Journal of Agricultural Engineering Vol. **47(1)**: January-March, 2010

Effect of Storage Methods on Quality of Lac - A Natural Resin

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ABSTRACT

A study was carried out to assess the changes in physico-chemical parameters of lac resin during storage for one year. All three forms of lac *viz*. sticklac, seedlac and shellac were stored following different methods as practiced by lac traders and industries, and some quality parameters of the products were evaluated during storage. Qualitative losses included decrease in flow, heat polymerization time (life) and rate of filtration; and increase in colour index and hot alcohol insolubles of lac resin during storage. In case of sticklac, maximum increase in hot alcohol insolubles (24% in *ari* and 69% in *phunki* sticklac) was noticed in samples stored in plastic bags and minimum increase (4.87 % in immature lac and 37 % in used-up broodlac) was observed in samples stored on cement floor. Very little difference in the value of flow was observed between different methods of storage. Better life and colour were observed in products stored on earthen floor. Seedlac stored on cemented floor best retained the properties i.e. minimum increase in hot alcohol insolubles (6.17%) and minimum decrease in flow (35.89%) and life (13.43%) after one year of storage. Storage in metal container resulted in 87.65% increase in hot alcohol insolubles, 61.54% decrease in flow and 19.4% decrease in life. Flow and life of cold stored shellac samples were found slightly higher (2 to 5 %) than the samples stored by other methods after one year of storage.

Lac is a natural resin of insect origin, which is non-toxic, biodegradable, and a product of renewable sources. It possesses a rare combination of many valuable and desirable properties and consequently find place in diverse and innumerable uses. Some of the areas of its applications include paint and varnish, adhesive, cosmetic, leather, food, pharmaceutical, printing ink and electrical industries. Lac has preserved its existence and also developed newer vistas of application and opportunities, in the face of continuous threats from synthetic substitutes. As the global demand for eco-friendly and safe natural products is growing, there is huge potential for increasing both domestic and overseas consumption of lac in future.

The basic raw material for lac industry is sticklac. It is obtained by scraping lac encrustation deposited on twigs of host trees like *kusum*, *palas* and *ber*, etc. It is collected either as *ari* (immature lac) or *phunki* (used up broodlac) from lac host trees. Lac, thus, gathered is known as sticklac. Removing the sticks, stones etc. as far as possible by crushing, sieving, winnowing and washing out the dye with water in primary processing yields the semi-refined product known as seedlac, which is an important commercial product used in preparation of shellac, bleached lac, aleuritic acid, etc.

Chemically, lac is a complex ester of polyhydroxy aliphatic and sesquiterpenic acids having an average molecular weight of 1006. Upon mild hydrolysis, shellac gives a complex mixture of aliphatic and alicyclic hydroxy-acids and their polymers, which varies in exact composition depending upon the source of the shellac and the season of collection. It is generally thermoplastic in nature. Shellac is soluble in alkaline solutions such as ammonia, sodium borate, sodium carbonate, and sodium hydroxide, and also in various organic solvents.

Shellac is a natural polymer and is chemically similar to synthetic polymers, and thus can be considered a natural form of plastic. Shellac exhibits number of unique properties such as film-forming, insulating and sealing. The lac resin undergoes polymerization and copolymerization as well as various other reactions such as esterification, amidification, condensation and other reactions with alcohols, organic acids, amines, formaldehyde, urea, thiourea, etc. (Maiti, 1990).

The lac resin undergoes various chemical changes during storage, as a result of which deterioration in the physical and chemical properties of lac takes place. As it ages, lac slowly loses its solubility in alcohol, becomes less fluid and possesses poorer life under heat. The extent of such deterioration depends upon various factors such as

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method of storage, storage environment (temperature and humidity), type of lac etc. Thus, when stored in improper conditions for a long time, the resin becomes useless for all practical purposes that become a major concern of lac industries. Polymerization of lac, which is responsible for the degradation of the product, occurs either on heating or aging.

Some studies have been conducted to reduce the heat degradation of lac in its various commercial forms (sticklac, seedlac and shellac). It has been reported that storage in air-conditioned go-down at 25°C and 60% relative humidity effectively checked the degradation in lac quality (Rangaswamy and De, 1944). The mechanism of degradation of lac on aging has also been studied by Saha (1992). In another study, it was found that storage of dry stick lac (at about 4% m.c.) in hessian bags was the best (Saha, 1993). It was also concluded that at ambient temperature, lac should be stored away from light, preferably at a relative humidity of around 45 per cent. Use of chemical retarders and antioxidant has also been attempted to control the degradation of lac when stored at room conditions (Goswami *et al*., 2009). Storage under controlled conditions of temperature and humidity being costly, and no study conducted to assess the losses in quality parameters of lac based products during storage under ambient conditions, a comparison of various methods of storage under ambient conditions was considered useful in order to find out the best method of storage within the range of the study. Hence, the objective of the study was to assess and compare the changes in some quality parameters of lac resin during storage by existing methods.

MATERIALS AND METHODS

Fresh *baisakhi* sticklac, seedlac and shellac were purchased from a private industry at Bundu, Ranchi and from the Institute Research Farm. Sticklac, seedlac and shellac samples were stored in a well-ventilated room by different methods normally followed by farmers, traders and industries of lac. Sticklac was stored by four different methods *viz.* spreading on earthen floor (EF), on cemented floor (CF), in gunny bags (GB), and in plastic bags (PB). Seedlac was stored by spreading on cemented floor (CF), in gunny bags (GB), in plastic bags (PB) and in metal container (MC). The mean maximum and minimum temperature during the storage period were 39.9°C and 7°C respectively, whereas the relative humidity varied between 30 and 90 per cent. Similarly, shellac was stored by five different methods viz. by spreading on cemented floor (CF), in gunny bags (GB), in gunny bags with cotton lining (GBc), in plastic bag (PB), and under cold storage (CS) in a refrigerator at 8-10°C and 65-70% relative humidity.

The initial quality parameters like moisture content, hot alcohol insolubles, cold alcohol insolubles, heat polymerization time (life), flow, rate of filtration, and colour index of the products were measured according to standard methods (Rangaswamy and Sen, 1952; Anon, 1973). A varnish composition of shellac was developed by dissolving in spirit. The varnishes were applied on wooden/tin panels and glass slides. Surface coating properties like gloss, scratch hardness, impact resistance, heat resistance, water resistance and flexibility of the film were evaluated by adopting standard methods. Quality of stored sticklac, seedlac and shellac was assessed during laboratory storage.

In all the cases, samples were drawn at intervals of three months and tested for the above mentioned properties. As sticklac contains large amount of impurities that create problem in measurement of different properties, the samples were stored as sticklac, but were converted to seedlac just before testing. The study was continued for one year. Statistical analysis (F-test) was carried out using SPSS Software (*Ver.* 14) to test whether any significant difference existed between different methods of storage with time.

RESULTS AND DISCUSSION

Effect of Storage Methods On Quality of Sticklac

The changes in different properties of sticklac with the period of storage under different methods are depicted in Fig. 1. It is clear that hot alcohol insoluble and cold alcohol insoluble increased during storage period. Maximum increase in hot alcohol insolubles (24% in *ari* and 69% in *phunki* sticklac) was noticed in samples stored inside plastic bags and minimum increase in hot alcohol insolubles (4.87% in *ari* and 37% in *phunki* sticklac) in case of samples stored on cemented floor.

The colour index of sticklac samples varied slightly from the original value after one year of storage. However, a mixed trend of decrease/increase was observed in the values during the storage period, which might be due to variation in environmental (temperature and relative humidity) conditions. In case of *ari* sticklac, which was initially dry (4% m.c.), there was a decrease in colour value after one year, where as in *phunki* sticklac (10% initial m.c.) the final colour value increased compared to the initial value. Colour index of *ari* sticklac decreased

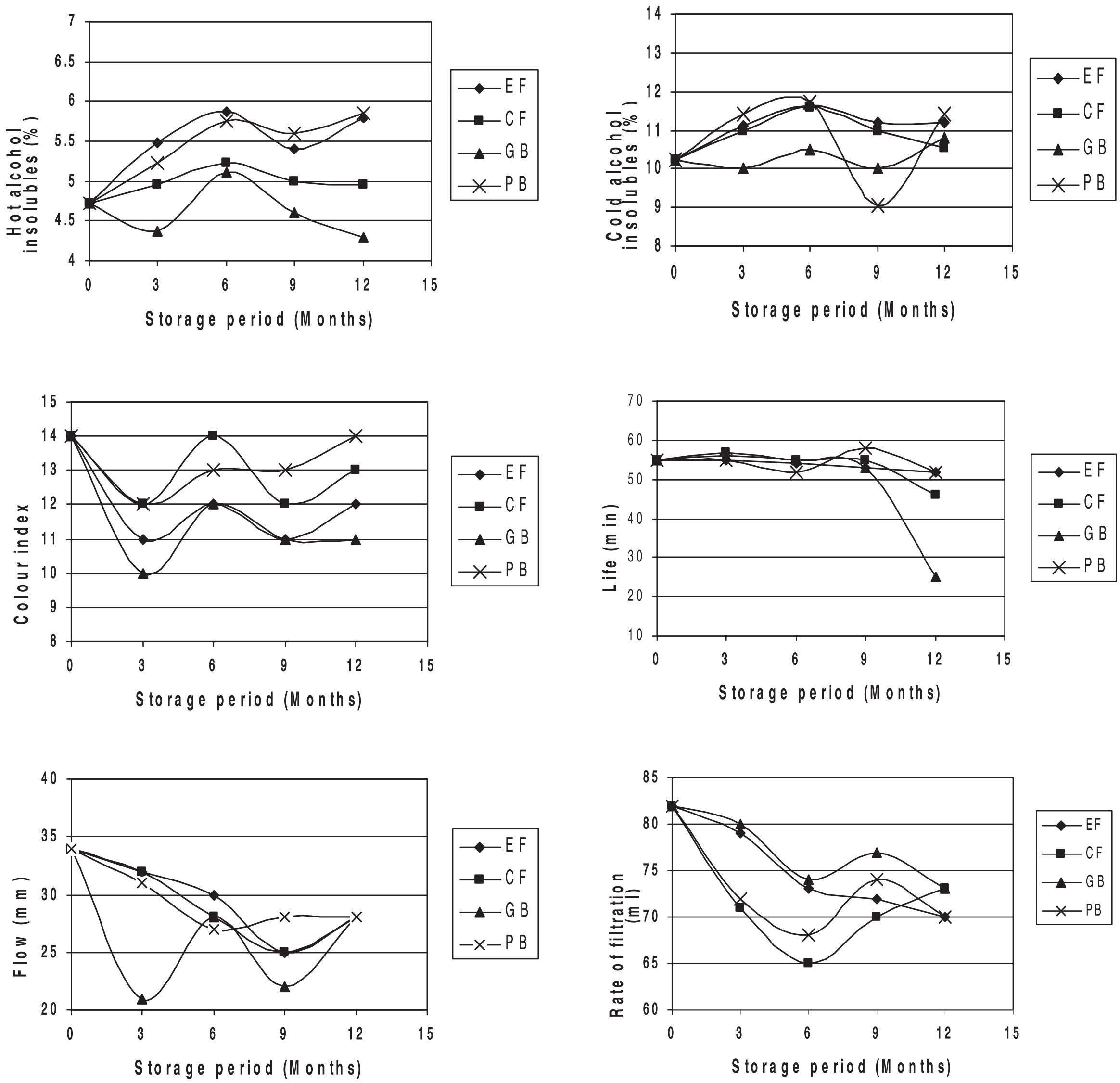

Fig. 1: Changes in different properties of sticklac (*ari*) with time during storage

after one year for all methods of storage except in plastic bag, where it remained unchanged. Maximum decrease in colour index (21%) was in case of samples stored inside gunny bags. Sticklac samples stored on earthen floor exhibited better life and colour.

Other parameters like flow, life and rate of filtration decreased with time for all the samples. Flow has been reported by previous researchers as an useful tool to get an idea of the age of lac, loss of fluidity being attributed to a process of gradual polymerization of lac (Rangaswami and De, 1944; Saha, 1992). Heat polymerization time, or life, is also an accelerated test method for shelf aging of lac. The decrease in life and flow values of sticklac with time indicated slow polymerization of lac resin during storage due to various factors like age, heat and light. The loss in flow was around 75 to 100% in case of *phunki* sticklac and 18% in case of *ari* sticklac after one year of storage. Highest loss in life was found in case of samples stored in gunny bags. Very little difference in the value of flow was observed between different methods after 1 year of storage.

Statistical analysis (Table 1) revealed significant difference (at 5% level) in hot alcohol insolubles, colour index and rate of filtration of *ari* sticklac among different methods of storage. All the properties, except cold alcohol insolubles and life, varied significantly with time from the initial values. Similarly, in case of *phunki* sticklac no

Table 1. Tests of significance for different storage methods and storage time of *ari* sticklac

Source	Dependent variable	df	Mean square	F-value	Sig.
Time	Hot alcohol insolubles	4	0.321	4.033	.027 *
	Cold alcohol insolubles	4	0.924	2.803	.074
	Flow	4	42.450	6.828	.004**
	Life	4	100.575	2.889	.069
	Colour	4	4.425	12.349	.000**
	Rate of filtration	4	88.050	13.044	.000**
Storage method	Hot alcohol insolubles	3	0.801	10.054	.001**
	Cold alcohol insolubles	3	0.537	1.630	.235
	Flow	3	11.383	1.831	.195
	Life	3	33.517	0.963	.442
	Colour	3	2.983	8.326	.003**
	Rate of filtration	3	24.583	3.642	.045*

(*significant at 5% level; ** significant at 1% level)

significant difference existed among different methods of storage for properties like flow, life under heat, colour index and rate of filtration; whereas for hot and cold alcohol insolubles there was significant difference among different methods. All the properties, except rate of filtration, varied significantly with time from the original values.

Effect of Storage Methods On Quality of Seedlac

Hot alcohol insolubles and cold alcohol insolubles were found to increase during storage period (Fig. 2) with highest increase in hot alcohol insolubles (87.65%) and cold alcohol insolubles (28.8%) for samples stored in metal containers. Lowest increase in insolubles (6.17% in hot alcohol insolubles and 1.79% in cold alcohol insolubles) was observed in case of samples stored on cemented floor. The increase in insolubles with storage was due to slow polymerization of lac resin with age (Khanna *et al*., 1986). Storage in metal container and plastic bags might have increased the rate of heat polymerization due to lack of air ventilation in these methods.

Colour index of seedlac samples was found to increase during the initial period of storage, which remained constant at the later stage. An increase in the colour indices of seedlac and shellac under ordinary storage conditions has also been reported by previous researchers (Rangaswami and De, 1944). Life under heat, flow and rate of filtration of seedlac decreased with time for all the methods of storage, indicating polymerization of seedlac samples during storage. Similar results were obtained by earlier researchers (Rangaswami and De, 1944; Khanna *et al*., 1986; Saha, 1992).

The quality of seedlac samples stored on cemented floor and inside gunny bags were found to be better than those of other samples during storage. Seedlac stored on cemented floor retained maximum properties after one year of storage. Storage in metal container resulted in maximum loss in properties *i.e*. maximum increase in hot and cold alcohol insolubles and colour index and maximum decrease in flow, life and rate of filtration. Similarly, the percent losses of other parameters like flow, life, rate of filtration and colour index were lower in case of sample stored on cemented floor and in gunny bags.

Significant difference existed among different methods of storage for all the properties of seedlac, except rate of filtration (Table 2). Variation in different properties with time was highly significant from the original value, except for cold alcohol insolubles.

Effect of Storage Methods On Quality of Shellac

It can be observed (Fig. 3) that life and flow of samples decreased during storage, while hot alcohol insolubles increased for all methods of storage. Moisture content decreased during the initial 3 months, and then increased up to 9 months. Thereafter, it decreased again. This might be due to variation in relative humidity of the storage atmosphere. Lac and lac-based products tend to absorb moisture during rainy season. Life and flow of samples

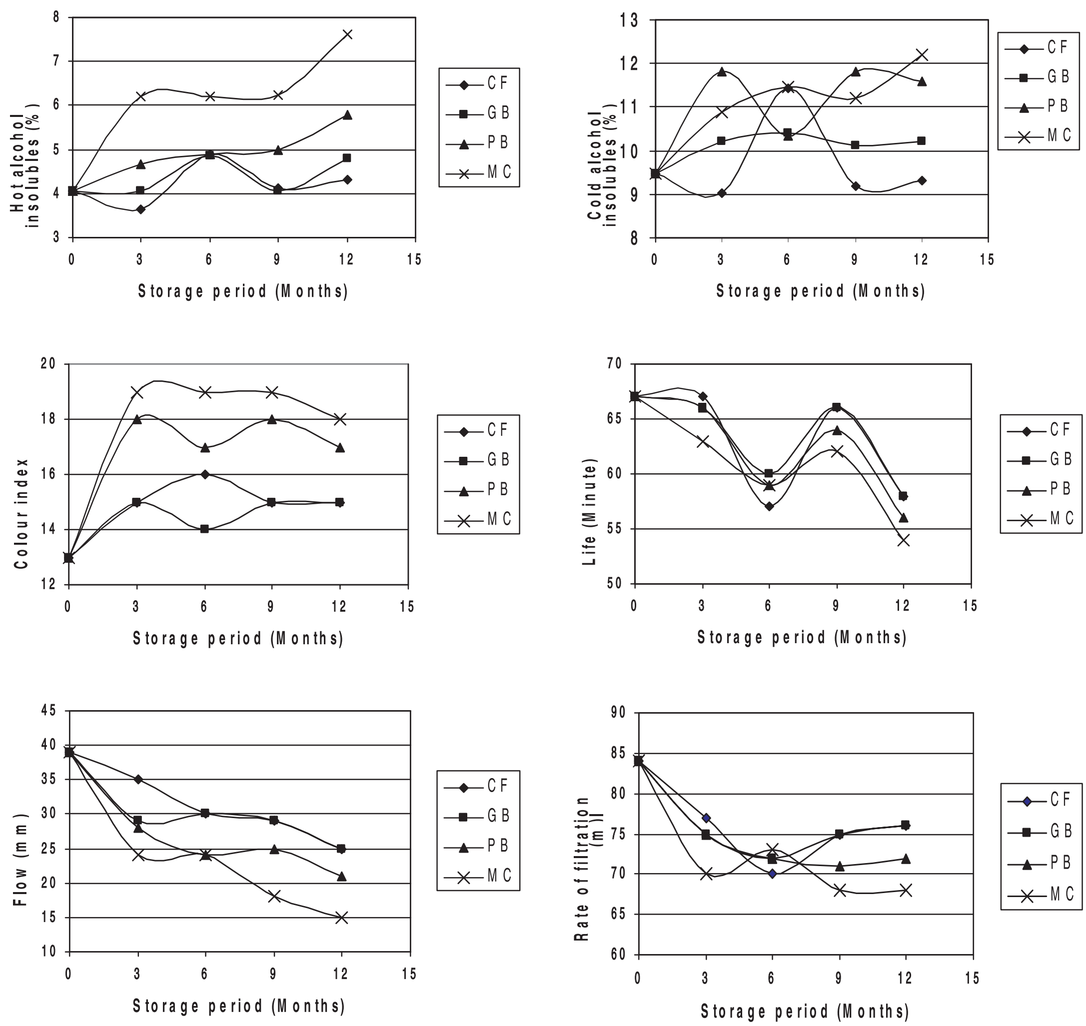

Fig. 2: Changes in different properties of seedlac with time during storage

Table 2. Tests of significance for different storage methods and storage time of seedlac

Source	Dependent variable	df	Mean square	F-value	Sig.
Time	Hot alcohol insolubles	4	1.410	4.220	.023*
	Cold alcohol insolubles	4	1.325	2.097	.144
	Flow	4	172.200	28.385	.000**
	Life	4	83.300	52.063	.000**
	Colour	4	10.325	11.162	.001**
	Rate of filtration	4	103.675	20.164	.000**
Storage method	Hot alcohol insolubles	3	3.538	10.587	.001**
	Cold alcohol insolubles	3	2.290	3.625	.045*
	Flow	3	57.650	9.503	.002**
	Life	3	5.517	3.448	.052
	Colour	3	11.383	12.306	.001**
	Rate of filtration	3	16.183	3.147	.065

(* significant at 5% level; ** significant at 1% level)

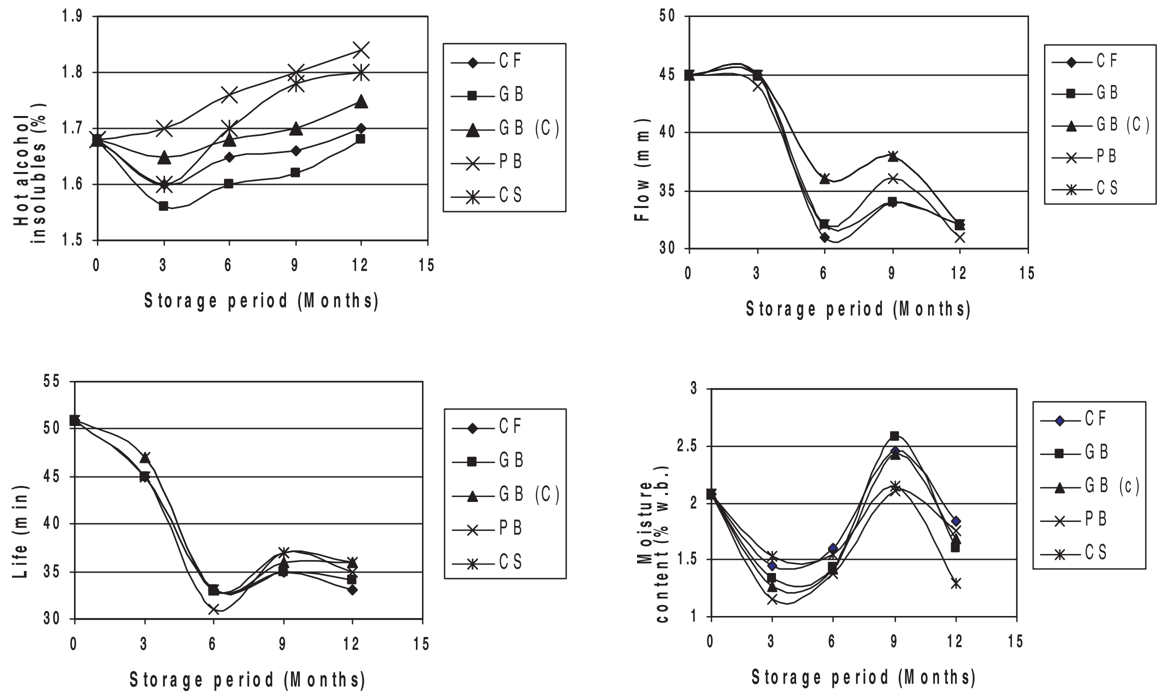

Fig. 3: Changes in properties of shellac with time during storage

stored under cold storage in refrigerator and inside gunny bags (with cotton lining) were slightly higher than those of samples stored under other methods after one year of storage. Maximum decrease in life, flow and melting/ softening point and maximum increase in hot alcohol insolubles was noticed in case of samples stored inside plastic bags. However, statistical analysis revealed no significant difference in properties between cold stored samples and samples stored inside gunny bag with cotton lining. Significant difference in parameters with time was found for all the methods of storage (Table 3).

Amongst surface coating properties of shellac samples, the gloss was highest in samples stored in plastic bag and lowest in cold stored samples (Table 4). Scratch hardness was also lowest for cold stored samples. Impact resistance failed for cold stored samples and samples stored on cemented floor, whereas it passed for other three storage methods. Higher temperature of products stored inside plastic bag might have resulted in higher gloss, as application of heat increases the gloss of lac resin.

Table 3. Tests of significance for different storage methods and storage time of shellac

Source	Dependent variable	df	Mean square	F-value	Sig.
Time	Hot alcohol insolubles	4	0.012	10.039	.000**
	Flow	4	198.300	132.200	.000**
	Life	4	315.540	457.304	.000**
	Melting point	4	0.940	62.667	.000**
Storage method	Hot alcohol insolubles	4	0.012	10.320	.000**
	Flow	4	4.200	2.800	.062
	Life	4	1.940	2.812	.061
	Melting point	4	0.015	1.000	.436

(**significant at 1% level)

Table 4. Surface coating properties of shellac after 1 year of storage

Parameter	Storage method				
	CF*	GB*	GB(C)*	PB*	CS*
Gloss	9.7	10.1	11.8	16.8	6.2
Scratch hardness, gm	600	500	600	400	300
Impact resistance	Fail	Pass	Pass	Pass	Fail
Water resistance	Fail	Fail	Fail	Fail	Fail
Heat resistance	Fail	Fail	Fail	Fail	Fail
Flexibility	Flexible	Flexible	Flexible	Flexible	Flexible

*CF: Spreading on cemented floor, GB: In gunny bags, GB(C): In gunny bags with cotton lining, PB: In plastic bag, CS : Under cold storage in refrigerator

CONCLUSIONS

The study demonstrated that the qualities of lac-based products viz. sticklac, seedlac and shellac deteriorated during storage. Among the conventional tests, flow and life under heat were quite sensitive to the effect of ageing. Hot and cold alcohol insolubles of sticklac were higher in samples stored inside plastic bags and on earthen floor. Very little difference in the value of flow was observed between different methods of storage. Better life and colour were noticed in products stored on earthen floor. More degradation in properties took place in *phunki* sticklac compared to *ari* sticklac. Seedlac stored on cemented floor retained maximum properties after one year of storage. Storage in metal container resulted in maximum loss in properties.

In case of shellac, flow and life of samples stored under cold storage and inside gunny bags (with cotton lining) were slightly higher than those of other samples after one year of storage.

Sticklac should be stored in loose form by spreading on earthen or cemented floor. Storage on earthen floor resulted in better colour. Storage in gunny bag was recommended for dried seedlac (less than 4% moisture content), as it required less floor space compared to loose storage on cemented floor. Seedlac should not be stored inside metal container or in plastic bags. Considering all parameters, shellac storage inside gunny bags with cotton lining was recommended.

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