Journal of AgriSearch, 8 (3): 264-269
An Open Access International Peer Reviewed Quarterly

ISSN : 2348-8808 (Print), 2348-8867 (Online)
https://doi.org/10.21921/jas.v8i03.1673

Effect of Blade Profile and Processing Parameters on Quality Seedlac

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ABSTRACT

Sticklac obtained after scraping the lac incrustations from mature lac stick of host trees and converted into seedlac at lac processing industries for its further use in making lac-based value added products. Sticklac converted into seedlac can be stored like grain, in gunny bag or metal bin for longer period without much deterioration in the quality so that lac grower can sell seedlac whenever they get remunerative price. Different profiles of the churning blade used to increase the working surface area to the maximum possible extent and enhance the turbulence during washing operation of sticklac in presence of water for quality seedlac without major change in conventional churning mechanism of lac washing machine developed under small scale lac processing unit. Minimum and maximum impurity content and color index in the prepared seedlac with churning time 15 min and lac-water ratio 1:1, 1:2 and 1:3 determined as 3.37, 3.87 and 4.76% and 7.33, 8.00 and 8.00 whereas with churning time 30 min 2.57, 2.64 and 4.00% and 6.00, 6.00 and 7.00, respectively which indicates that higher amount of water increased impurity and color index, enhanced churning time reduced impurity content and color index, while warm water reduced impurity level from 2.57 to 2.00%, 2.64 to 2.70% and 4.00 to 2.80% with churning time 30 min and lac-water ratio 1:1, 1:2 and 1:3, respectively but color index was found higher (7.00) compared to normal water (6.00). Impurity content and color index were lowest in seedlac (3.51% and 7.00) prepared using modified churning blade 'rod parallel to the shaft' compared to other modified churning blade and conventional blade.

KEYWORDS

Lac, sticklac, processing parameter, blade profile, seedlac

ARTICLE INFO

Received on	:	22/04/2021
Accepted on	:	16/08/2021
Published online	:	05/09/2021

INTRODUCTION

Lac is a natural resin secreted by lac insect (*Kerria lacca* Kerr) which is generally used in our country for lac production (Sharma and Jaiswal, 2010). Lac is mainly produced in India, Thailand, Indonesia, part of China, Myanmar, Philippines, Vietnam, Cambodia etc. and India is the largest producer of lac in the world. In India, lac is mainly produced in Jharkhand, Chhattisgarh, Madhya Pradesh, West Bengal, Maharashtra, Odisha and part of Uttar Pradesh, Andhra Pradesh, Gujarat and NEH region. Lac production in India was about 18,746 tons during year 2015-16. During the year 2015-16 India exported 7668.42 tons of lac in different forms valued Rs. 24,755.18 lakhs (Yogi *et al*, 2018).

In India, lac growers rear lac insects on host trees i.e. *palas* (*Butea monosperma*), ber (*Ziziphus mauritiana*) and kusum (*Schleichera oleosa*) for commercial production of lac crop. Rearing of lac insects on host trees is known as lac cultivation. Lac growers harvest mature lac crop from host trees alongwith branches and then scrape. Scraped lac encrustation, from lac stick, is known as sticklac which contains impurities in the form of stick, stone, sand, insect body etc. and water-soluble lac dye.

Lac growers sell their produce in the form of scraped lac or cut bits immediately after harvest at prevailing price in the local market to merchants due to lac of knowledge for proper storage, lack of storage facility and in need of immediate cash. The merchants associated with lac, supply the scraped lac or cut bits to lac processing industries where it is processed into seedlac for its further use in making lac-based products. Processing of lac involves five major unit operations like crushing, washing, drying, cleaning and grading. Scraped lac or cut bits converted into seedlac can be stored for longer duration like grain, in gunny bags or metal bin. Having done so, lac grower can sell seedlac whenever they get remunerative price. Therefore, need was felt to develop facility for converting scraped lac or cut bits into seedlac at village level. Considering the need, machines required for establishing such facility at village level lac scrapers (Prasad *et al* (2005) and Prasad *et al* (2001)) and small scale lac processing were developed at ICAR - Indian Institute of Natural Resins and Gums, Ranchi. Small Scale Lac Processing Unit consists of lac crusher, lac washing machine (Prasad *et al*, 2008), lac winnower and lac grader.

Washing machine developed at ICAR – Indian Institute of Natural Resins and Gums, Ranchi under small scale lac processing unit was utilized for the present investigation with different profile of churning blades i.e., conventional blade, rod parallel to the shaft, rod 45^0 to the shaft, rod perpendicular to the shaft and flat parallel to the shaft to study the effect of

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blade profile on washing quality of seedlac as detailed below.

MATERIALS AND METHODS

The power operated lac washing machine developed at ICAR – Indian Institute of Natural Resins and Gums, Ranchi was used for the present investigation with different treatments i.e. lac and water ratio (1:1, 1:2 and 1:3), churning time (15 and 30 min), water temperature (normal – 25^{0}C and warm water — 37^{0}C) along with existing conventional blades and different type of modified churning blade i.e. rod parallel to the shaft, rod 45^{0} to the shaft, rod perpendicular to the shaft and flat parallel to the shaft developed based on blade profile to observe the effect on quality parameters of seedlac. Each washing experiment with different treatments as detailed above was replicated thrice to minimize manual error. Quality parameters of the prepared seedlac with different treatments as detailed above was evaluated for impurity and color index form Quality Evaluation Laboratory, ICAR – Indian Institute of Natural Resins and Gums, Ranchi (IS/ISO 9001:2008 accredited laboratory).

Lac washing machine

The lac washing machine developed at ICAR — Indian Institute of Natural Resins and Gums, Ranchi (Figure 1) mainly consists of a barrel, agitator mounted on the shaft, power transmission system mounted on a MS frame. A cylindrical washing barrel of 500 mm diameter and 1000 mm length was fabricated using 4.0 mm thick mild steel sheet to hold a charge of maximum 35 kg crushed lac per batch during washing operation under primary lac processing. The barrel was closed at both the ends out of which one end is fixed and other is detachable to easily install the shaft with fixed agitator mechanism inside the washing barrel. Developed washing barrel had three openings on its curved surface. Out of which one square opening provided at the top is used for charging the crushed lac and water. Another opening was provided vertically below the first opening with a lid for discharging washed lac. Third opening was provided mid way between the top and the bottom openings through which wash water drain out during lac washing operation. A 60-mesh wire net was also provided on the third opening so that the lac particles movement from washing barrel through third outlet may be restricted. The barrel was fitted with mild steel shaft having diameter 50 mm mounted on self align bearing (UPC) with main frame at both ends. Power transmission to the shaft of washing barrel is provided through 1.0 hp single phase electric motor comprised of V- groove pulley and V-belt with provision of tightening the belt tension as per requirement. Pedaling mechanism is also provided at the other end of lac washing machine so that washing operation can be performed manually where electrical power availability is a problem. Mild steel blades (Figure 2) were fixed in spiral shape for uniform distribution of load during its operation. The blades were fixed at an interval of 55.0 mm along the axis on the shaft with 22.5^{0} angular spacing between the adjacent blades (Prasad *et al*, 2008). The approximate cost of the washing machine is Rs. 55,000/- excluding GST.

Fig. 1: Lac washing machine

Conventional blade

The existing conventional churning blade was made using 5.0 mm thick mild steel flat having length 200.0 mm and width 25.0 mm. Another piece of mild steel flat of same thickness and width having 100.0 mm length was welded at 90^{0} from the top end of the main body of blade (Figure 2). Main body of the blade was welded on the shaft of washing barrel for churning lac in presence of water to remove impurities and water-soluble lac dye from crushed sticklac during washing operation.

Development of modified churning blades

Profile of the existing churning blade in lac washing machine was modified considering possible design based on rotation of blade attached with shaft of the lac washing machine to study the effect of different blade profile on quality of washed seedlac. To enhance the turbulence during lac washing operations, four sets comprising of eleven number of different types of modified blades i.e. rod parallel to the shaft, rod 45^{0} to the shaft, rod perpendicular to the shaft and flat parallel to the shaft were developed to know the effect of churning mechanism for easy removal of water soluble lac dye from sticklac and efficient washing operation. Each set of modified churning blade was fixed on the main shaft for creating enhanced turbulence during churning/washing operation inside the washing barrel (Anonymous, 2014). Details of the developed modified blades are as under:

Rod parallel to the shaft

To develop modified churning blade "rod parallel to the shaft" a piece of mild steel flat (similar to conventional blade) having length 185.0 mm, width 25.0 mm and 5.0 mm thickness was taken and another piece of mild steel flat of same thickness and width having 95.0 mm length was welded at 90^{0} from the top end of the main body of blade (Figure 2). On the plain face of smaller piece of mild steel flat, five round bars having length 70.0 mm and diameter 9.0 mm were welded at equal intervals of 12.5 mm to increase the turbulence during washing operation of sticklac in presence of water.

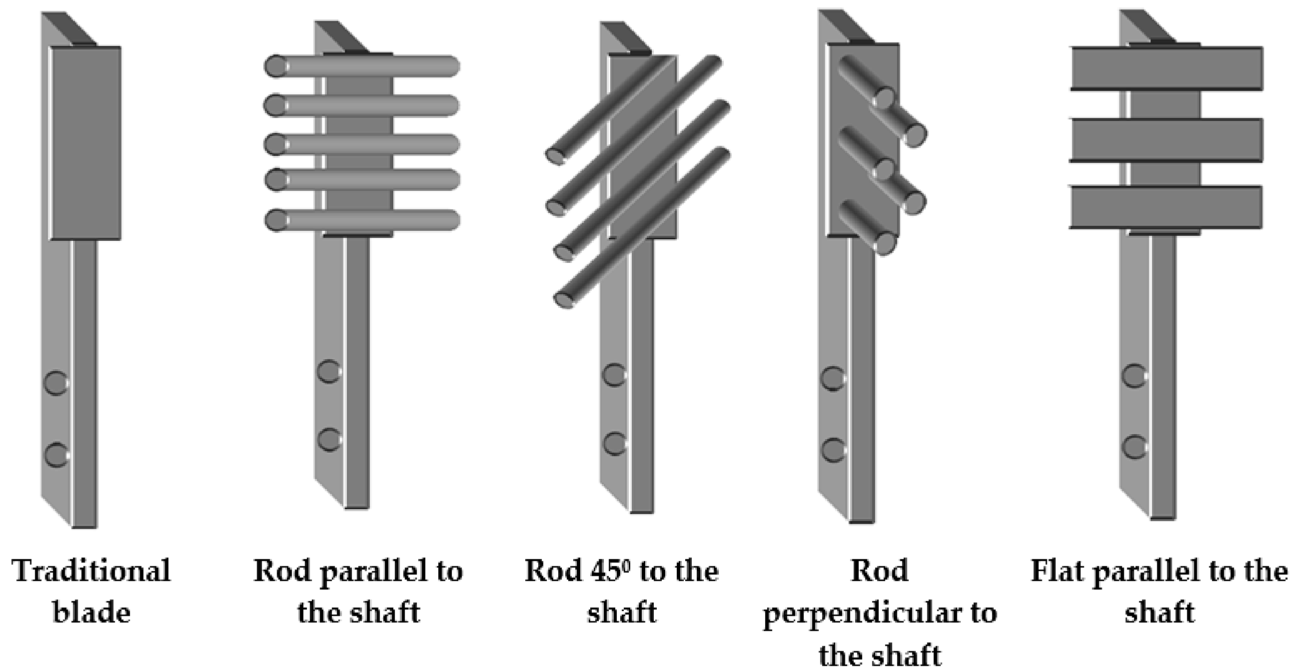

Fig. 2: Traditional and modified churning blades

Rod 45^0 to the shaft

Similar to modified churning blade "rod parallel to the shaft" another set of modified churning blade "rod 45^0 to the shaft" (Figure 2) was developed but four round bars having 75.0 mm length and diameter 9.0 mm were welded on the face of smaller piece of mild steel flat inclined at 45^0 having equal interval of 20.0 mm to increase the turbulence during washing operation of sticklac in presence of water.

Rod perpendicular to the shaft

To develop modified churning blade "rod perpendicular to the shaft" a piece of mild steel flat (similar to conventional blade) having length 185.0 mm, width 25.0 mm and 5.0 mm thickness was taken and another piece of mild steel flat of same thickness and width having 95.0 mm length was welded at 90^0 from the top end of the main body of blade (Figure 2). On the plain face of smaller piece of mild steel flat five round bars having length 45.0 mm and diameter 9.0 mm was welded perpendicular on the face of smaller mild steel flat at equal intervals of 12.5 mm in zig-jag pattern to increase turbulence during washing operation of sticklac in presence of water.

Flat parallel to the shaft

To develop modified churning blade "flat parallel to the shaft" a piece of mild steel flat having length 185.0 mm, width 25.0 mm and 5.0 mm thickness was taken and another piece of mild steel flat of same thickness and width having 95.0 mm length was welded at 90^0 from the top end of the main body of blade similar to conventional blade (Figure 2). On the plain face of smaller piece of mild steel flat, three mild steel flat having length 80.0 mm, width 25.0 mm and thickness 5.0 mm were welded at equal intervals of 10.0 mm parallel to the shaft to increase the turbulence during washing operation of sticklac in presence of water.

Modification in churning mechanism of washing machine

The existing shaft of washing barrel was modified for fixing different type of blade having different type of blade profile to study the effect of blade profile on quality parameters of seedlac. To modify the existing churning mechanism, length of main body of each conventional blade was reduced to a length up to 80.0 mm from the fixed end of the shaft and two holes of diameter 10.0 mm was made at a distance of 35.0 and 65.0 mm from the fixed end. The distance between two holes was kept 35.0 mm for fixing modified churning blades with nut and bolt as shown in Figure 3.

Effect of blade profile on quality parameters of seedlac

To evaluate the performance of different blade profile on quality parameters of seedlac, each set of modified churning blade was fixed on the shaft of washing machine utilizing the mechanism developed for fixing the blades considering the direction of rotation of the shaft. After fixing one set of the modified churning blade on the shaft of washing machine, the shaft along with modified churning blade was placed inside the washing barrel of the machine and closed with the outer cover provided in the machine. After proper placing and fixing the shaft along with set of modified churning blades, the machine was initially tested without any charge for its smooth working. Similarly, each set of different type of modified churning blade were fixed on the main shaft of the washing machine and tested before actual lac washing operation.

Fig. 3: Modified churning blade mounted on shaft of washing machine

For washing seedlac utilizing lac washing machine with set of modified churning blade, one set of modified churning blade were fixed on the shaft of washing barrel and required quantity of crushed sticklac having grain size 8 – 10 mesh was charged and washing was performed as detailed in Table 1. Wash water present inside the washing barrel was discharged completely by loosening the nut and bolt provided at the bottom gate of the washing machine. After final washing operation or removal of color of wash water, washed seedlac was discharged by completely opening the gate provided below the washing machine so that it is collected and dried. After collection of washed seedlac it was spread on the cemented floor in thin layer and time to time raking was done using wooden rack till complete drying of washed seedlac. Dried and washed seedlac was than winnowed using lac winnower to remove lighter impurities which were not removed during washing operation. The winnowed seedlac was than graded using lac grader to make the lac grains of uniform size. The washing process detailed below (Table 1) followed for each set of modified churning blade and quality parameters i.e. impurity and color index were determined for seedlac prepared using different profile of modified churning blade and compared.

RESULTS AND DISCUSSION

Under the present investigation, effect of lac-water ratio (1:1, 1:2 and 1:3) quality of seedlac, churning time (15 and 30 min.), washing water temperature (normal water – 25^0C and warm water – 37^0C) and blade profile (rod parallel to the shaft, rod 45^0 to the shaft, rod perpendicular to the shaft and flat parallel to the shaft) on quality parameters of seedlac were studied. The results of the experiments in terms of mean values are presented in Tables 2 and 3 and Table 4 and discussed in following sections.

Table 1: Detailed procedure of experiment

Steps	Activities
I	Charging 5.0 kg crushed kusmi sticklac obtained from ber (*Ziziphus mauritiana*) host plant inoculated with Indian lac insect *Kerria lacca* Kerr in the washing machine
II	Addition of water
III	Soaking for 15 min
IV	Churning for 15 min
V	Addition of water
VI	Churning for 15 min
VII	Discharge the wash water
VIII	Addition of washing agent by weight of sticklac (0.0425%)
IX	Mixing of washing agent with sticklac
X	Addition of water
XI	Churning for 15 min
XII	Discharge the wash water
XIII	Addition of water
XIV	Discharge the wash water
XV	Addition of water
XVI	Discharge the wash water
XVII	Addition of water
XVIII	Discharge the wash water

Effect of lac-water ratio on washing quality of seedlac

To observe the effect of ratio of water and crushed lac mixture on quality parameters (impurity and color index) of seedlac, experiment was conducted as detailed in Table 1 with ratio of lac and water (normal tap water) as 1:1, 1:2 and 1:3 with churning time 15 minutes using conventional existing churning blade inside the washing barrel and evaluated. Mean impurity content and color index of the seedlac was determined as 3.37%, 3.87% and 4.76% and 7.33, 8.00 and 8.00 with minimum and maximum impurity value as 2.51% and 4.10%; 3.62% and 4.00%; 4.32% and 5.33% and color index 06 and 08; 07 and 09; 07 and 09, respectively for lac and water ratio 1:1, 1:2 and 1:3 (Table 2). The data reveals that when amount of water for washing seedlac increases, impurity level and color index of seedlac increases which may be due to less turbulence and rubbing of lac particles in presence of higher quantity of water.

Effect of churning time on quality parameters of seedlac

To observe the effect of churning time on quality parameters (impurity and color index) of seedlac, experiment was conducted as detailed in Table 1 with ratio of lac and water (normal/tap) as 1:1, 1:2 and 1:3 with churning time 15 and 30 minutes using conventional existing churning blade inside the washing barrel and evaluated.

Table 2: Effect of churning time and lac-water ratio on quality parameters of seedlac using normal water with churning time 15 and 30 min.

Blade profile	Churning time, min	Lac-water ratio	Mean value of quality parameters	
			Impurity, %	Color index
Conventional blade	15	1:1	3.37	7.33
		1:2	3.87	8.00
		1:3	4.76	8.00
	30	1:1	2.57	6.00
		1:2	2.64	6.00
		1:3	4.00	7.00

Mean impurity content of the seedlac was determined as 3.37%, 3.87% and 4.76% and 2.57%, 2.64 and 4.00% whereas color index was 7.33, 8.00 and 8.00 and 6.00, 6.00 and 7.00 respectively for lac and water ratio 1:1, 1:2 and 1:3 with churning time 15 and 30 min (Table 2). It was clear from the data that when amount of water for washing seedlac increased, impurity level and color index of seedlac increased similar to the result obtained in case of effect of lac and water ratio with churning time 15 min but as the churning time was increased for 30 min, impurity content and color index reduced with same treatment which may be due to more rubbing of lac particles with higher churning time.

Table 3: Effect of water temperature on quality parameters of seedlac with churning time 30 min.

Blade profile	Type of water	Lac-water ratio	Mean value of quality parameters	
			Impurity, %	Color index
Conventional blade	Normal water (25^0C)	1:1	2.57	6.00
		1:2	2.64	6.00
		1:3	4.00	7.00
	Warm water (37^0C)	1:1	2.00	7.00
		1:2	2.70	7.00
		1:3	2.80	7.00

Effect of water temperature on quality parameters of seedlac

To observe the effect of water temperature on quality parameters (impurity and color index) of seedlac, experiment was conducted as detailed in Table 1 with ratio of lac and water (normal tap water) as 1:1, 1:2 and 1:3 with churning time 30 minutes and warm water (37^0C) using conventional existing churning blade inside the washing barrel and evaluated. Mean impurity content of seedlac prepared using normal water and warm water (37^0C) was determined as 2.57%, 2.64% and 4.00% and 2.00%, 2.70 and 2.80% while mean color index were determined to be 6.00, 6.00 and 7.00 and 7.00, 7.00 and 7.00 respectively for normal water and warm water (37^0C) with lac and water ratio 1:1, 1:2, and 1:3 and churning time 30 min (Table 3). Table 3 indicates that warm water (37^0C) reduced impurity level in the seedlac but increased color index. Reduction in impurity level of seedlac may be possible due to easy detachment of impurity adhered with the lac resin in warm water compared to normal water. Enhancement in color index value may be due to less solubility of natural color in presence of warm water.

Table 4: Effect of blade profile on quality parameters of seedlac using normal water (25^0C) and churning time 15 min and lac-water ratio 1:3

Blade profile	Mean value of quality parameters	
	Impurity, %	Color index
Traditional blade	4.76	8.00
Rod parallel to the shaft	3.51	7.00
Rod 45^0 to the shaft	4.40	8.00
Rod perpendicular to the shaft	4.53	8.00
Flat parallel to the shaft	3.72	10.00

Effect of blade profile on quality parameters of seedlac

Different type of developed/fabricated churning blade improved churning operation inside the washing barrel with increase turbulence compared to conventional blade (Figure 2). To evaluate the performance of modified churning blades, each set of modified churning blade was mounted on the shaft with the mechanism developed for fixing the same and washing experiment was conducted as detailed in Table 1 with normal water and churning time 15 min and lac and water ratio 1:3. Details of results obtained for each set of modified churning blade are depicted in Table 4.

Seedlac prepared separately with different set of modified churning blade was evaluated at Quality Evaluation Laboratory, ICAR – Indian Institute of Natural Resins and Gums, Ranchi following standard procedure for quality parameters (impurity content and color index). Mean impurity content of prepared seedlac were determined to be 4.76%, 3.51%, 4.40%, 4.53% and 3.72% whereas color index was determined as 8.00, 7.00, 8.00, 8.00 and 10.00 respectively for conventional blade, rod parallel to the shaft, rod 45^0 to the shaft, rod perpendicular to the shaft and flat parallel to the shaft with normal water, churning time 15 min and lac and water ratio 1:3 (Table 4). The impurity content in seedlac prepared using rod parallel to the shaft (Figure 3) was lowest followed by flat parallel to the shaft , rod 45^0 to the shaft, rod perpendicular to the shaft and conventional blade whereas color index was found to be lowest in case of rod parallel to the shaft followed by rod 45^0 to the shaft, rod perpendicular to the shaft, Conventional blade and flat parallel to the shaft. The lowest impurity content and color index using rod parallel to the shaft may be due to increase in turbulence area with free flowing of lac grains in presence of water during washing operation. Data of quality parameters of seedlac prepared with different type of churning blade shows encouraging results which indicates that blade profile has an effect on quality of washing seedlac. Out of different modified churning blade developed, rod parallel to the shaft performed best and reduced impurity content and color index up to the maximum possible extent with same treatment as in case of other modified churning blades and conventional blade.

CONCLUSIONS

- Higher amount of water for washing seedlac increased impurity level and color index due to less turbulence and rubbing of lac particles in presence of more water.
- Enhanced churning time reduced impurity content and color index of the seedlac due to more rubbing of lac particles with longer churning time.
- Warm water (37^0C) reduced impurity level and increased color index value of the seedlac as impurity adhered with the lac resin easily got detached in presence of warm water compared to normal water and possibly less solubility of natural color in presence of warm water.
- Impurity content and color index were lowest in seedlac prepared using rod parallel to the shaft due to increase in turbulence area with free flowing of lac grains in presence of water during washing operation compared to another modified churning blade and conventional blade.
- Different type of churning blade showed encouraging results compared to conventional blade which indicated that blade profile has effect on quality parameters of washed seedlac.
- Out of different modified churning blade developed, rod parallel to the shaft performed best and recommended for washing seedlac with minimum impurity content and low color index (lighter color).

ACKNOWLEDGEMENTS

Authors express their sincere thanks to Dr. R. Ramani, Ex - Director, ICAR - Indian Institute of Natural Resins and Gums, Ranchi for constructive suggestions throughout the present investigation and Dr. K. K. Sharma, Director, ICAR - Indian Institute of Natural Resins and Gums, Ranchi for technical guidance and support provided during course of investigation. Authors also acknowledge the assistance provided during experimentation by Mr. S. K. Tirky, Ex-Technical Assistant, Process and Product Development Division, ICAR – Indian Institute of Natural Resins and Gums, Ranchi. Financial support provided by the Indian Council of Agricultural Research, New Delhi under the present investigation is thankfully acknowledged.

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Citation:
Sharma SC, Pandey SK and Prasad N. 2021. Effect of Blade Profile and Processing Parameters on Quality Seedlac. *Journal of AgriSearch* **8**(3): 264-269