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11 August 2022

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 21, No. 6, p. 1-6, 2022

RESEARCH PAPER OPEN ACCESS

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

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Key words: Edible oil, Pre-treatment, Raw silk, Silk fabric, Silk quality, Soaking agents

http://dx.doi.org/10.12692/ijb/21.6.1-6 Article published on December 01, 2022

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 seri-plane 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 orkgf) 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 (T_2) registered the highest number of breaks of 132, followed by castor oil (T_1) with 105 while the lowest was seen in coconut oil (T_3). Results of the Analysis of Variance (ANOVA) on the three treatments were compared (post hok test) using Tukey's HSD. Comparison among treatment means revealed that coconut oil (T_3) had the lowest mean number of breaks of 86.00. However, this was also comparable to castor oil (T_1) with a mean of 108.00. The highest number of breaks was recorded in corn oil (T_2) but did not vary significantly with T_1. 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 T_1 and T_2, while T_3 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, T_3 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 T_2 has the lowest reflectance measurement of 43.10% with a mean of 40.57 wherein T_3 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	*
T1	49.89	48.31	a
T2	43.10	40.57	b
T3	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, T_2 did not differ significantly from T_1 but shows a significant difference with T_3. On the other hand, T_1 and T_3 had no significant differences on the reflectance measurement.

Noticeably, the sample treated with coconut oil (T_3) registered the highest reflectance percentage and mean. Since higher reflectance percentage was recorded that led to a whiter fabric, this implies that T_3 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, T_1 ruptured at a force of 40.89kgf or 401.13 N with a mean of 339.00; T_2 ruptured at a force of 38.72kgf or 379.84 N with a mean of 331.33; and T_3 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 T_1, T_2 and T_3 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 T_1, T_2 and T_3 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 T_1 shrunk by a mean of 4.13%, T_2 shrunk by a mean of 3.93%, and T_3 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)
T1	1.73
T2	1.47
T3	1.40

On the other hand, the result of dimensional change for weft or width shows that T_1, T_2 and T_3 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)
T1	4.17
T2	3.83
T3	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 T_1, T_2, and T_3 were graded 4.17, 3.83, and 4.17 respectively. It is notably that only T_2 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, T_3 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.

Acknowledgment

The authors acknowledge Don Mariano Marcos Memorial State University for funding the study and greatly appreciate the support of all personnel of the Research and Development Division of the Sericulture Research and Development Institute.

References

Ahmedullah ANM. 2014. Comparative study on the effect of vegetable batching oil emulsion using Morident-B with conventional emulsion using mineral oil on yarn quality **4(1),** 1-3.

Babu KM. 2012. Silk production and future of natural silk manufacture. In: Handbook of natural fibres **2,** Woodhead Publishing Limited p. 3-29.

Bhat TA. 2014. An Analysis of Public Private Partnership in Sericulture in Jammu and Kashmir State (India). Journal of Economics and Sustainable Development **5(11),** 121-126.

Caccam M, Mendoza T. 2010. Factors affecting productivity and profitability of sericulture-based agroecosystems. NLR Journal **3(4),** 73-88.

Ghosh A, Mal P. 2019. Testing of Fibres, Yarns and Fabrics and their Recent Developments. In book: Fibres to Smart Textiles 221-256.
DOI: 10.1201 /97804 29446511-12.

Grant T. 2020. https://plant-breeding-genomics.extension.org/randomized-complete-block-design/ (May 13, 2021)

Karthik T, Rathinamoorthy R. 2017. Sustainable silk production. Sustainable Fibres and Textiles **6,** 135-170.

Lee YW. 1999. Silk reeling and testing manual (No. 136). Food and Agriculture Organization.

Pop L, Mărghitaş LA, Bobis O, Moise AR, Dezmirean DS. 2020. Analysis of Market Trends within the Romanian Silk Industry. Bulletin UASVM Animal Science and Biotechnologies **77(1),** 23-34. DOI: 10.15835/buasvmcn-asb: 0024.19.

Popescu A. 2013. Trends in World Silk Cocoons and Silk Production and Trade, 2007-2010. Scientific Papers. Series Animal Science and Biotechnologies **46 (2),** 418-423.

Raichurkar P, Subramanium V, Ramachandran R. 2017. Performance of silk yarn with the effect of soaking in Mrudula soaking oil. Colourage 41-44.

Shao Z, Vollrath F. 2002. Surprising strength of silkworm silk. Nature **418,** 741.
https://doi.org /10.1038 /418741a.

Shirsath HL. 2017. Moriculture: Cultivation of Mulberry Plants.
https://indiaagronet.com/Moriculture

Sonwalkar TN. 1993. Handbook for Silk Technology (New Age International, India)

Sumranpath K, Aungsuratana A, Auttathom T, Poramacom N. 2015. Existing condition of commercial sericulture production in Northeastern Thailand. Kasetsart Journal (Soc. Sci) **36,** 155-164.