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Bleaching of *Bambusa tulda* sticks for handicrafts

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Abstract: The effects of different bleaching agents on *Bambusa tulda* sticks were studied. The bamboo sticks were bleached using different concentrations of hydrogen peroxide, sodium hypochlorite and sodium chlorite. Sequential bleaching was also carried out using two different bleaching agents. The extent of whitening was measured using colour coordinates (L*, a* and b*), colour difference formula (*E) and Hunter Whiteness Index (WI). The WI of full grown *B. tulda* sticks was around 8.14. A WI of 56 was obtained by bleaching bamboo sticks with 5 per cent sodium chlorite solution without damaging the surface of bamboo. The whiteness achieved by other methods was lower than that obtained with 5 per cent of sodium chlorite solution. The bamboo sticks bleached with hydrogen peroxide retained a yellowish tint which was absent when bleached with sodium chlorite. Sodium hypochlorite solution was not effective in whitening of *B. tulda* sticks. Sequential bleaching gave WI in the range of 20 by using 0.2 per cent hydrogen peroxide and 0.3 per cent sodium chlorite.

Key words: *Bambusa tulda*, bleaching, sodium hypochlorite.

INTRODUCTION

Bambusa tulda is traditionally used for making baskets and other woven products. *B. tulda* is grown in Assam, Arunachal Pradesh, Nagaland, West Bengal and Meghalaya and bamboo handicraft products are mainly crafted in the cottage industries of these states. The natural colour of bamboo strips used for handicrafts varies from culm to culm and to some extent, between internodal and nodal portions in a single culm. The natural colour of bamboo also depends on the age of the culm and the lignin content. Hence, to achieve a certain degree of homogeneity in the natural colour of the bamboo strips in the handicraft products, bamboo slivers and sticks have to be bleached prior to weaving to craft products. Moreover, bleaching of sticks and slivers would enable uniform dyeing of the bamboo products in a wide range of shades. Therefore, selection of the correct bleaching agent and the appropriate process parameters are important to increase the aesthetic value of the handicraft products, without damaging the surface structure of bamboo.

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Bleaching of Malaysian bamboo strips with sodium hypochlorite, hydrogen peroxide and oxalic acid using either cold or hot soaking, boiling and steaming process has been reported by Zaidon *et al.* (2000). Ganapathy *et al.* (1999) reported that boiling in 6 per cent hydrogen peroxide for 30 min or soaking bamboo strips in 2 per cent sodium hypochlorite for 16 h was effective in bleaching of Malaysian bamboos, but the surface of the strips deteriorated quite significantly by this method. Zaidon *et al.* (2000) also reported bleaching of bamboo strips by initially soaking in a solution of 1 per cent sodium hydroxide, followed by 12.5 per cent solution of hydrogen peroxide. A mixture of 1 per cent oxalic acid and 0.5 per cent of sodium hydroxide was also used for bleaching of bamboo material. The hydrogen peroxide bleached bamboo sticks showed a higher whiteness than the other method (Zaidon *et al.*, 2004). It has also been claimed that Chinese bamboo material can be bleached using a mixture of hydrogen peroxide, sodium pyrophosphate and fluorescent brightener for 48 h at 50-60°C (Yu *et al.*, 1986). But the above mentioned bleaching procedures which are effective for Malaysian bamboos are not effective in bleaching full grown Indian bamboos. Studies on bleaching of sticks and slivers of Indian bamboos are limited. Moreover, the effect of different bleaching agents like hydrogen peroxide, sodium hypochlorite and sodium chlorite on the extent of whiteness of the Indian bamboo sticks has not been reported. Therefore, this study has been undertaken to examine the effect of different bleaching agents and bleaching conditions on the extent of whitening of bamboo.

MATERIALS AND METHODS

Bamboo (*B. tulda*) sticks were supplied by Nagaland Bamboo Resource Centre, Dimapur (India). The sticks had an average diameter of 1.68 mm. The chemicals used for bleaching bamboo sticks were:

1. Hydrogen peroxide (H_2O_2) (30%) from Merck Ltd (India).
2. Sodium hypochlorite (NaOCl) (4% of available chlorine) from Merck Ltd (India).
3. Sodium chlorite ($NaClO_2$)from CDH (P) Ltd. (India).

Bleaching with hydrogen peroxide

The different concentrations of hydrogen peroxide used for bleaching the bamboo sticks are shown in Table 1. The material-to-liquor ratio was kept at 1:20 for all the bleaching trials. The pH of the bleaching agents was maintained at 10.5 with sodium hydroxide 1g/l. Sodium silicate 5g/l was used as a stabilizer. The bleaching was carried out at 90°C for different durations as shown in Table 1. Bleaching with hydrogen peroxide was also carried out at room temperature by using 12.5 per cent hydrogen peroxide for 24 h at pH 5 as per Zaidon *et al.* (2000). The bamboo samples were washed thoroughly in cold water after bleaching, followed by neutralizing with acetic acid.

Table 1. Parameters for bleaching of bamboo sticks with hydrogen peroxide

Concentration of hydrogen peroxide (30%) used for bleaching of bamboo sticks	Duration of bleaching (h)	Other constant parameters
2% (w/v)	2	pH = 10.5 (maintained by adding soda ash)
5% (w/v)	2	Stabilizer = Sodium silicate 5 g/l
6% (w/v)	1	MLR = 1:20
8% (w/v)	1	Temperature = 90°C
10% (w/v)	1	

Bleaching with sodium hypochlorite

The process of bleaching with sodium hypochlorite was carried out at room temperature (30 °C) at pH 9 with 3, 5 and 20 per cent of sodium hypochlorite for 1 h. As satisfactory results were not obtained on bleaching for 1 h, the duration of bleaching was increased to 12 h with 20 per cent of sodium hypochlorite. The bamboo sticks were washed thoroughly in cold water after bleaching, followed by neutralizing with acetic acid.

Bleaching with sodium chlorite

The process of bleaching with sodium chlorite was carried out at 90 °C at pH 3-4 with 2, 3, 4 and 5 per cent sodium chlorite for 1 h. The pH was maintained by addition of formic acid. The material-to-liquor ratio was kept at 1:5. The bamboo sticks were washed thoroughly in cold water after bleaching.

Measurement of Hunter Whiteness Index (WI) and Colour Difference (ΔE)

Colour of the bamboo sticks was measured before and after bleaching using Jaypak X-4000 Spectrophotometer interfaced with Jay4806 computer colour matching software. CMC (1:2) colour difference formula was used for calculating the colour difference ("E) of the bleached bamboo sticks from the colour coordinates (L^*, a^*, b^*) of the bamboo samples. Hunter Whiteness Index (WI) of the bleached samples was measured under D65 light source and 10° observer.

RESULTS AND DISCUSSION

Bleaching with hydrogen peroxide

The results of bleaching with different concentrations of hydrogen peroxide on the whitening of bamboo sticks are presented in Table 2. The change in the natural colour of the bamboo sticks after bleaching can be observed from the changes in the L^*, a^*, b^* and the colour difference values (ΔE). It is apparent from the Table that the unbleached bamboo sticks had $L^* = 67.03$, $a^* = 6.41$ and $b^* = 25.95$ and a WI of 8.14. On bleaching with 2-10 per cent of hydrogen peroxide at 90 °C the L^* value increased significantly

Table 2. Effect of different bleaching reagents on *B. tulda* sticks

Bleaching agent	Concentration of bleaching agent (w/v)	Bleaching duration (h)	L*	a*	b*	ΔE	Hunter Whiteness Index
Unbleached	nil	nil	67.03	6.41	25.95	-	8.14
Hydrogen peroxide	2%	2	80.65	2.18	24.85	6.89	21.88
	5%	2	82.44	1.02	24.13	8.02	24.32
	6%	1	80.89	2.27	24.32	6.90	20.56
	8%	1	84.32	0.61	22.06	9.09	29.30
	10%	1	86.03	0.01	19.09	10.27	36.41
	12.5%	24	74.61	6.35	28.31	8.01	6.70
Sodium hypochlorite	3%	1	63.45	6.02	33.93	4.80	-4.28
	5%	1	59.35	6.47	32.40	4.72	-4.02
	20%	1	59.07	5.85	30.96	4.38	-3.08
	20%	12	68.59	2.19	26.12	4.42	11.71
Sodium chlorite	2%	1	85.71	1.74	19.73	8.73	22.28
	3%	1	84.78	1.52	16.84	9.73	44.29
	4%	1	85.31	1.34	14.78	10.09	47.67
	5%	1	87.88	0.65	11.33	12.05	56.54
H_2O_2 followed by NaOCl	H_2O_2 (6%) followed by NaOCl (2%)	0.5 16	72.77	3.56	35.22	6.77	-9.09
NaOCl followed by H_2O_2	NaOCl (20%) followed by H_2O_2 (6%)	1 1	66.13	3.56	30.89	4.48	-3.90
H_2O_2 followed by $NaClO_2$	H_2O_2 (2%) followed by $NaClO_2$ (0.3%)	2 2	80.02	2.02	23.03	6.50	20.5

in the range of 80-86. The a* values also reduced significantly. The b* values did not show significant change and it was in the range of 19-25. This indicates that the hydrogen peroxide bleached samples which retained the yellowish tint were not as effectively bleached. The WI of almost all the samples increased with the increase in the concentration of hydrogen peroxide with the exception of the samples that were bleached at room temperature at pH 5 for 24 h according to the process described by Zaidon *et al.* (2000). While bleaching with 10 per cent hydrogen peroxide for one hour at 90 °C a maximum WI of 36.4 was achieved. The weight loss on bleaching with 2-12.5 per cent hydrogen peroxide was in the range of 3-5 per cent.

Bleaching with sodium hypochlorite

The results of bleaching bamboo with 3, 5 and 20 per cent sodium hypochlorite are shown in Table 2. It is evident that the improvement in whiteness was not significant with sodium hypochlorite as there was slight change in the L*, a*, b* values and the ΔE

values were in the range of 4-5 for all the concentrations. The WI was negative for all samples bleached with sodium hypochlorite for 1 h. The WI increased to 11.7 on bleaching with 20 per cent sodium hypochlorite for 12 h. The weight loss on bleaching with 3-20 per cent sodium hypochlorite was in the range of 4-5 per cent.

Bleaching with sodium chlorite

The results of bleaching of the bamboo sticks with 2, 3, 4 and 5 per cent sodium chlorite are given in Table 2. It can be observed that there is a significant change in the L^*, a^*, b^* values and the WI on bleaching with sodium chlorite. A maximum WI of 56.5 was achieved when bleached with 5 per cent sodium chlorite. The WI obtained on bleaching with sodium chlorite was much higher than that obtained after bleaching with hydrogen peroxide and sodium hypochlorite. With the increase in concentration of sodium chlorite, the whiteness of the sample also increased as shown in Figure 1.

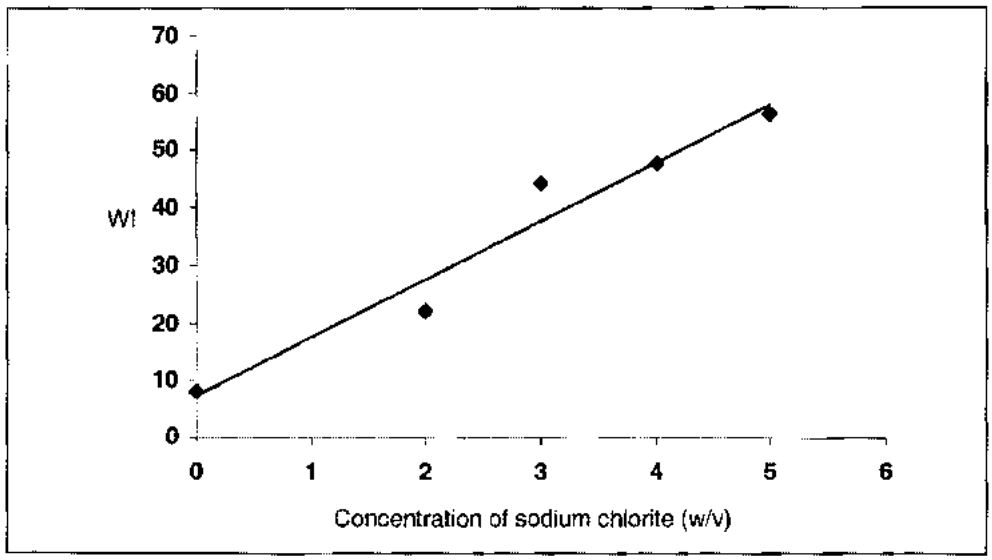

Figure 1. Change in WI with increase in concentration of sodium chlorite.

Fibrillation of the bamboo sticks was not observed on bleaching with sodium chlorite as it does not attack the cellulose present in the bamboo. Chlorine dioxide formed on dissolution of sodium chlorite in acidic medium acts as oxidative bleach. The weight loss was in the range of 6-12 per cent on bleaching with 1-5 per cent of sodium chlorite. The loss in weight was higher than that from bleaching with hydrogen peroxide and sodium hypochlorite.

The main disadvantage in bleaching with sodium chlorite was the liberation of chlorine dioxide, which is toxic in nature. Also normal stainless steel troughs cannot be used for bleaching with sodium chlorite as they undergo corrosion. Only stainless steel with molybdenum is suitable for this purpose.

Effect of sequential bleaching with two different bleaching agents

Bleaching of the bamboo sticks was carried out by using two bleaching agents in sequence. Bamboo sticks were bleached by 6 per cent hydrogen peroxide at boil for 30 min followed by 2 per cent sodium hypochlorite for 16 h at room temperature. The bleached samples were yellowish with b* value as high as 35. The WI of the bleached samples was in the negative range (Table 2). When bleached with 20 per cent sodium hypochlorite for 1 h at room temperature, followed by 6 per cent hydrogen peroxide for 1 h, the whiteness obtained was not satisfactory. When bleached with 2 per cent hydrogen peroxide at 90 °C for 2 h, followed by 0.3 per cent sodium chlorite for 2 h, a WI of 20.5 was achieved, which is higher than the other two sequential methods. But the bamboo sticks retained the yellowish tint when bleached by this method as evident from the b* value.

Of the three different bleaching agents and the sequential bleaching methods, satisfactory bleaching could be obtained by using 3-5 per cent sodium chlorite. Hydrogen peroxide also increased the whiteness of the samples but the samples retained the yellowish tint.

CONCLUSIONS

B. tulda sticks used for handicrafts can be bleached with 3-5 per cent sodium chlorite solution at pH 3-4 for 1 h at 90 °C to achieve good whiteness. The higher the concentration of sodium chlorite, the higher is the whiteness. This method of bleaching gives better results compared to hydrogen peroxide and sodium hypochlorite. Bleaching with hydrogen peroxide retained a yellowish tint in the samples which is absent while bleaching with sodium chlorite. Sodium hypochlorite solution was not effective in bleaching of *B. tulda* sticks. Sequential bleaching with hydrogen peroxide followed by sodium hypochlorite was also not effective in whitening of bamboo sticks. Sequential bleaching with hydrogen peroxide followed by sodium chlorite was more effective.

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