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Comparison of Cocoon and Filament Quality of *Bombyx mori* L. Chinese Egg Seeds and Perum Perhutani Egg Seeds

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The sustainability of natural silk in South Sulawesi, especially in Soppeng Regency, has experienced a decline in production related to the quality of silkworms. The Indonesian government tried to import silkworm eggs from the Chinese to restore the silk business. It is necessary to know how the quality of silkworm eggs from the Chinese compares with local silkworm eggs produced by the State Forestry Public Company (Perum Perhutani). Therefore, this research aims to compare the quality of cocoons and filaments between Chinese egg seeds and Perum Perhutani egg seeds so that we can find out which egg seeds produce the best quality and production. The two egg seeds were tested in Pising Village, Donri-Donri District, Soppeng Regency. The parameters observed were fresh cocoon weight, cocoon shell weight, percentage, filament length, reelability and filament weight. The results of the research showed that there was a significant difference between egg seeds from Chinese and Perum Perhutani egg seeds in the reelability variable. Reelability of egg seeds from Chinese shows that the average cocoon weight is 74.06% higher compared to 69.31% for Perum Perhutani egg seeds. Apart from that, those produced from egg seeds from Chinese were also greater with differences in fresh cocoon weight of 1.56 g, cocoon shell weight of 0,29 g, cocoon shell percentage of 19.65%, filament weight of 0.25 g, while filament length was higher in seeds. Perum Perhutani eggs with a difference of 1118.39 m. The quality of cocoons and silkworm filaments from Chinese seeds and Perum Perhutani is classified into class C based on SNI: 2011. These results indicate that egg seeds from the Chinese have a higher potential to produce quality silk. This research emphasizes the importance of choosing the right egg seed to increase the quality and quantity of silk production. With the results obtained, it is hoped that the silk industry can choose more sources of egg seeds, especially to increase the competitiveness of silk products in the global market.
Keywords: Chinese egg seed, cocoon quality, filament quality, Perum Perhutani egg seed, reelability, sustainability.

INTRODUCTION

The silkworm (*Bombyx mori* L.) is an insect with high economic value. The world of silk is not a new activity for the people of Indonesia. It is noted that silk activities have been carried out since the beginning of the 18th century in several areas in West Java, Central Java, West Sumatra, and South Sulawesi in the form of side businesses. Based on the Decree of the Minister of Forestry number 50 / Kpts-II / 1997 dated January 20, 1997, natural silk is part of social forestry activities with cocoons or silk threads consisting of mulberry planting, silkworm breeding, silkworm maintenance, and cocoon management (Harbi *et al*., 2015). According to A. Masallangka Chaeruddin, who is a 'Silk activist from Soppeng Regency,' said silk was first introduced in 1964 and developed into a business in Soppeng Regency during its heyday from 1968 to 1971. The area of land managed reached 5,500 hectares, involving 9,900 households. At that time, Soppeng Regency was the biggest seller of silk products in several regions of Indonesia and even exported to foreign countries. In 1973, silkworm yields began to decline, and the quality of the silkworms was no longer qualified. This was because the silkworms were exposed to Pebrin's disease. To restore the Silk business in Soppeng Regency, the Government tried to buy silkworm eggs from the Chinese, each box containing approximately 25,000 silkworm eggs (Andadari *et al*., 2022). Silk production in Soppeng Regency has an important role in the local economy. As one of the largest silk-producing areas in South Sulawesi, Soppeng has long been known for the quality of the silk it produces. The silk industry provides livelihoods for many silkworm farmers, weavers, and other industry players (Widiarti *et al*., 2021). Apart from that, Soppeng silk is also a superior commodity contributing to regional income through local sales and

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exports. The presence of the silk industry not only maintains the traditions of distinctive weaving crafts but also supports economic stability by creating jobs and improving the welfare of local communities (Basole, 2016). In Soppeng Regency, silkworm seeds play an important role in the silk cultivation industry, one of the region's important economic sectors. High-quality silkworm seeds are the key to success in producing good cocoons, which will later be spun into silk thread (Wang *et al*., 2023). Farmers in Soppeng specifically select superior seeds to ensure healthy caterpillar growth and optimal cocoon production. In addition, using good seeds also contributes to the caterpillars' resistance to disease and increases the quality of the silk produced (Fambayun *et al*., 2022). Thus, the role of silkworm seeds is very important in maintaining the continuity and development of the silk industry in Soppeng, which has a positive impact on the local economy and the welfare of local communities. To measure the quality classification of silkworm cocoons and filaments, Indonesia established the Indonesian National Standard (SNI) in 2011. The classification based on SNI is categorized into classes A to D. The cocoon quality is quite good (C) and still meets the quality standards for commercial cocoons (Nuraeni *et al*., 2021). Therefore, this research aimed to compare the quality of the cocoons and filaments of Chinese silkworm seeds and the Perum Perhutani silkworm seeds of Soppeng Regency based on SNI. The utility of this research is to provide input and information to improve the quality of cocoon production and as a consideration for silkworm farmers and other parties related to natural silk.

MATERIALS AND METHODS

Location and materials**:** The location for the respondent interview was Pising Village, Donri-Donri District, Soppeng Regency, while cocoon and filament quality testing was conducted in the Social Forestry and Partnership Agency, Ministry of Environment and Forestry, Bili Bili, Gowa Regency. The tools used in this research were as follows: tools for cocooning in the form of a sari frame, equipment for spinning: semi-automatic spinning machine, and additional tools: cutters, scissors, slotted spoons, calculators, scales, digital cameras, labels, and writing instruments. The materials used in this study were cocoons from 300 Chinese egg seeds and 300 Perum Perhutani egg seeds.

Research procedure**:** After the caterpillar shows the cocooning characteristics, namely, the caterpillar stops eating, is yellowish and shriveled, and the spinneret (tool under the mouth) of the caterpillar releases filaments. The caterpillars were inserted into the seriframe, each as many as 300 individuals on the tool simultaneously. After 5-6 days of cocooning, the cocoons were ready to be harvested. The harvested cocoons were then measured the weight of the cocoons and the weight of the cocoon shells. The procedure of the silk reeling was to heat the water to a boil in a boiling pot with a temperature of 95 - 98°C, then put the cocoons in the boiling water so that the boiling can be evenly distributed. The cocoons were stirred using a slotted spoon until they cooked evenly (± 15 minutes); stir with a soft brush so that the outer silk layer was peeled off and the ends of the filaments of each cocoon stuck to the brush. The clumps of filament, due to brushing, were separated and cut, and then the ends of the filaments were ready for spinning. Cocoons that had obtained their filament ends (ready to be spun) were transferred to a basin filled with hot water at 40-50°C. The ends of the cocoon filaments, as many as 50 grains, were pulled and joined to form one filament, and then they were inserted into the hole of the porcelain bowl. From the porcelain bowl, it was pulled through the conveying roller and then wrapped around 8-10 turns. Furthermore, the filament was pulled through the next rollers and directly wrapped around the Haspel, which previously passed through the yarn regulator and then spun. After all the cocoons were spun, the numbers on the counter were recorded, and the spun silk thread (reeling) was then re-reeled again to form larger strands so that the water content was reduced; each strand of yarn was engulfed, tied, and then weighed.

Data analysis**:** The research data were analyzed for one-way ANOVA using the SPSS 29.0 tool. The treatments showing significant differences were compared using the Tuckey test. Indonesia has set cocoon quality standards and classifies them according to SNI:7635 (2011). Cocoon quality is divided into fresh cocoon weight (g) cocoon shell weight (g), and percentage of cocoon shells (%) with the equation:

Weight of fresh cocoons (g) = weight of fresh cocoons before they are removed from their pupas [1]

Cocoon shell weight (g) = fresh cocoon weight after removing the pupae [2]

$$\text{Percentage of cocoon shells (\%)} = \frac{\text{weight of cocoons without pupae}}{\text{fresh cocoon weight}} \times 100\% \quad [3]$$

Filament quality is divided into filament length (m) [4], reelability (%) [5], and filament length (g) [6], with the equation:

$$\text{Filament length (m)} = \frac{\text{yarn length} \times \text{average number of shading}}{\text{the number of cocoons spun}} \quad [4]$$

Length of thread = length of yarn wound on the Haspel.

Number of cocoons spun = number of cocoons tested – total conversion value I from the leftover cocoon.

$$\text{Reelability (\%)} = \frac{\text{number of cocoons spun}}{\text{the number of cocoons spun}} \times 100\% \quad [5]$$

$$\text{Filament weight (g)} = \frac{\text{actual yarn weight}}{\text{the number of cocoons spun}} \quad [6]$$

The number of cocoons spun = number of cocoons tested - total conversion value II of cocoons the rest.

RESULTS

***Cocoon quality*:** The observation results were obtained based on the t-test or the average difference test on the weight of fresh cocoons, the weight of cocoons without pupae, and percentage of cocoon shells from Chinese seeds and Perum Perhutani (Figure 1).

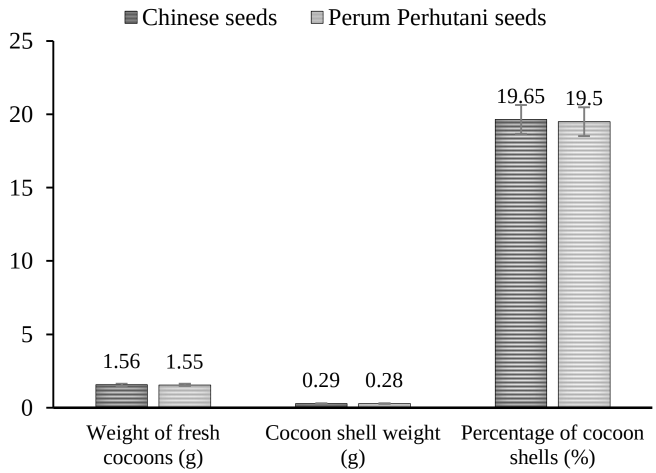

Figure 1. Cocoon quality.

***Weight of fresh cocoons*:** Fresh cocoon weight is an important parameter in every silkworm rearing result. According to Mallikarjuna and Balasaraswathi (2023), fresh cocoon weight is the weight of cocoons that have just been harvested and cleaned from the fine filaments on the surface of the cocoon skin (thread). Based on the data obtained, there was no significant difference in fresh cocoon weight between Chinese seeds and Perum Perhutani seeds at the 5% confidence level, where fresh cocoon weights were 1.56 g and 1.55 g, respectively. This illustrates that both types of silkworms have the same ability regarding fresh cocoon weight productivity.

***Cocoon shell weight*:** The cocoon skin is a layer of natural silk filaments consisting of sericin and fibroin, which is a covering for the pupa (Kunz *et al*., 2016). The test results showed that the weight of cocoons without pupae between Chinese seeds and Perum Perhutani seeds showed no significant difference at the 5% confidence level, where the weight of cocoons without pupae was 0.29 g and 0.28 g, respectively. One of the things that influences the decrease in the quality of the weight of the cocoon shell is storing the eggs for too long.

***Percentage of cocoon shell*:** The percentage of cocoon skin is obtained from the comparison between the weight of the cocoon skin and the total weight of the cocoon, and then it is multiplied by 100%. The percentage value of cocoon shells is closely related to the percentage of filaments and is one of the determining factors for the quality of cocoon yields (Kalita and Dutta, 2020). Based on the data obtained, there is an insignificant difference between Chinese and Perum Perhutani seeds, where the respective percentages are 19.65% and 19.50%.

***Filament Quality*:** The results of the observations were obtained based on the t-test or the average difference test on tightness, winding power, bulk, and yield of filaments (Table 1).

Table 2. Filament quality.

Variable	Average observation results in each treatment	
	Chinese seeds	**Perum Perhutani seeds**
Filament length (m)	1085.30	1118.39
Reelability (%)	74.06a	69.31b
Filament weight (g)	0.25	0.24

Note: Numbers followed by the same letter on the same line are not significant.

***Filament length*:** The longer the filament produced from a cocoon, the better the quality of the filament. The length of the silkworm filament produced is related to the degree of decomposition of the cocoon filament (Zhou and Wang, 2020). Test results on the filament length of Chinese seeds and Perum Perhutani seeds showed no significant difference at the 5% significance level, where the average filament length between the two races was 1085.30 m and 1118.39 m.

***Reelability*:** Rolling power is the ease of spinning the cocoon, as indicated by the frequency of the cocoon breaking when spinning (Yin *et al*., 2021). If the number of breaks is large, then the winding power is low; conversely, if the number of breaks is small, then the winding power is high. In this study, the rolling capacity of Chinese and Perum Perhutani seeds showed a significant difference at the 5% significance level. The average rolling capacity produced by Chinese seeds was 74.06%, and Perhutani seeds were 69.31%.

***Filament weight*:** The weight of the filament is obtained from weighing the rolled filament. According to Chattopadhyay *et al*. (2018), the longer the filament, the greater its weight; likewise, the larger the cocoon shell, the greater its weight. The weight of the Chinese and Perum Perhutani seed filaments in this study showed no significant difference at the 5% level of significance, with each being 0.25 g and 0.24 g.

DISCUSSION

This research looked at two types of silkworm seeds, namely from China and Perum Perhutani. The mulberry leaf food source used is *Morus alba* (*M. alba*) and *Morus multicaulis* (*M. multicaulis*). *M. alba* feed has higher protein levels than other types (Yan *et al*., 2024). Feeding M. alba to small caterpillars and *M. multicaulis* to large caterpillars provides the highest maintenance yield and good cocoon quality to obtain healthy caterpillars and good cocoon quality. At the small caterpillar stage (instars 1^{st}-3^{rd}), they must be given good food. Small silkworms will grow well in conditions and food with sufficient protein and carbohydrate sources (Borah and Boro, 2020).

The results showed that the quality of cocoons on Chinese and Perum Perhutani seeds was not significant. The quality of Chinese seed cocoons and Perum Perhutani, as a result of observations based on the SNI, falls into class C. The quality of class C cocoons is classified as the adequate (standard) quality of the cocoons produced. The quality of the cocoon can be influenced by the type of silkworm race that is maintained (Swathiga *et al*., 2019). The weight of Chinese seed cocoons in this study experienced a significant increase of 1.56 g compared to research conducted by Andadari *et al*. (2023), where the weight of Chinese seed cocoons was only 1.38 g. The maintenance process and environmental conditions can influence this. Silkworm-rearing conditions greatly influence the silk filaments produced (Srinu and Maruthi, 2022). The greater the final weight of the 5th instar, the greater the weight of fresh cocoons and the greater the weight of cocoon shells, increasing the percentage of cocoon shells.

From the results of observing the quality of the filament, it was found that only reelability had a significant effect. In contrast, the length and weight of the filament did not differ much. The quality of the filaments in both seeds, as a result of observations based on SNI, is included in class C. Rearing conditions can influence the quality of the filaments during cocoon production and the amount and quality of feed provided (Gupta and Dubey, 2021). The length of the cocoon filament has a very close relationship with the weight of the cocoon shell. Larger silkworms will produce a larger diet and more filaments (Nonsrirach *et al*., 2020). According to Padaki *et al*. (2015), a good filament length ranges from 600–1500 m. Therefore, research on the length of the filaments produced by Chinese and Perum Perhutani seeds is quite good. Storage conditions for Chinese and Perum Perhutani seeds for silkworm cocoons are carried out at a temperature of ±25°C with humidity ≤70%. Silkworm cocoon storage conditions can affect the filament's quality (Manzoor *et al*., 2024). The rolling technique used in the study used a semi-traditional process using a foot-spinning tool and a hand-spinning tool. The quality of the silk thread produced is directly proportional to the quality of the spinning tool, the spinning machine operator, and the hardness of the water used (Karthik and Rathinamoorthy, 2017).

The quality of the cocoons and silkworm filaments from Chinese seeds and Perum Perhutani is relatively the same, which can inform farmers regarding the type of silkworms being reared. The qualities of these two silkworm seeds can be developed simultaneously and become an option for farmers. Things that need to be considered are the maintenance process and appropriate environmental conditions so that the cocoons produced can meet standards.

Conclusion**:** The research results showed that egg seeds from China produced almost the same quality of cocoons and filaments. The research results showed significant reliability values for both silkworm seeds, where Chinese silkworm seeds were 74.06% higher than Perum Perhutani silkworm seeds at 69.31%. Other variables such as fresh cocoon weight, cocoon shell weight, cocoon shell percentage, and filament weight in Chinese silkworm seeds were better than in Perum Perhutani seeds. On the other hand, seeds from Perhutani showed an advantage in filament length, although not significant. The quality of the cocoons from the Chinese and Perum Perhutani seeds is in class C, as is the quality of the filaments of the two seeds. These findings indicate that although egg seeds from Chinese have advantages in several aspects of cocoon and filament quality, Perum Perhutani seeds still offer decent production potential, especially in terms of filament length, which can be an important consideration in the development of the silk industry in Indonesia, especially Soppeng Regency. The optimal combination and utilization of these two types of seeds can provide the best solution to increase efficiency and productivity in silk production in Indonesia, considering the significant differences in the quality and characteristics produced by each seed.

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Conflict of interest**:** The authors declare no conflict of interest.

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***SDGs addressed*:** Zero Hunger, Decent Work and Economic Growth

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