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Effect of Process Variables on Chemical Treatment of Jute Fibers

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Abstract
The present study was conducted to ascertain the effect of process variables on chemical treatment of jute fiber. It was found that variables have direct impact on the quality, strength and other parameters of the fiber and with the increase of concentration of penetrating agent, the strength, extension at break and fineness were almost same, but with the increase of caustic soda concentration, the strength, extension at break and the fineness were decreased. Strength has been decreased but extension at break and fineness was unchanged with the increase of time, temperature and stabilizer concentration. With the increase of liquor ratio strength and extension at break were observed to increase but fineness was decreased.

Keywords: Jute; H_2O_2; Silicate; Sodium hydroxide; Variable

Introduction
Jute (*Corchorus olitorious*) is a commercial bast fiber crop widely grown in Bangladesh. It is one of the most affordable natural fibers second only to Cotton in terms of production. This is widely used as industrial raw material for the production of jute goods (Hossain et al., 2008; Mahabubuzzaman, 2006; Mahmuda, 2008; Shah and Prasad, 1995; Shahabuddin et al. 1996; Jubayer et al., 2007; Khan et al., 2011). Appropriate products made from jute and cotton blends are in great demand both in our country as well as abroad (Brindha et al., 2012; Abdullah et al., 1987; Hossain et al., 2008). But the market of traditional jute products like sacking, hessian, CBC etc. is being shrunk day by day. So, for the survival of jute, it has become imperative to develop new jute products (Sheikh 1982; Khan et al., 1996; Ali et al., 1999; Choudhury et al., 2014; Mohanty et al., 2000; Islam et al., 2009; Haydaruzzaman et al., 2009).

To develop a new product, we must have to improve the fiber quality of jute. A better fiber can assure a better yarn product. Jute fiber is a bast fiber obtained from the bark of jute plant containing three main categories of chemical compounds namely cellulose (58~63%), hemicellulose (20~24%) and lignin (12~15%), and some other small quantities of constituents like fats, pectin, aqueous extract, et al. Jute fiber is composed of small units of cellulose surrounded and cemented together by lignin and hemi-cellulose. These hemicellulose and lignin are unwanted substances in a spinnable fiber. A chemical treatment can remove these hemicellulose and lignin. By determining the effect of variables of chemical treatment a better jute fiber may be possible to obtain. The objectives of the project were to optimize the process parameters by using the bottom part of jute cuttings to produce coarser blended yarn with a view to making next operation easier and reducing overall wastage.

Materials and methods
The present study was conducted at Jute-textile research wing of Bangladesh Jute Research Institute. The raw jute fiber was cut into 1.5 inches of length by cutting machine which was put into the chemical processing unit for processing. The effect of process variables like surfactant (Sandoclean PCLF) as penetrating agent, Hydrogen peroxide (H_2O_2) as bleaching agent, sodium

silicate as stabilizer of H_2O_2, sodium hydroxide as alkali, fiber to liquor ratio 1:10 at 95°C temperatures for one hour by varying one and by keeping the other variables fixed (Fig. 1). Finally the fibers were hydro extracted and dried.

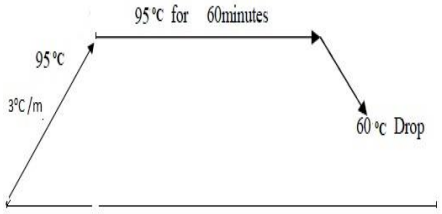

Fig. 1. Pretreatment / Scouring of fabrics

The fibers were chemically treated with above standard chemical recipe. The weight of fiber after chemical treatment was measured (Table 1).

Table 1: Recipes used to analyze the effect of parameters

Chemicals	Effect of Surfactant	Effect of Sodium Hydroxide	Oxidative agent	Effect of Time	Effect of Temperature	Effect of Sodium Silicate Conc.	Effect of Fiber to Liquor Ratio
Sandoclean PCLF	1.0 - 5.0g/L	1.0	1.0	1.0 - 5.0g/L	1.0	1.0	1.0
Sodium silicate g/l	0.30g/L	0.30g/l	0.30g/l	0.30g/L	0.30g/l	0.30,0.50 1.0, 1.5, 2.0	0.30g/L
Sodium hydroxide	4.0g/L	1.0-30.0 g/l	1.0-5.0 g/l	4.0g/L	4.0 g/l	4g/L	4g/L
H_2O_2	4.0 g/l	4.0 g/l	1.0-5.0	4.0 g/l	4.0 g/l	4.0 g/l	4.0 g/l
Temperature	95°C	95°C	95°C	95°C	60°C,70°C, 80°C.90°C, 100°C	95°C	95°C
LR1	10	10	10	10	10	10	10,15,20, 30, 40
Time in minutes	for 60 min	60	60	60,90,120, 180,240	60	60	60

To determine the effect of Sandoclean PCLF all the chemicals were kept fixed but the amount of Sandoclean PCLF was varied. The experiment was done in the laboratory. After completion of the laboratory experiment, the experiment was used in test basis in the chemical plant of Jute-Textile Research Wing of BJRI.

Result and discussion

The amount of Sandoclean PCLF was found varied as shown in column-1 in Table 2. It seems that the breaking strength reduces by 2/cN with the increases of sandoclean PCLF. It means penetrating agent may help wetting but does not affect the process so significantly (Fig. 2).

Table 2: Effect of Concentration of Sandoclean PCLF(penetrating agent) on properties of jute

Sandoclean PCLF	Breaking strength/cN	Breaking extension%	Fineness/tex
1.0	80.50	5.67	2.60
2.0	79.80	6.0	2.55
3.0	79.80	5.5	2.50
4.0	78.5	5.5	2.50
5.0	78.5	5.0	2.50

To determine the effect of sodium hydroxide all the chemicals were kept fixed but the amount of sodium hydroxide was varied (Table 3).

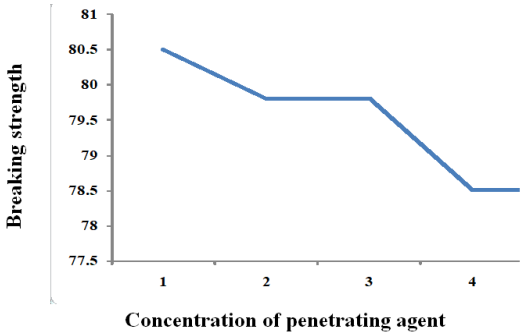

Fig. 2. Effect of Concentration penetrating agent

Table 3: Effect of Sodium Hydroxide Concentration on properties of jute

Sodium Hydroxide Concentration	Breaking strength/cN	Breaking extension%	Fineness/tex
01.0	68	5.70	3.6
05.0	65	4.65	3.5
10.0	60	4.50	2.7
20.0	58	4.50	2.55
30.0	44	4.25	1.85

Found that the breaking strength reduces by 22/cN and the fineness reduces (3.5 to 1.85 g/tex) with the increases of sodium hydroxide concentration. It was found that sodium hydroxide concentration affects the strength significantly and sodium hydroxide may play a vital role in the processing of jute fiber (Fig. 3).

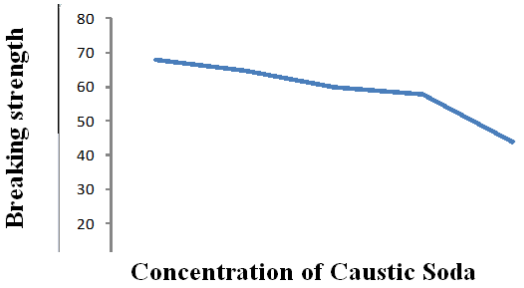

Fig. 3. Effect of Concentration Caustic Soda

The time was varied but all the chemicals were kept fixed and that the breaking strength reduces by 6/cN with the increases of time. In the starting time, the effect is more (Table 4).

Table 4: Effect of time on properties of jute

Time	Breaking strength/cN	Breaking extension%	Fineness/tex
60	44	3.6	3.1
90	42	3.6	3.1
120	40	3.5	3.1
150	39	3.5	3.1
240	38	3.5	3.1

To determine the effect of temperature all the chemicals were kept fixed but the amount of temperature varied as in column-1 where the breaking strength reduces by 25/cN with the increases of temperature. The rate of chemical action on jute increases with the increase of temperature (Table 5, Fig. 5).

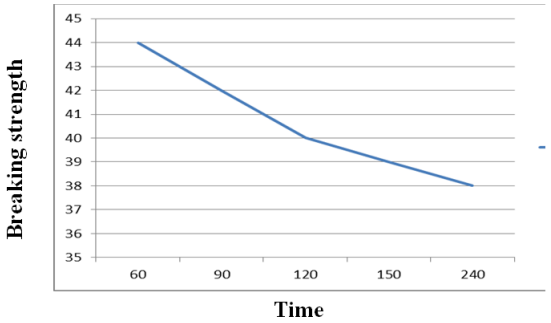

Fig. 4. Effect of Time

The excessive removal of non-cellulosic materials could also be negatively accompanied by a formidable decrease in the breaking strength of the jute fiber. Thankfully the breaking strength was acceptable for spinning, so it was concluded that the optimum temperature should be controlled at 100℃ (Table 5, Fig. 5).

Table 5: Effect of temperature on properties of jute

Temperature	Breaking strength/cN	Breaking extension%	Fineness/tex
60	68	5.25	3.0
70	65	4.6	3.0
80	63	4.5	3.0
90	53	4.0	3.0
100	43	3.8	2.8

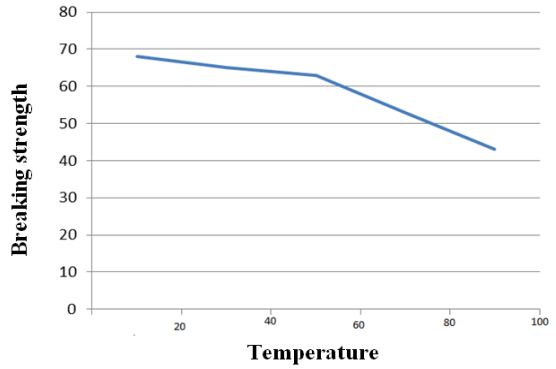

Fig. 5. Effect of Temperature

It was thought that sodium silicate does not have any action directly but it controls the action of hydrogen peroxide. All the chemicals were kept fixed but the amount of sodium silicate was varied as in column-1 in table 6. It seems that the breaking strength reduces by 9/cN with the increases of sodium silicate. From the result it is assumed that sodium silicate does not affect the fibre fineness and strength so significantly (Table 6, Fig. 6).

Table 6: Effect of Sodium silicate on properties of jute

Sodium silicate Concentration	Breaking strength/cN	Breaking extension%	Fineness g/tex
0.30	69	2.6	2.6
0.50	63	2.6	2.6
1.00	61	2.6	2.6
1.50	60	2.6	2.6
2.00	64	2.6	2.6

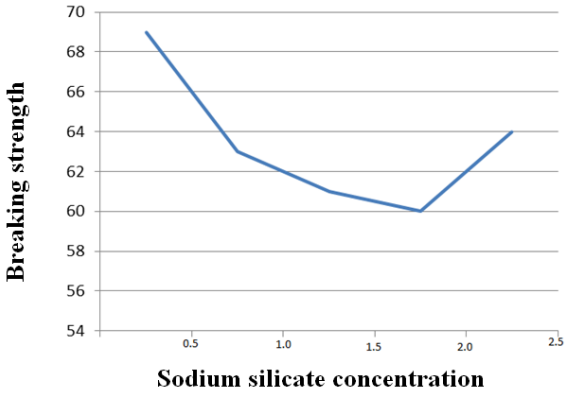

Fig. 6. Effect of sodium silicate concentration

The material liquor ratio varied. It seems that the breaking strength increases with the increases of material liquor ratio (Table 7, Fig. 7).

Table 7: Effect of fiber to liquor ratio on jute mechanical properties

Liqour Ratio	Breaking strength/cN	Breaking extension%	Fineness/tex
10	44	4.2	3.3
15	44	2.75	3.0
20	48	3.45	2.8
30	53	3.6	2.6
40	63	3.6	2.6

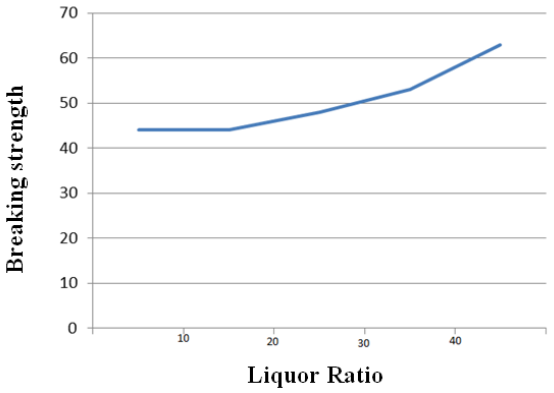

Fig. 7. Effect of Liquor Ratio

Conclusion

The strength of yarn is considered as a major quality in spinning and the fibre strength has a direct effect on yarn strength. The strength of the fibre was observed closely. From the above findings of the results from table-2 to table-7, it is assumed that sodium hydroxide plays a vital role in the chemical processing of jute. Hydrogen peroxide may cause the reduction of strength of the fibre. From column-1 in table 4 it is seen that with prolonged time, the chemicals weaken the fibre. The higher the temperature, the weaker the fibre. The increased amount of sodium silicate over stabilizes the bath and the activity of the hydrogen peroxide is reduced or stopped consequently. The penetrating agent acts as wetting agent but does not take part in a reaction. The breaking strength increases with the increase of material liquor ratio. Determination of the effect of process variables can optimize the process. Hence, it will save time, cost and ensure a better quality of jute fiber.

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MA, HMZH, ZA and MK conceived the concept, wrote and approved the manuscript.

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The authors declare no competing interests.

Ethics approval
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