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Use of Pineapple Fruit Juice as a Technology for Softening of Oak Tasar Cocoons

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Abstract

Oak tasar cocoons are difficult to reel due to the presence of high amounts of protein-tannin complexes. The chemical methods developed for reeling these cocoons is not readily adopted by the common tasar silk reelers and weavers due to various reasons including relatively low reeling performance, low fuel efficiency, complicated procedure and prolonged cooking time. Proteolytic enzymes that cleaves the internal peptide bonds in an amino acid chain have the potential to effect partial solubilisation of the proteinaceous silk gum (sericin) involved in biding the silk (fibroin) strands together in silkworm cocoon, an essential step in the silk cocoon cooking and reeling. Pineapple fruit extract rich in cysteine endopeptidases has a potential application in cooking and reeling of oak tasar (*Antheraea proylei* J.) silk cocoons which cannot be softened by boiling in plain water unlike the mulberry cocoons (*Bombyx mori* L). The experimental results from the present investigation on the oak tasar cocoon cooking with pineapple extract at room temperature and subsequent study have indicated for an applicability of pineapple extract as an effective agent for the oak tasar (*Antheraea proylei* J.) cocoon cooking and reeling. It is observed that enzymatic cocoon cooking has advantages over chemical method. The method involving pineapple extract is a relatively better method regarding its overall better reeling performances and also mostly due to the abundant availability of pineapples grown in the oak tasar belt in India. Moreover, the method is environmentally friendly and is readily accessible to the common tasar silk reelers and weavers.

1. Introduction

The oak tasar (*Antheraea proylei* J.) silkworm, the larvae of which feed on leaves of oak tree *Quercus* species (Family-Fagaceae), is an important source of tasar silk (Singh and Singh, 1998). The extensive survey of the Sub-Himalayan belt of India conducted in 1966 by the Central Tasar Research Station, Ranchi, Bihar, India, brought to light the vast wealth of oak in the region (Jolly, 1970). The oak tasar track extends from Jammu and Kashmir in the west to Manipur in the east, embracing Himachal Pradesh, Uttar Pradesh, West Bengal, Sikkim, Assam, Arunachal Pradesh, Meghalaya, Mizoram and Nagaland. Unlike the mulberry (*Bombyx mori* L.) silk cocoons, the oak tasar silk cocoons cannot be satisfactorily softened by boiling in plain water (Jolly *et al.*, 1979). The oak tasar cocoons contain relatively high amounts of protein-tannin complexes in the form of proanthocyanidins (Pandey, 1990) and are thus difficult to reel. Generally the cocoons are cooked in presence of strong alkali agent or other harsh chemicals (Tikoo and Goel, 1987; Das, 1993; Iizuka *et al.,* 1993; Moon *et al.*, 1996; Chattopadhyay *et al.*, 1997). Since the chemical methods reduce the quality of the tasar silk thread in many ways (Tikoo and Goel, 1987), an alternative method for the oak tasar cocoon cooking based on the abundantly available pineapple fruit extract containing proteolytic enzymes was studied.

2. Materials and Methods

The cocoons produced by the oak tasar silkworm *Antheraea proylei* J. fed on *Quercus serrata* (Thunb.) leaves, hot air stifled for 6-7 hrs at 70 °C, and then stored for 2-3 months were used in the present investigation. Fresh and ripe (mature and yellow) fruit of pineapple *Ananus comosus* (L.) Merr. cv. Queen was purchased from the markets in and around Imphal, Manipur, India. The pineapple extract was prepared by homogenizing 150 g of the fruit pulp (prepared by first detaching the crown and stem parts of the mature and yellow fruit and then slicing off the skin part) with 1 litre of distilled water and the resulting homogenate was strained through a coarse cotton cloth. The supernatant having high proteinase

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activity (Singh *et al.*, 2003) was used for softening of the oak tasar cocoons.

Thirty oak tasar cocoons (ten replications of three cocoons each) were wrapped in a coarse cotton cloth and subjected to 30 minutes pressure cooking at 15 lbs./sq inch pressure and were then soaked in the above pineapple extract at room temperature (26-31 °C) for 12 hours. At the end of soaking, cocoons along with the wrapper were taken out from the cooking medium, and then washed repeatedly with tap water until the associated brown colour and proteinase activity were washed out. The cocoons were then removed from the wrapper, semi-dried on blotting papers, deflossed, and then subjected to single filament reeling on an epprouvette machine. For all the methods, single filament reeling was performed on an epprouvette machine and mass yarn reeling was performed on a modified CTR&TI pedal reeling cum twisting machine. The silk fibres were subjected to tensile and elongation tests at 64% humidity and 25 °C using Instron Tensile Strength Tester 6021 and also subjected to scanning electron microscopic examination using Scanning Electron Microscopic Model Stereoscan 360 of Cambridge Instruments.

Alternatively for comparative study, the cocoons were cooked by commonly adopted chemical procedure using soda developed by Tikoo and Goel (1987). The oak tasar cocoons were boiled for 30 mins in distilled water containing 1% sodium carbonate and were washed with hot water to remove sodium carbonate and semi dried for dry basin reeling.

3. Results and Discussion

The reeling parameters for determining the reeling performances were evaluated as indicated by FAO - Silk Reeling and Testing Manual (1999). The results of the single filament reeling performances are given in Table 1 and the results of the mass yarn reeling performances are given in Table 2. The following results on the single filament reeling parameters were recorded as Mean of 30 cocoons ± S.D and of mass yarn filament reeling performance as average of 5 replications of 50 cocoons each.

Data reveals that cocoon cooking with 1% Na_2CO_3 for 30 mins gives good reeling performances, however, it was found to reduce the strength of the fibre (Tenacity of 1.67 and 1.55 in case of single filament and mass yarn reeling). The silk filament was found to have reduced lustre and smoothness causing naps, consequently presenting an obstacle to the oak tasar silk reeling and weaving efficiencies. Moreover, soda may cause irritation to the workers of silk industry and may also cause effluent environmental problems.

The reeling performance of the cocoons subjected to 30 minutes pressure cooking at 15 lbs/ sq inch pressure and soaked in the above pineapple extract at room temperature (26-31 °C) for 12 hours was relatively better with respect to single filament reeling performance and mass yarn filament reeling performance as compared to that of soda treatment. It was also observed that there is an increase in the tenacity (2.15 and 3.02 in case of single filament and mass yarn reeling). Moreover on visual examination the silk filament was found to have more luster and smoothness.

The use of enzymes in the silk industry is relatively unexplored. Proteinases, enzymes characterized by their proteolytic activity, have the potential to effect partial solubilition of the proteinaceous gum sericin involved in binding the silk strands together in cocoon, an essential process in the silk cocoon cooking and reeling. The pineapple fruit contains a cysteine protease known as fruit bromelain, an acidic protein having a broad range of specificity towards polypeptides (Rowan and Buttle, 1994). Scanning electron microscopic studies (Figure 1) showed that the silk filaments obtained from treatment by pineapple fruit extract were sufficiently free from the silk gum sericin and no surface damage characterized by rupture/ fibrillation of filament was seen due to excessive removal of sericin and is suitable for optimum yarn reeling. These results showed that pineapple extract which is rich in cysteine endopeptidases can cleave the internal peptide bonds in an amino acid chain effecting partial solubilisation of the proteinaceous silk gum (sericin) involved in binding the silk (fibroin) strands together in silkworm cocoon.

Table 1: Comparison between the developed method using pineapple extract with commonly adopted soda treatment method of (*Antheraea proylei J.*) cocoons with respect to single filament reeling performance

Method for cocoon treatment	Soda treatment	Developed pineapple extract treatment
Number of ends feeding/ cocoon	3.4 ± 2.0	2.5 ± 1.4
Filament length (m)	666.2 ± 179.1	678.6 ± 140.5
Recovery %	64.7 ± 5.6	69.7 ± 9.2
Denier (D)	5.6 ± 0.5	6.7 ± 1.0
Reelability %	29.41	40.0
NBFL (m)	195.9	195.9
Tenacity (g/D)	1.67 ± 0.04	2.15 ± 0.07
Elongation %	34.40 ± 7.96	36.94 ± 8.13

* Each value is an average of 30 replications

➢ Number of ends feeding per cocoon = Number of breaks encountered by a cocoon while reeling

➢ Filament length = Length of reeled silk filament per cocoon in meters

➢ Recovery % = (Filament weight/ cocoon shell weight) × 100

➢ Non- breakable filament length = (Filament length in meters × reelability %) / 100

➢ Reelability % = Number of reeled cocoons/ Number of ends feeding

➢ Denier (D) = (Total weight of reeled silk (g)/ Total length of

reeled silk (m) × 9000)

➢ Tenacity (g/D) and Elongation (%) as averages of twenty repetitions taking outer, middle and inner reeled filaments of the cocoon in more or less equal proportions

Table 2: Comparison between the developed method using pineapple extract with commonly adopted soda treatment method of (*Antheraea proylei J.*) cocoons with respect to mass yarn filament reeling performance

Method for cocoon treatment	Soda treatment	Developed pineapple extract treatment
Cooking efficiency %	90	95
Raw silk %	60.1	64.4
Yield/ 1000 cocoons (g)	347	380
Production/ 8 hr/ reeler (g)	200	175
Tenacity (g/D)	1.55	3.02
Elongation %	25.01	31.06

* Each value is an average of 5 replications of 50 cocoons each.

Figure 1: Scanning electron photomicrograph of single silk filaments reeled from oak tasar (*Antheraea proylei J.*) cocoons. The cocoons were cooked prior to reeling by a standardized pineapple extract procedure involving initial 30 min pressure cooking followed by 12 hr soaking in pineapple extract at room temperature (26-31 °C)

4. Conclusion

Tasar silk production is one of the major agro based industries playing an important role in the rural economy of the North Eastern states of India owing to advantage of availability of abundant nature grown host plant and skilled reelers and weavers. It can be concluded from the above observations that pineapple fruit pulp extract having proteolytic activity due to presence of cysteine proteinases, the most abundant among them being the fruit bromelain have the potential to effect partial solubilization of the proteinaceous gum sericin involved in binding the silk strands fibroin together in cocoon. The method involving pineapple extract is a relatively better method regarding its overall better reeling performances and also mostly due to the abundant availability of pineapples grown in the oak tasar belt in India. The common silk reelers and weavers mostly residing in villages with poor economic conditions may preferably adopt the pineapple extract cocoon cooking procedures involving incubation at room temperature.

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