



RESEARCH PAPER

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Improving the quality of silk yarn and fabric using various edible oils during pre-treatment

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Abstract

Silk, being the “queen of textiles”, passes through various procedures to ensure its quality. Pre-treatment is the process of soaking raw silk in a solution consisting of soap, oil, and water. Its primary purpose is to smoothen and elasticize the raw silk to expedite throwing operations. This paper aimed to modify the soaking solution for raw silk being used at DMMMSU-Sericulture Research and Development Institute, to improve the quality of fabric produced. The study utilized an experimental research design, using raw silk from silkworm hybrid DMMMSU 406. Pre-treatment was done using three types of edible oils such as castor oil, corn oil, and coconut oil as soaking agents with a material liquor ratio of 1:4:5:6. All the treatments passed the standards for breaking strength, dimensional change, and colorfastness. Results revealed that coconut oil had the lowest registered number of breaks, and the highest registered reflectance percentage. The same treatment also performed better in terms of cleanness, evenness, and neatness test.

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Introduction

Sericulture is the science focusing both on silkworm rearing, and on the processing of silk and silk-derived products (Pop *et al.*, 2020). This is a laborious farm-based livelihood activity suited for rural-based farmers. The leading countries producing silk, accounting for 60% of silk world production, are China and India (Popescu, 2013). The entire process, from soil to silk, can be classified into four agro-industrial activities namely: mulberry farming for leaf production; silkworm rearing for cocoon production; production of raw silk; and production of silk fabrics (Shirsath, 2017).

Being the “queen of textiles”, silk fabric undergoes a lot of procedures to ensure its quality. This fabric is the end product of processed raw silk. Raw silk processing involves cooking of cocoons, reeling, re-reeling, and pre-treatment (Karthik & Rathinamoorthy, 2017; Lee, 1999). Textile materials are tested involving methodical assessment of fiber, yarn, and fabric characteristics such as fiber length, fineness, strength, yarn count, twist, strength, evenness and hairiness, fabric thickness, weight, strength, durability, serviceability, comfort, color fastness, aesthetic and low-stress mechanical properties (Ghosh & Mal, 2019). One of the testing methods done is pre-treatment which refers to the process of soaking raw silk in a solution consisting of soap, oil and water using the material liquor ratio 1:4:5:6. Primarily, soaking the silk in the solution aims to soften and slacken the gum and to lubricate the thread. This process is important to thicken the thread and to provide an oily substance on the thread, thereby preventing damage during thrown silk production (Babu, 2012).

Improving the quality of silk yarn remains an interesting area for research. Some studies modified the combination of their soaking solution to improve the quality of the yarn. These utilized Mrudula oil (Raichurkar *et al.*, 2017) and emulsion of oil which can be vegetable, mineral, sulfated or any combination of these as soaking agents (Ahmedullah, 2014). Rice-wash water was also used for silk combing (Sumranpath *et al.*, 2015). Further, an artificial reeling method to produce stronger silk thread was also suggested (Shao & Vollrath, 2002).

Soaking is the foremost procedure in the production of silk fabrics and its primary purpose is to smoothen and elasticize the raw silk to expedite throwing operations (Raichurkar *et al.*, 2017). This process is practiced with the use of emulsion, lubricants, and soap with proper consideration to the quantity and quality of soap and lubricant to be utilized in the emulsion. In the same study, it was also stated that due to the presence of castor oil, the degree of hydrolysis was considerably reduced when compared with other soaking oil.

In Region 1, Philippines, DMMMSU-Sericulture Research and Development Institute is one of the leading producers of cocoon and silk (Caccam & Mendoza, 2010). Majority of its silk fabric buyers have observed that after washing, yellowish spots appear on the cloth. These instances have prompted clients to return their fabrics for bleaching from time to time.

Hence, this study modified the pre-treatment procedure using edible oils such as castor oil, corn oil, and coconut oil as soaking agents. The study determined the lowest registered number of breaks among the different treatments. It also evaluated the performance of the different treatments as to breaking strength, dimensional change, and colorfastness to laundering. Lastly, the grade in cleanness, evenness, neatness, and reflectance measurement percentage of three different treatments was compared.

Materials and methods

An experimental procedure was used to compare the three treatments, each having material liquor ratio of 1:4:5:6 (i. e. 1 kg raw silk, 4% mild soap, 5 li water and 6% of edible oil). The soap utilized in the study is comprised of sodium palmate, sodium palm kernelate, sodium cocoate, talc, glycerin, palmitic acid, titanium dioxide, nonfat dry milk and Ci 74260 and the edible oils used are castor oil, corn oil and coconut oil.

In each treatment, the soap and edible oil were diluted in five liters of boiling water and mixed

carefully before soaking the raw silk. Then the silk was soaked for at least six hours before squeezing and air drying for a day.

The entire procedure for pre-treatment process was strictly followed and only raw silk produced from silkworm hybrid DMMMSU 406 was used to avoid variation. After pre-treatment, winding was done and parts of the wound raw silk were subjected to number of breaks, cleanness, evenness and neatness test.

The number of breaks was tested because it is one of the most important factors in the quality testing of the silk. The cleanness test was used to determine the number of cleanness defects of the raw silk. The neatness test was used to determine the neatness percentage of raw silk, where neatness defects were similar imperfections in the raw silk threads to those classified as minor defects. Evenness test was used to determine the degree of evenness of raw silk within approximately the same length as the sizing skein.

Evenness defects are those positions of raw silk threads on an inspection board showing stripes caused by variations in the size of the raw silk to such a degree easily noticeable by visual inspection. As a general rule on raw silk testing, the lowest grade obtained is the grade of the raw silk for cleanness, evenness, and neatness test (Philippine Textile Research Institute).

The number of breaks in each skein was counted during the winding process. Results of cleanness, evenness and neatness tests were read using the seriplane board as a reference for grading the raw silk.

After weaving, one meter of woven silk fabric from each treatment was submitted to the Philippine Textile Research Institute (PRTI) for testing. Reflectance Measurement (percent) was tested using PNS/PTRI ISO 105-B02 or AATCC 16E/F Testing Method. Breaking Strength (kilogram-force or kgf) was tested using the American Standard Testing Method (ASTM) 1683. Dimensional Change (percent) was tested using PNS 1850/ PTRI 6330/AATCC 135

(one cycle testing method), while the colorfastness to laundering (rating) was tested using PNS/ISO 106-C06 or AATCC 61, respectively.

The study was laid out using the Randomized Complete Block Design (RCBD) with three replications.

Results and discussion

Total Number of Breaks of 10 Hanks per Treatment during Winding

The number of breaks of raw silk is one of the most important tests, as it affects the quality of silk yarn, efficiency of weaving, and the quality of the fabric. This signifies that the quality of silk is good if it has a lesser number of breaks during the winding process.

The number of breaks of raw silk as influenced by the three (3) different kinds of edible oil during pre-treatment was tested (Table 1). Results show that corn oil (T₂) registered the highest number of breaks of 132, followed by castor oil (T₁) with 105 while the lowest was seen in coconut oil (T₃). Results of the Analysis of Variance (ANOVA) on the three treatments were compared (post hoc test) using Tukey's HSD. Comparison among treatment means revealed that coconut oil (T₃) had the lowest mean number of breaks of 86.00. However, this was also comparable to castor oil (T₁) with a mean of 108.00. The highest number of breaks was recorded in corn oil (T₂) but did not vary significantly with T₁. Based on these findings, coconut oil can be a better pre-treatment soaking agent based on the number of breaks. This also implies that raw silk pre-treated using coconut oil has a better quality.

Table 1. Summary of Results for Number of Breaks.

| Treatment | Registered # of breaks | Means | * |
|------------------------------|------------------------|--------|----|
| T ₁ – Castor oil | 105 | 108.00 | ab |
| T ₂ – Corn oil | 132 | 123.67 | a |
| T ₃ – Coconut oil | 67 | 86.00 | b |

* All means followed by the same letter are not significantly different at 0.05 level (Tukey's HSD)

Cleanness, Evenness, and Neatness Test

The results of the cleanness, evenness, and neatness tests (Table 2) show that the lowest grade of 70% was recorded by T₁ and T₂, while T₃ recorded the lowest grade of 90% for the three tests conducted.

Registered means (Table 3) as to cleanness show that there is no significant difference among the three treatments with F value of 4.17 with a p value of 0.0734. Registered means (Table 3) as to evenness shows that there is no significant difference among treatments with F value of 2.67 with a p value of 0.15. As to neatness, registered means (Table 3) shows that there is no significant difference between the treatments with F value of 4.33 with a p value of 0.0685.

Table 2. Summary of Results for Cleanness, Evenness, and Neatness Test of Silk Fabric.

| Treatment | Percentage | | |
|----------------|--------------|------------|--------------|
| | Cleanness | Evenness | Neatness |
| T ₁ | 70, 90, 80 | 80, 70, 90 | 70, 80, 80 |
| T ₂ | 80, 90, 70 | 70, 80, 80 | 70, 90, 80 |
| T ₃ | 100, 90, 100 | 90, 90, 90 | 100, 90, 100 |

Table 3. Comparison of Means for Cleanness, Evenness and Neatness Test.

| Treatment | Mean | | |
|----------------|-----------|----------|----------|
| | Cleanness | Evenness | Neatness |
| T ₁ | 76.67 | 83.33 | 86.67 |
| T ₂ | 76.67 | 83.33 | 83.33 |
| T ₃ | 93.33 | 96.67 | 96.67 |

The result shows that the treatments did not vary significantly in terms of cleanness, evenness and neatness. However, T₃ notably has the highest grade of silk based on the parameters tested.

Reflectance Measurement (%)

Material of an opaque or non-transparent (but not translucent or not completely clear), are measured by reflectance methods to obtain a numerical representation of the color of the specimen using the AATCC Testing Method.

The result shows that T₂ has the lowest reflectance measurement of 43.10% with a mean of 40.57 wherein T₃ registered the highest reflectance measurement of 57.59% with a mean of 53.35. The result of the analysis of variance shows that the computed F value of 17.83 (higher than the tabular value of 4.34) with a p value of 0.0030 which is less than 0.05 level of significance (Table 4).

Table 4. Summary of Results for Reflectance Measurement.

| Treatments | Reflectance Measurements (%) | Mean | * |
|----------------|------------------------------|-------|---|
| T ₁ | 49.89 | 48.31 | a |
| T ₂ | 43.10 | 40.57 | b |
| T ₃ | 57.59 | 53.35 | a |

*All means followed by the same letter are not significantly different at 0.05 levels (Tukey's HSD)

On the comparison among means (post hook test) using Tukey's HSD, T₂ did not differ significantly from T₁ but shows a significant difference with T₃. On the other hand, T₁ and T₃ had no significant differences on the reflectance measurement.

Noticeably, the sample treated with coconut oil (T₃) registered the highest reflectance percentage and mean. Since higher reflectance percentage was recorded that led to a whiter fabric, this implies that T₃ successfully eliminated the yellowish stain in the fabric.

Breaking Strength (kgf)

Based on the breaking strength or the capacity of a fabric to withstand ultimate force to rupture, T₁ ruptured at a force of 40.89kgf or 401.13 N with a mean of 339.00; T₂ ruptured at a force of 38.72kgf or 379.84 N with a mean of 331.33; and T₃ ruptured at a force of 36.24kgf or 335.51 N with a mean of 315.00 (Table 5).

Table 5. Breaking Strength for the warp.

| Treatment | Breaking Strength for warp | | |
|----------------|----------------------------|-----------------|--------|
| | kgf | N ^{1/} | Mean |
| T ₁ | 40.89 | 401.13 | 339.00 |
| T ₂ | 38.72 | 379.84 | 331.33 |
| T ₃ | 36.24 | 355.51 | 315.00 |

Analysis of variance shows that the registered means are all comparable to each other with an F value of 0.20 with a p value of 0.8251 which is higher than 0.05 level of significance. This shows that treatments do not have significant difference as to breaking strength for the warp.

The result of breaking strength for the weft shows that T₁, T₂ and T₃ ruptured at a force of 25.82kgf or 253.29 N, 24.27kgf or 238.09 N and 20.91kgf or 205.13 N respectively (Table 6). Registered means for T₁, T₂ and T₃ are 243.67, 227.67 and 202.33 respectively.

The result of the analysis of variance shows that the computed F value is 13.62 with a p value of 0.0059 which is less than 0.05 level of significance.

Table 6. Breaking Strength for the weft.

| Treatment | Breaking Strength for weft | | | * |
|----------------|----------------------------|-----------------|--------|---|
| | kgf | N ^{1/} | Mean | |
| T ₁ | 25.82 | 253.29 | 243.67 | a |
| T ₂ | 24.27 | 238.09 | 227.67 | a |
| T ₃ | 20.91 | 205.13 | 202.33 | b |

On the comparison of the means, T₁ and T₂ did not differ significantly but both treatments are significantly different with T₃ on the breaking strength for weft. Results show that both breaking strength for warp and weft passed the standard set by PRTI that for a medium weight fabric, like silk, the minimum force required to be applied is 178 N.

Dimensional Change (%)

Dimensional change refers to the decrease (shrinkage) and/or increase (elongation) in the length or width of the fabric due to washing. The minimum requirement set by the American Association of Textile Chemist and Colorists (AATCC) Testing Method is not more than 2.5%. The result for dimensional change for warp or length shows that T₁ shrunk by a mean of 4.13%, T₂ shrunk by a mean of 3.93%, and T₃ shrunk by a mean of 3.20. Analysis of variance shows that the acquired means do not have significant differences among each other because the p -value of 0.5310 is higher than 0.05 level of significance (Table 7).

Table 7. Comparison of Means of Dimensional Change for Warp.

| Treatments | Dimensional Change for warp (mean) |
|----------------|------------------------------------|
| T ₁ | 1.73 |
| T ₂ | 1.47 |
| T ₃ | 1.40 |

On the other hand, the result of dimensional change for weft or width shows that T₁, T₂ and T₃ shrunk by means of 1.73%, 1.47% and 1.40%, respectively. Analysis of variance shows the F value of 0.32 with a p -value of 0.7382 is higher than 0.05 level of significance (Table 8).

Results show that for warp, all treatments did not meet the standard set by AATCC which is 2.5%. This

could be attributed to the lesser efficiency of the twisting machine used. On the other hand, for the weft, all treatments passed the standard set.

Table 8. Comparison of Means of Colorfastness to Laundering.

| Treatments | Colorfastness to Laundering (mean) |
|----------------|------------------------------------|
| T ₁ | 4.17 |
| T ₂ | 3.83 |
| T ₃ | 4.17 |

Colorfastness to Laundering

Colorfastness to laundering is the ability of a fabric to retain its color or resist the transfer of its colorant(s) to any adjacent material during laundering using AATCC Testing Method. The minimum requirement is Grade 4.

The results for colorfastness to laundering show that T₁, T₂, and T₃ were graded 4.17, 3.83, and 4.17 respectively. It is notably that only T₂ did not meet the standard set by AATCC. Analysis of variance shows that the acquired means do not have significant differences from each other because the p -value of 0.5477 is higher than 0.05 level of significance (Table 9).

Based on the results, T₃ remarkably has a better quality of silk among the three treatments. This means that coconut oil is an effective replacement for the edible oil used in the pre-treatment to improve the quality of the silk fabric.

Conclusions

The purpose of soaking the silk in soap and oil solution is to soften and slacken the gum and to lubricate the thread. This study aimed to modify the soaking solution used at DMMMSU-SRDI with the purpose of improving the quality of fabric produced. All treatments passed the standard for both warp and weft for breaking strength test, dimensional change, and the change in color and staining test. However, among the three treatments, the solution with coconut oil registered the lowest number of breaks, thus considered as having the best quality of silk among the three treatments. It also has a better grade of silk for cleanness, evenness, and neatness and registered the highest reflectance percentage.

However, further studies can be conducted using other promising silkworm breeds and explore other kinds of edible oils to possibly obtain a higher grade requirement for colorfastness to laundering.

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