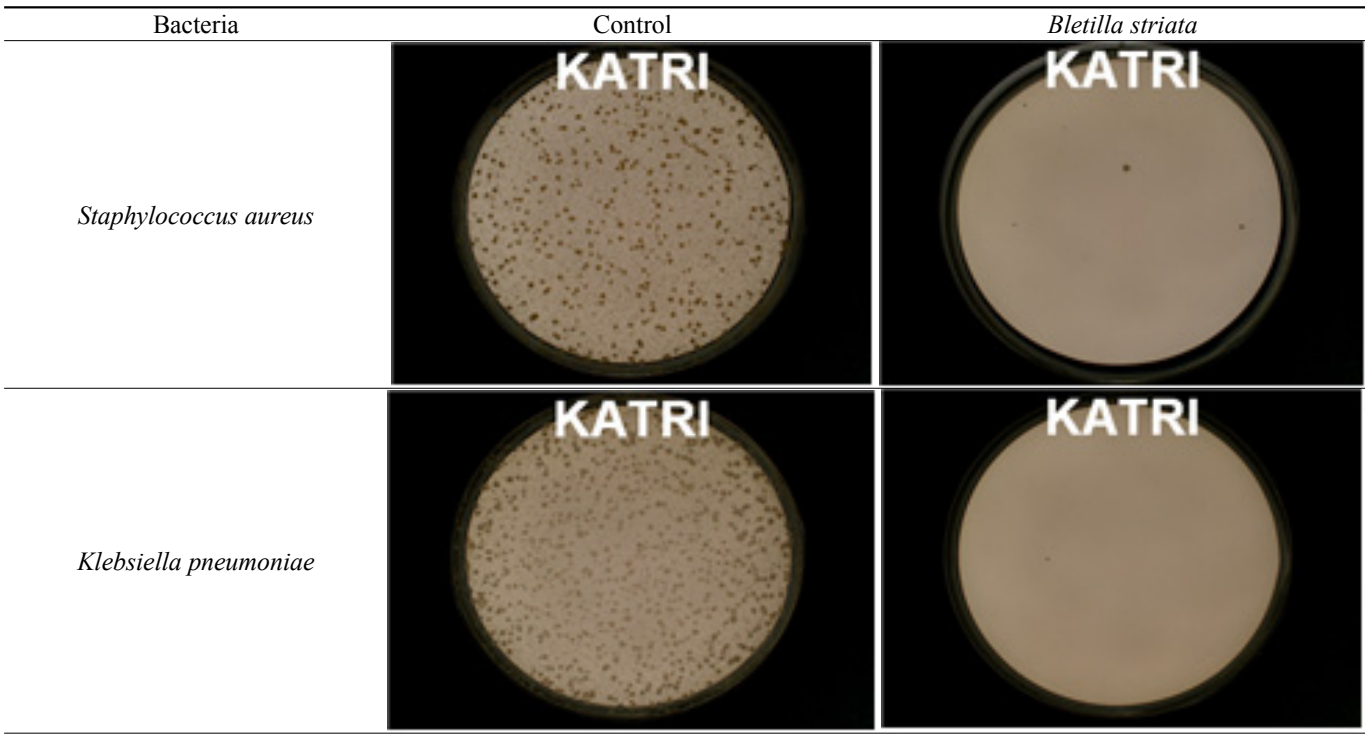

Figure 1. Images of the antibacterial reaction of the control and silk treated with *Bletilla striata.*

striata starch had anti-microbial characteristics against *Escherichia coli* and *Bacillus*. The D-mannose of bletilla-glucomannan (D-mannose:D-glucose=3:1) in *Bletilla striata* is believed to be the main anti-microbial substance. D-mannose is a component of hemicellulose and a viscous material (Park *et al*., 2009) and has been used in the production of bio-ethanol (Lee *et al*., 2010). In addition, the solution has an effect on the anti-microbial characteristics (Lee, 1968), which has recently been used as a remedy for cystitis.

4. CONCLUSION

This study examined the viscosity, mechanical characteristics and anti-microbial characteristics of *Bletilla striata* extract, which is used as an additive material applied to textiles and for paper conservation in traditional literature.

The viscosity of *Bletilla striata* was low, the transparency was good and the ΔE value was approximately 1, which means that the unique color of dyed fabrics is maintained after a starching treatment. In addition, measurements of the mechanical characteristics of treated fabrics revealed *Bletilla striata* starch to be more suitable for maintaining the shape than general wheat flour starch because of its superior stretching and recovering characteristics.

The anti-microbial characteristics of silk fabric treated with *Bletilla striata* starch were superior, highlighting its potential in the development of functional fiber materials. Overall, this study clarified the science from traditional costume culture, and assessed the potential applications of *Bletilla striata* to modern fabrics with particular focus on the development of functional fiber materials.

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