Cocoon Characteristics of *Antheraea pernyi* Silkworm Reared in Korean Oak Field

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Antheraea pernyi silkworm is a well known wild silkworm to produce a valuable silk fiber. *A. pernyi* silkworm was reared in Korean oak field and examined the cocoon characteristics, such as cocoon weight, cocoon shell weight, and percentage of cocoon shell weight. Degumming loss was also measured after alkali degumming process. *A. pernyi* silkworm spins tawny color cocoon in oval shape. Cocoon shell weight of *A. pernyi* silkworm, 0.78 g, was heavier than that of *B. mori* silkworm, 0.51 to 0.63 g. Cocoon shell percentage of *A. pernyi* silkworm, 32.8%, was higher than that of *B. mori* silkworm, 23.4 to 25.2%. Degumming loss percentage of *A. pernyi* silkworm, 17.1%, was lower than that of *B. mori* silkworm, 25.0%. SEM showed that the surface of the cocoon filament was coarse and oriented with longitudinal direction.

Key words: *Antheraea pernyi*, Cocoon trait, Cocoon shape, Degumming loss

Introduction

Cocoon has been used as a source of textile fiber in the world. It is spun by various kinds of silkworm; domestic silkworm, *Bombyx mori*, and wild silkworm, *Antheraea species*. Among them, *Antheraea pernyi* silkworm is one of the most useful insect to produce valuable textile fiber. In general, *A. pernyi* silkworm spun tawny color cocoon. The tawny color of pernyi cocoon is due to the cross-linked polymer of gentisic acid and silk protein (Tao *et al.*,

1993). In Korea, *A. pernyi* silkworm has been reared until 1964 (Moon, 2000). Silk protein spun by *A. pernyi* is more stable against chemicals than that spun by *B. mori* silkworm (Kweon *et al.*, 1998). Now a day, *A. pernyi* silk fibroin had been studied as a non-textile resource in various fields. Dissolution method of *A. pernyi* silk fibroin using various salts and characterized regenerated silk fibroin were reported by Kweon's research group (Kweon *et al.*, 2002; Kweon *et al.*, 2003; Woo *et al.*, 2000). Various types of architecture from pernyi fibroin has been reported such as nanofibers, scaffold, powder, and gel (He *et al.*, 2011; Zhao *et al.*, 2011; Lee *et al.*, 2011; Yan *et al.*, 2010). Lee *et al.*, (2011) reported that hydrolyzed *A. pernyi* silk fibroin was separated into two parts: alanine-rich fraction and tyrosine-rich fraction. Wild silk fibroin hydrolysate enhances lipid metabolism and antioxidant defense (Um *et al.*, 2011).

Though pernyi silk fibroin has been studied as non-textile materials such as food ingredient and biomaterials, the cocoon characteristics of *A. pernyi* silkworm cocoon has not been reported. Therefore, the authors examined cocoon characteristics of *A. pernyi* silkworm as a basic study for *A. pernyi* silk fibroin. .

Materials and Methods

Materials

Wild silkworm cocoon, *A. pernyi* silkworm cocoon was harvested from oak field, National Academy of Agricultural Science, Suwon, Korea. The number of harvested one is 189 in 2009. Sodium carbonate and other chemicals were purchased and used without further purification.

Examination of *A. pernyi* silkworm cocoon

Each cocoon was weighed to calculate whole cocoon weight, cocoon shell weight, and percentage of cocoon shell weight. Thickness of the cocoon shell was measured

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with vernier calipers. The surface morphology of cocoon filament was observed using Field-Emission Scanning Electron Microscope (SUPRA 55VP, Carl Zeiss, Germany) after platinum coating.

Degumming

Wild cocoon was sliced and degummed as following method. One hundred fifty grams of cocoon was soaked into the degumming solution (sodium carbonate 2.5 g/L) at boiling temperature for 30 minutes and then washed with distilled water. The degumming process was repeated three times. Degumming loss percentage was calculated according to the following equation.

$$\text{Degumming loss percentage (\%)} = (W_i - W_f) / W_i * 100$$

Where, W_i is initial weight of dry cocoon; W_f , final weight of dry cocoon.

Results and Discussion

A. pernyi silkworm cocoon

Oak silkworm is distributed on the far-east area including Korea, Japan, and northeastern China. There are two kinds of silkworms, *A. pernyi* and *A. yamamai*. Silkworm *A. yamamai* spins bright green color cocoon and fiber. However, *A. pernyi* silkworm makes a cocoon yellowish color shown in Fig. 1. The silkworms are fed on plantations of specially trimmed oak trees in National Academy of Agricultural Science. *A. pernyi* cocoon was harvested in 2009 and stored in conditioned room with low humidity and temperature.

The cocoons are oval in shape. The surface of cocoon is printed by oak leaf. After taking out the pupa, the thickness of the cocoon shell was measured. The thickness of the *A. pernyi* silkworm cocoon shell was 0.409 ± 0.101 mm. On the other hand, that of *B. mori* silkworm cocoon was 0.517 ± 0.077 mm. The thickness of the cocoon shell of *A. pernyi* silkworm was thinner than that of the authorized *B. mori* silkworm, YangWonJam.

The most important traits economically for silk production are single cocoon weight, cocoon shell weight, and cocoon shell percentage. Table 1 showed the cocoon traits of *A. pernyi* cocoon compared with *B. mori* cocoons. The average weight of *A. pernyi* cocoon completely dried is 2.36 g. To compare the cocoon traits, *Bombyx mori* silkworm variety, YangWonJam cocoon was harvested from Korean Farmer in 2012 and weighed cocoon characteristics. The reported average dry weights of authorized *Bombyx mori* cocoon for reeling test were 2.43 – 2.72 g. The dry weight of our result is similar to those of authorized them. The average weight of *A. pernyi* cocoon shell is 0.78 g. On the other hand, *B. mori* cocoons showed 0.51

(a)

(b)

Fig. 1. Photographs of *Antheraea pernyi* silkworm cocoon(a), and pupa(b).

Table 1. Cocoon traits of *Antheraea pernyi* silkworm cocoon

Kinds of cocoon	Single cocoon weight (g)	Cocoon shell weight (g)	Cocoon shell percentage (%)	Reference
<i>Antheraea pernyi</i>	2.36	0.78	32.8	This study
YangWonJam	-	0.51	23.4	This study
DaePoongJam	2.54	0.59	23.6	Kang <i>et al.</i> , (2012a)
DaeBakJam	2.72	0.63	23.2	Kang <i>et al.</i> , (2012a)
SooOkJam	2.55	0.60	23.7	Kang <i>et al.</i> , (2012b)
HanSaengJam	2.43	0.61	25.2	Kang <i>et al.</i> , (2011)

Table 2. Degumming loss percentage of *A. pernyi* silkworm cocoon

Kinds of cocoon	Degumming loss percentage
<i>Antheraea pernyi</i> silkworm cocoon	17.1
<i>Bombyx mori</i> silkworm cocoon	25.0
BaegOkJam fiber*	25.4

*Kweon *et al.*, (2012) **Fig. 2.** Scanning electron microscopic photograph of *Antheraea pernyi* cocoon filament after degumming.

– 0.63 g. These data can be explained by the size of the cocoons because the wild cocoon is larger than domestic ones. Cocoon shell percentage is one of important trait for silk industry. Cocoon shell percentage of *A. pernyi* cocoon is 32.8%. Authorized domestic ones are 23.2 – 25.2%.

Degumming loss of *A. pernyi* silkworm cocoon

Silkworm cocoon is composed of fibroin and sericin. Sericin is a gummed material to stick together silk fibroin brins in order to make a single silk filament. Generally, sericin was removed to make good texture of silk fabrics. The weight loss of cocoon filament through degumming process was calculated and showed in Table 1. The degumming loss weights of *A. pernyi* and *B. mori* silkworm cocoon were 17.1%, and 25.0%, respectively.

Kawahara and Nakajima (1992) examined the degumming loss of wild silk fibers with bacterial protease and reported that those of *A. pernyi*, *A. yamamai*, and *A. assama* were 11.6%, 16.0%, and 7.4%, respectively. Similarly, those of wild silk fiber with sodium hydrogen carbonate were 11.8% (*A. pernyi*), 16.5% (*A. yamamai*), and 6.4% (*A. assama*). BaegOkJam, an authorized Korean silkworm variety, shows 25.4% of degumming ratio

(Kweon *et al.*, 2012). Our data were similar to those of the other researchers.

Fig. 2 showed the surface morphology of *A. pernyi* cocoon filament. As shown in Fig. 2, the surface of cocoon filament was coarse and was shown have an orientation with the longitudinal direction. Degummed *A. pernyi* cocoon filament was shown something is attached on the surface of the filament. The attached is might be considered as damaged cocoon filament or sericin remained. According to Kawahara and Nakajima (1992), the surface morphology of wild silk fiber was different with each other in spite of the similar degumming loss. Our result obtained after sodium carbonate degumming was similar to that of Kawahara and Nakajima (1992) after sodium hydrogen carbonate degumming. The reason why the surface morphology is different is not clear until now. Therefore, the systematic degumming research for *A. pernyi* cocoon filament will be needed to elucidate the relationship between degumming ratio and surface morphology of wild cocoon filament.

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