Hydrogen Peroxide Alkaline Pulping of Bagasse

Zenat A. Nagieb, Essam S. Abd-El-Sayed, Mohamed E-l-Sakhawy and Eid M. Khalil,

ABSTRACT

Studies were carried out on the preparation of a new chemical pulp from non-woody cellulosic materials by H_2O_2 - alkaline pulping of depithed sugar cane bagasse. The cooking liquor was a mixture of water, sodium hydroxide as Na_2O (15% on raw material), varying amount of H_2O_2 from 1-4% on raw material and small quantities of auxiliary (EDTA). The liquor ratio of the mixture to cellulosic materials being 6:1 and the time of cooking was from 0.5-1h at 140-160°C.

Addition of EDTA as a chelating agent during peroxide pulping enhances the efficiency of cooking liquor towards delignification process and carbohydrate protection. 0.3% of EDTA is considered the best concentration that could be added to peroxide alkaline pulping liquor to increase the efficiency of delignification process where, at this ratio, the best delignification is achieved i.e., the most favorable yield to kappa number relationship is observed.

Relative viscosity, water retention value and fiber lengths were investigated for different pulps such as soda, soda-anthraquinone and peroxide alkaline pulps with and without EDTA addition.

INTRODUCTION

The global raw material shortage, growing demand for pulp products, increasing concern with environmental pollution and effective use of costly chemicals are the major factors to have a fresh look at the conventional pulping processes which leave a large portion of the lignin in pulps to be removed by chlorine based chemicals during bleaching. The effluents of these stages causes pollution of water streams if not treated. Many investigators have reported that if oxygen or H_2O_2 and alkali used to delignify wood, better pulps with a scope to reduce the pollution load are obtained (1-4).

In order to reach a still lower kappa number an additional delignification agent has to be found Hydrogen peroxide in alkaline medium achieves this goal advantageously.

The delignification process with H_2O_2 is most likely the result of the following reactions.

$$H_2O_2 \xrightarrow{\text{Fast}} O_x$$

$$\text{Lignin} + O_x \xrightarrow{\text{Fast}} \text{Oxidized lingnin}$$

$$\text{Oxidized lignin} + OH^- \xrightarrow{\text{Slow}} \text{dissolved lignin}$$

The first step of delignification seems to be fast

Cellulose and Paper Dep.
National Research Center El-Tahir St.,
Dokki. Cairo P.O. 11262
Egypt

oxidation of the lignin by O_x components (OH^-, O_2^-, O^2. The second step would be a slow dissolution of the oxidized lignin in alkaline medium (4). This explains the fast disapearance of the hydrogen peroxide and accounts for the lack of effect displayed by the sodium silicate, other researchers have found that in certain case a pulp quality was improved by the addition of magnesium sulphate (5). The latter decreases the depolymerisation of the cellulose.

Addition of EDTA as a chelating agent has a great role in accelerating the rate of delignification reactions besides enhanced oxidative stabilization of the reduced end groups in carbohydrates (6,7).

The main object of this work is to study the optimum pulping conditions of non-sulfur alkaline hydrogen peroxide pulping processes of Egyptian deptithed sugar-cane bagasse. Effect of addition of EDTA on delignification rate, viscosity and water retention value of the pulp produced.

EXPERIMENTAL

The bagase used in this work has been delivered from the Edfu pulp mill. Generally, bagasse pulps are used successfully in Egypt to make printing and writing paper.

ANALYSIS OF RAW MATERIAL

Bagasse was extracted with a methanol-benzene (1:1) mixture for 8 hours. The material was left to dry at room temperature, conditioned and the moisture content was estimated. Some analytical data of the raw material are illustrated in table 1.

TABLE-1

Some analytical data of bagasse

Lignin content	21.74%
Holocellulose content	73.35%
Hemicellulose content	22.75%
α-cellulose content	38.36%
Ash content	1.31%
Fiber length (mm)	1.95
Fiber width (m)	0.35

PULPING

All pulping experiments in this work have been carried out in a 4-liter stainless steel rotating pressure reactor, immersed in a temperature controlled oil bath. In each experiment, 100g oven dry of depithed bagasse and the cooking liquor were mixed in the reactor at ambient temperature. The cooking liquor consisted of a mixture of 16% sodium hydroxide, 0.1% anthraquinone, and different doses of hydrogen peroxide from 1 to 4% based on oven dry bagasse basis. In some experiments small quantities of chelating agent (EDTA) were used as a carbohydrate degradation inhibitor. The liquor to bagasse ratio was 6:1, the degree of temprature was 140 and 160°C for 30 and 60 minutes. All these data mentioned before specified for the production of peroxide-alkaline bagasse pulps.

ALKALI RESISTANCE OF PULP

The alkali resistance (R_{10}) of pulp is defined as the fraction of pulp, which is insoluble in a solution of sodium hydroxide of fixed concentration (generally 10% or 18% by weight). This method is an improvement of cellulose estimation procedure and avoids its inconsistency. It is recommended now by the pulp and paper chemists not to make further practical use of the cellulose method, and to use the method described according to APPCE standard IV/39/67.

WATER RETENTION VALUE

The water retention value is an indication of the tested sample water affinity. The decrease in WRV of the samples means that their water repelling increases. Water retention was estimated according to Tappi (8).

VISCOSITY

The standardized capillary tube of Ostwald's viscometer (9) measured it.

KAPPA NUMBER

Kappa number is a test

For measuring the degree of delignification. The method employed in this work is according to Tappi standard 236-60A.

RESULTS AND DISCUSSION

ALKALINE PEROXIDE PULPING OF BAGASSE

Alkaline hydrogen peroxide pulping experiments have been carried out on depithed bagasse at varying concentration of hydrogen peroxide (1, 2, 2.5, 3, 3.5 and 4% based on oven-dry bagasse basis). The maximum cooking temperature were 140 and 160°C,

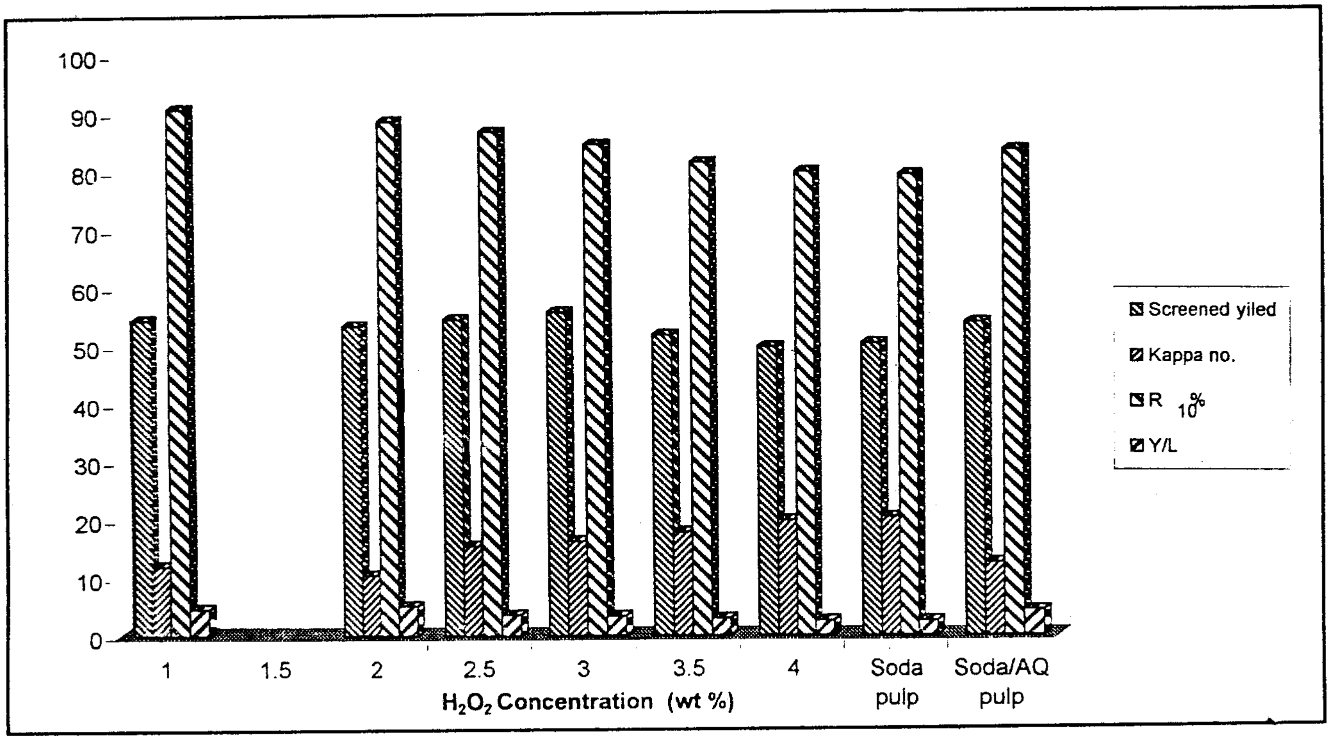

Figure (1) Effect of different of hydrogen peroxide concentration on pulp properties.

for a reaction time 30 and 60 minutes, and liquid to raw material ratio (liquor ratio) of 6:1 containing 16% NaOH and 0.1% AQ. In some experiments a few amount of chelating agent (EDTA) has been added to cooking liquor of alkaline peroxide to evaluate its effect on the physical and chemical properties of the produced pulps. In this work, peroxide alkaline pulps have been washed by tap water and then screened to remove the unreacted

TABLE-2

Effect of different hydrogen peroxide concentration of pulp properties.

Exp. No.	Concentration of H_2O_2 (wt %)	Screened Yield %	Kappa No.	${}^aR_{10}$ %	Selectivity (Y/L)
1	1.0	54.4	11.9	90.7	4.6
2	2.0	53.4	10.4	88.6	5.1
3	2.5	54.5	15.4	86.7	3.6
4	3.0	55.7	16.2	84.5	3.4
5	3.5	51.7	17.7	81.3	2.9
2	4.0	49.6	19.7	79.7	2.5
7	*Soda pulp	50.2	20.2	79.2	2.5
8	**Soda / AQ pulp	53.8	12.4	83.4	4.3

Liquor ratio 6:1, time 30 min. at 160°C, NaOH 16% & 0.1% AQ

* **16% NaOH, 160°C, 60 min.**

** **16% NaOH, 0.1% AQ, 160°C, 60 min.**

a: **The alkali resistance of pulp (R_{10}) represents the amount of carbohydrates in the pulps which resist 10% NaOH.**

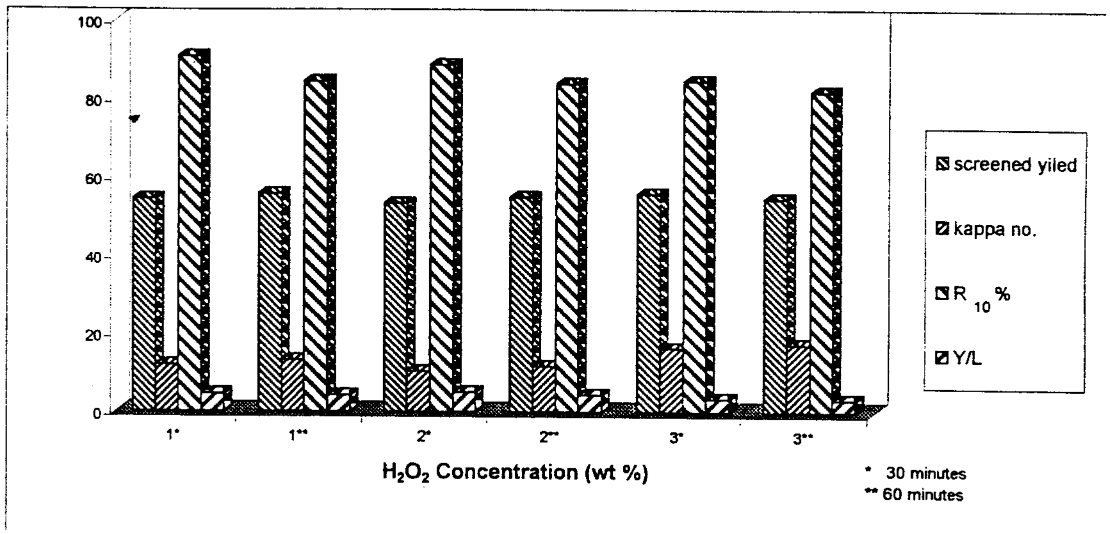

Figure (2) Peroxide - alkaline pulping of bagasse at different hydrogen peroxide concentrations and cooking times.

parts (rejects). It has been found that the amount of rejects is negligible, so that in alkaline peroxide pulping, the screened yield can be considered as the total pulp yield.

Alkaline-hydrogen peroxide pulping conditions and the results of the produced pulps are reported and illustrated in comparison with soda and soda-anthraquinone (SAQ) pulping.

EFFECT OF HYDROGEN PEROXIDE CONCENTRATION

In order to evaluate the effect of adding hydrogen peroxide to pulping liquor of soda-anthraquinone pulping on the properties of the produced pulps, alkali charge, AQ charge, degree of temperature and cooking time were held constant as, 16% 0.1%, 160°C and 30 minutes respectively, However, hydrogen peroxide charge was varied from 1 to 4% based on bagasse. Pulp

TABLE-3

Peroxide-alkaline pulping of bagasse at different hydrogen peroxide concentration and cooking times.

Exp. No.	Cooking Chemicals %			Time (min)	Screened Yield %	Kappa No.	*R_{10} %	Selectivity (Y/L)
	NaOH	AQ	H_2O_2					
3	16	10.1	1	30	54.4	11.9	90.7	4.6
9	16	0.1	1	60	55.7	13.2	84.3	4.2
2	16	0.1	2	30	53.3	10.4	88.6	5.1
10	16	0.1	2	60	54.9	11.7	83.7	4.4
4	16	0.1	3	30	55.7	16.2	84.5	3.4
11	16	0.1	3	60	54.5	17.3	81.7	3.2

Liquor ratio 6:1. temp. 160°C.

yield %, kappa number, alkali resistance, and pulping selectivity of the produced pulps have been studied and the results were reported in Table-2 and illustrated in Fig. 1. It can be noticed that increasing the hydrogen peroxide concentration from 1 to 2% in cooking liquor of (SAQ), is accompanied by a slight decrease in kappa number from 11.9 to 10.4, i.e., improvement in the delignification process. Also, the slight decrease in the screened yield % and alkali resistance is observed by 1 unit and 2 units respectively, may be due to breaking down of carbohydrates by H_2O_2. A further increase in H_2O_2 charge from 2% to 2.5% resulted in a slight additional increase in pulp yield % and a pronounced increase in kappa number by 1 and 5 units.

Moreover, it has been noted that at moderate H_2O_2 concentration from (1-2%) the pulping liquor improve the dissolve of lignin with simultaneous protection of the carbohydrates, as has been reported (4). At these concentration the most favorable yield to kappa number relationship is observed, i.e., low kappa number with high yields. At higher H_2O_2 concentration >2%, higher yields are due to higher kappa numbers (residual lignin content) as (exp. 3 and 4), while at H_2O_2 concentration above 3%, there was a drop in yields, although kappa numbers are increased (exp. 5 and 6). The decrease in yield may be due to the carbohydrate hydrolysis at this H_2O_2 concentration. Table (2) shows that 16% NoaH can delignify bagasse almost to the same extent as 4% H_2O_2 concentration (exp.6).

Addition of anthraquinone improves the delignification process, the well-known advantageous effect characterizing anthraquinone (11), and a low kappa number is obtained at high pulp yield. However, the alkali resistance of soda and soda-anthraquinone pulps is relatively low, when compared with R values of different peroxide alkaline pulps. This would indicate that the carbohydrates would be more accessible for soda than for peroxide. Confirming thereby the reduced swelling of the carbohydrate in hydrogen peroxide media, thus preventing them from hydrolysis.

EFFECT OF COOKING TIME

The effect of cooking time has been studied at three different hydrogen peroxide concentrations (1,2 and 3% on o.d. bagasse basis) and the results are reported in Table 3 and illustrated in Fig. 2.1% and 2% H_2O_2 concentration has been chosen for this study, because it gave the best delignification at 30 min cooking time. 3% H_2O_2 concentration is also included in this study for comparison.

From Table-3 and Fig. 2, it can be noticed that increasing the cooking time from 30 to 60 min retards both the delignification process and carbohydrate protection (R_{10} values) significantly. As shown in Table (3), increasing the cooking time is accompanied by a slight increase in both kappa number and pulp yield. The magnitude of increase in kappa number was found about unit in all different pulps. The pulp yield showed

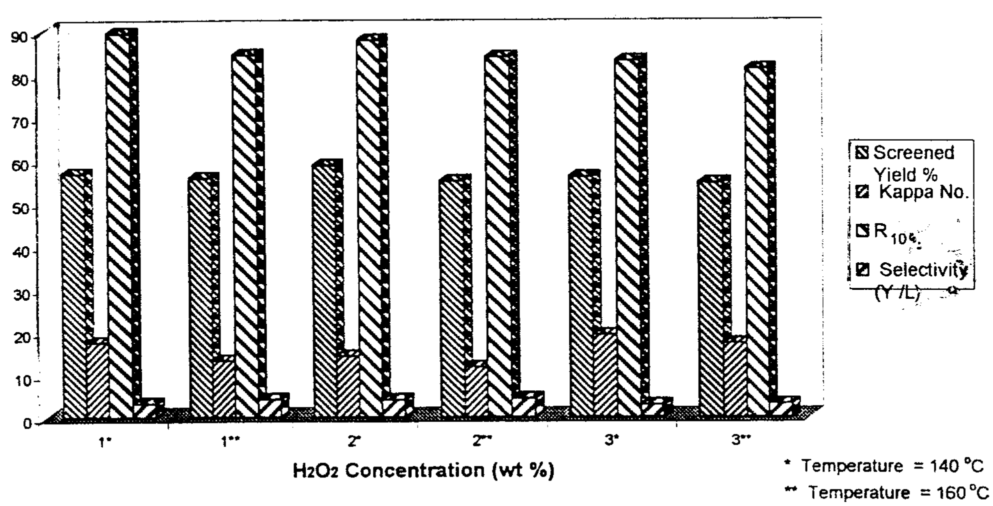

Figure (3) Peroxide - alkaline pulping of bagasse at different hydrogen peroxide concentrations and cooking times.

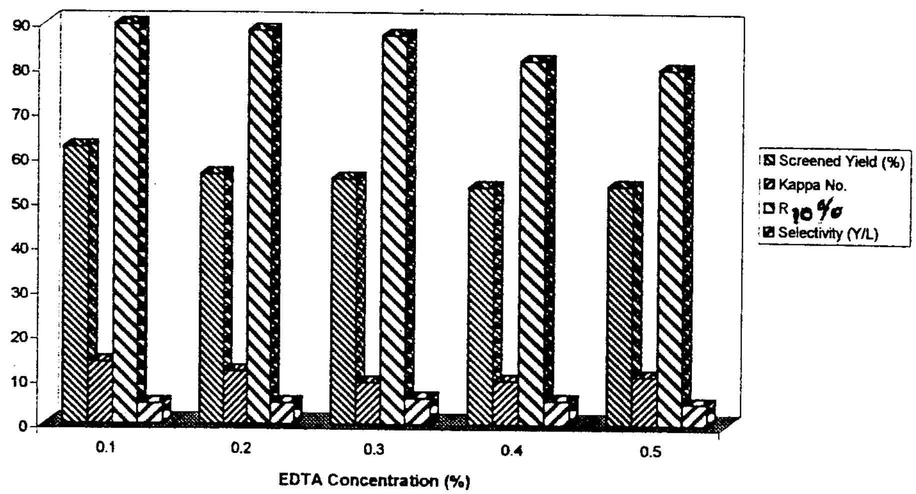

Figure (4) Peroxide - alkaline pulping of bagasse at different EDTAconcentrations.

marginal improving trend especially in (exp.9 and 10) may be due to high kappa number (residual lignin content), however, the marginal decrease in pulp yield of (exp.11) may be due to carbohydrate hydrolysis by increasing the cooking time. On other hand, the alkali resistance is negatively affected by times, as illutrated in Table 3.

It can be concluded that increasing the cooking time from 30 to 60 min. results on inferior delignification selectivity and also inferior alkali resistance.

It can be also said that increasing the amount of hydrogen peroxide from 1 to 2% in the cooking liquor accelerates the rate of delignification, significantly and shifts the optimum delignification process towards shorter cooking times.

EFFECT OF TEMPERATURE

The influence of cooking temperature on alkali peroxide pulp properties has been studied at two different temperature 140 and 160°C, on three different hydrogen peroxide concentration (1,2 and 3% H_2O_2).

TABLE-4

Peroxide-alkaline pulping of bagasse at different hydrogen peroxide concentration and cooking temperature.

Exp. No.	Cooking Chemicals %			Temp. °C	Screened Yield %	Kappa No.	*R_{10} %	Selectivity (Y/L)
	NaOH	AQ	H_2O_2					
12	16	0.1	1	140	56.7	17.5	89.4	3.3
9	16	0.1	1	160	55.7	13..2	84.3	4.2
13	16	0.1	2	140	58.6	15.3	87.7	4.1
10	16	0.1	2	160	54.9	11.7	83.7	4.4
14	16	0.1	3	140	55.9	19.2	82.9	2.9
11	16	0.1	3	160	54.5	17.3	80.9	3.2

Liquor ratio 6:1, temp. 60°C.

From Table 4 and fig.3, it is clear that increasing the temperature of pulping liquor from 140 to 160°C improves the delignification process for the different pulps. The kappa numbers dropped by 4 units at 1% H_2O_2 concentration, 3 units at 2% H_2O_2 and about 2 units at 3% H_2O_2 concentration. It has been also found that, the pulp yield % decreases by raising the cooking temperature from 140 to 160°C for all different pulps. However, the alkali resistance value is deteriorating, which means that the carbohydrate fractions are more degraded in the presence of H_2O_2 charge more than 2% in cooking liquor.

It can be concluded that increasing the percentage of H_2O_2 in alkaline peroxide pulping of bagasse, the deterioration in both the delignification process and carbohydrate protection (R_{10} values) increases. It can be said that pulping liquor with H_2O_2 concentration >2% is an unsuitable pulping media due to the poor dissolution of lignin and weak carbohydrate protection (4). However, pulping liquors with 1-2% H_2O_2 are suitable and delignification process reaches a satisfactory level.

It can be concluded that, increasing the cooking temperature, has a negative effect on both the pulp yield and alkali resistance of different pulps, this may be due to accelerate the decomposition hydrogen peroxide by action of high temperature (12). On the other hand, increasing the cooking temperature is accompanied by a pronounced increase in the delignification selectivity.

EFFECT OF EDTA ADDITION

It order to evaluate the effect of adding EDTA (ethylene diamine tetra acetic acid) as chelating agent to cooking liquor of peroxide - alkaline pulping of bagasse, the alkali charge, anthraquinone percent, hydrogen peroxide concentration, cooking time and cooking temperature were held constant as 16%, 0.1%, 1%, 60 min and 160°C respectively, whereas, EDTA charges were varied from 0.1 to 0.5% based on dry weight of bagasse. The pulp yield, kappa number, alkali resistance and pulping selectivity of the produced pulps have been investigated and the results are reported in Table-6 and illustrated in fig. 4.

It has been found that increasing the percentage of EDTA in cooking liquor from 0.1 to 0.3% is accompanied by a pronounced decrease in kappa number from 13.9 to 9.4, i.e., improvement in the delignification process.

Further increase in EDTA percent decreases the pulping selectivity, the kappa number slightly increase to reach 10.9 at 0.5% EDTA concentration. Therefore, it can be said that the best delignification is achieved at 0.3% EDTA, where, the kappa number attains the least value, as shown in fig. 4.

The increase in kappa number either at higher or

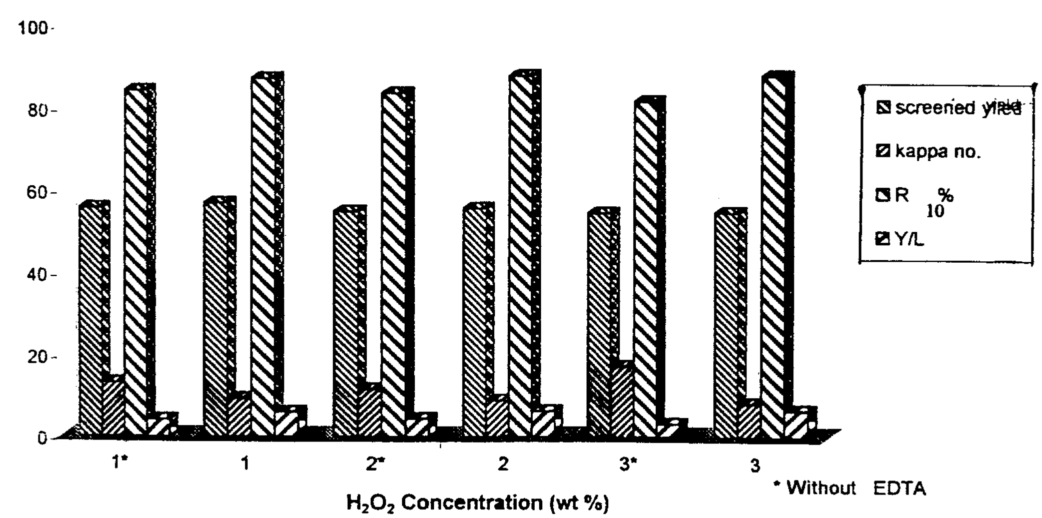

Figure (5) Effect of Chelating agent (0.3% EDTA) on peroxide - alkaline pulping of bagasse.

TABLE-5

Peroxide-alkaline pulping of bagasse at different EDTA Concentrations and.

Exp. No.	Cooking Chemicals %				Screened Yield %	Kappa No.	*R_{10} %	Selectivity (Y/L)
	NaOH	AQ	H_2O_2	EDTA				
15	16	0.1	1	0.1	62.2	13.9	89.7	4.5
16	16	0.1	1	0.2	56.1	11.8	88.4	4.7
17	16	0.1	1	0.3	55.3	9.4	87.3	5.9
18	16	0.1	1	0.4	53.4	9.8	81.7	5.4
19	16	0.1	1	0.5	53.7	10.9	79.9	4.8

Liquor ratio 6:1, time min. at 160°C.

lower than 0.3% EDTA indicates decreasing in the delignification rate during pulping process. More over, Fig. 4 indicates that the major improvement in the pulping selectivity has been achieved at 0.3% EDTA. At this value, the most favorable yield to kappa number relationship is observed, i.e., low kappa number with high pulp yield. At charge lower than 0.3% EDTA, high yields are due to high kappa number (residual lignin content) of the pulps. However, at higher charges than 0.3% the pulp yield decline and kappa number increase. The decrease in yield may be due to hydrolysis of carbohydrate fraction during the pulping process by action of hydrogen peroxide and alkaline medium.

Also,from Table 6 the alkali resistance (R_{10}) values of different pulpare negatively affected by increasing in the percentage of EDTA.

EFFECT OF EDTA AS CHELATING AGENT ON PA

The Effect of presence a few amount of EDTA as chelating agent which act as peroxide decomposition inhibitor, on pulp properties of peroxide -alkaline pulping of bagasse has been studied at three difference concentration of hydrogen peroxide. The results of obtained pulps are reported in Table 6 and illustrated in fig. 5. 0.3% EDTA has been chosen for this study, because it gave the best delignification at 60 min cooking time.

From Table 6 and fig. 5 it is clear that increasing the concentration of hydrogen peroxide from 1 to 3% in the presence of 0.3% EDTA, is accompanied by a slight decrease in the kappa number of the pulp from 9.4 to 8.2, i.e., improvement in the delignification

TABLE-6

Peroxide-alkaline pulping of bagasse in presence of 0.3% EDTA.

Exp. No.	H_2O_2 Conc.	Screened Yield %	Kappa No.	*R_{10} %	Selectivity (Y/L)
9	1*	55.7	13.2	84.3	4.2
20	1	56.9	9.4	87.3	6.1
10	2*	54.9	11.7	83.7	4.4
21	2	55.7	8.9	87.9	6.3
11	3*	54.5	17.3	81.7	3.2
22	3	54.8	8.2	88.2	6.6

Liquor ratio 6:1, time min. at 160°C NaOH 16% & 0.1 % AQ
*** The same pulping conditions but without chelating agent (EDTA).**

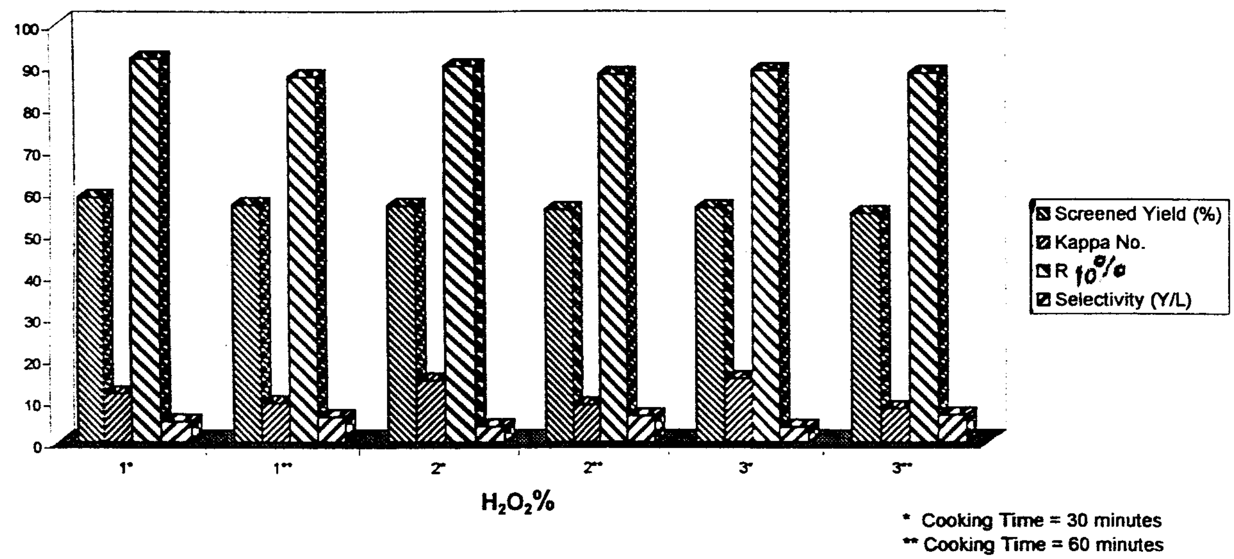

Figure (6) Peroxide - alkaline 0.3% EDTA pulping at different hydrogen peroxide concentration and cooking times.

process. It has been also found that the pulp yield decreases considerably by increase the concentration of H_2O_2.

The decrease in the pulp yield are due to the lower kappa number (residual lignin content) of the pulp. On the other hand, the alkali resistance (R_{10}) values are improved in the presence of EDTA during (PA) pulping process.

This indicates that the carbohydrates are less degraded by presence of EDTA in cooking liquor of (PA process) as compared with our previous results obtained from (PA) delignification in absence of EDTA as shown in Table 6.

From all these results, it can be concluded that the addition of a few amount of (EDTA) as chelating agent during the peroxide alkaline pulping of bagasse enhance the efficiency of the cooking liquor towards delignification process and carbohydrate protection, i.e. improvement the quality of the produced pulps. 0.3% EDTA concentration is considered the best concentration could be added to peroxide alkaline pulping liquor to increase the efficiency of the delignification process, where, at this ratio, the best

TABLE-7

Peroxide-alkaline EDTA pulping at different hydrogen peroxide concentration and cooking times.

Exp. No.	Cooking Chemicals %				Cooking time min	Screened Yield %	Kappa No.	*R_{10} %	Selectivity (Y/L)
	NaOH	AQ	H_2O_2	EDTA					
23	16	0.1	1	0.3	30	58.7	11.7	91.7	5.0
20	16	0.1	1	0.3	60	56.9	9.4	87.3	6.1
24	16	0.1	2	0.3	30	56.7	14.9	89.9	3.8
21	16	0.1	2	0.3	60	55.7	8.9	87.9	6.3
25	16	0.1	3	0.3	30	56.2	15.3	88.9	3.7
22	16	0.1	3	0.3	60	54.8	8.2	88.2	6.6

Liquor ratio 6:1, time min. at 160°C.

delignification is achieved i.e., the most favorable yield to kapp number relationship is observed.

EFFECT OF COOKING TIME ON PA-EDTA

The effect of 0.3% EDTA on different concentration of hydrogen peroxide at different cooking time was studied. The results are reported in Table 7 and illustrated in fig 6. Our results are also compared with previous our results of peroxide alkaline pulping without EDTA as blank.

From Table 7 and fig. 6 it has been found that increasing the cooking time from 30 to 60 min. improves the delignification process for different pulps. The kappa number dropped by 2 units at 1% H_2O_2, 6 units at 2% and 7 units at 3% H_2O_2. On the other hand, as mentioned before in the Table 4 increasing the cooking time for peroxide-alkaline pulping liquor without (EDTA), is accompanied by deterioration in both delignification process and carbohydrates protection as shown before in Table 4. Therefore, it can be said pulping liquors of peroxide -alkaline process contains a few amount of chelating agent as EDTA are a suitable pulping media and the delignification process reaches a satisfactory level at 2% and 7 units at 3% H_2O_2. On the other hand, as mentioned before in the Table 4 increasing the cooking time for peroxide-alkaline pulping liquor without (EDTA), is accompanied by deterioration in both delignification process and carbohydrates protection as shown before in Table 4. Therefore, it can be said pulping liquors of peroxide-alkaline process contains a few amount of chelating agent as EDTA are a suitable pulping media and the delignification process reaches a satisfactory level.

It has been also found that the pulp yield % decreases considerably by raising the cooking time from 30 to 60 min. The pulp yield dropped by ca. 2.7% at 1% H_2O_2, 1.8% at 2% and ca: 2.6% at 3% H_2O_2 charges. The decrease in pulp yield of different pulps may be due to decreasing in kappa number of different pulps (residual lignin content). The alkali resistance is also negatively affected by time of cooking illustrated in Table 7, but the decrease in alkali resistance values (R_{10}) of peroxide alkaline EDTA pulps is lower than the decreases of R_{10} values of alkali peroxide pulps (without EDTA) a shown previous in Table 4 for comparison, i.e., pulping liquor of peroxide -alkaline contains a few amount of chelating agent (EDTA) results ia slight attack to carbohydrates lower than peroxide alkaline pulping liquor without EDTA. These results are agreement with (3). This may be attributed to decrease the degree of carbohydrates swelling during the (PA) pulping in the presence of chelating agent (EDTA).

Table 8 collecting the optimum pulping results of alkali peroxide and alkali-peroxide-EDTA bagasse pulp. Soda, and Soda-anthraquinone bagasse pulps are also included in this study for comparison. All these pulps have been compared at the same pulping condition. It should be noted that all the results in Table 8 are chosen for this study according to the previous studies of the influence of different variables of pulping process on obtained pulp properties. The relative viscosity (7), water retention value and the fiber lengths of diferent pulps are also investigated the results are reported in Table 8 for comparison.

It is clear that the peroxide alkaline-EDTA

TABLE-8

Comparative study on the peroxide alkali (PA), PA-EDTA, Soda and Soda-AQ different bagasse pulps

Exp. No.	Cooking Chemicals %				Screened Yield %	Kappa No.	•R_{10} %	Selectivity (Y/L)	η	WRV %	F.L (mm)
	NaOH	AQ	EDTA	H_2O_2							
I	16	---	---	---	50.3	20.2	79.2	2.5	35.4	109	1.13
II	16	0.1	---	---	53.8	12.4	83.2	4.3	41.2	126	1.20
III	16	0.1	---	2	54.5	11.6	83.7	4.6	37.1	172	1.24
IV	16	0.1	0.3	2	55.7	8.9	87.9	6.3	39.7	210	1.28

Liquor ratio 6:1, time min. at 160°C.

η : is the relative viscosity

W R V : is the water retention value

F. L. : is the fiber length

pulping offers higher selectivity in the delignification process. The kappa number of different pulps is in the order PA-EDTA<PA<Soda-AQ<Soda.

Moreover, the peroxide alkaline EDTA process is superior in each of the pulp yield and R_{10} in the order: PA - EDTA>PA> Soda-AQ> Soda

The degree of polymerization of cellulose bagasse pulps obtained from different pulping methods, using xanthate pulps in sodium hydroxide solution indicated by relative viscosity (7) as compared with the different pulps.

At comparable pulping conditions of different processes, the maximum relative viscosity (7) obtained with sod-AQ pulp, while the minimum viscosity obtained in the case of soda pulp as shown in Table 8. The order in decrease the relative viscosity of different pulps is:

Soda<PA<PA-EDAT<Soda-AQ

The fiber length gives an indication of the degradation of fibers, due to different methods. It can be seen from Table 8. The decrease in fiber length is in the order: PA-EDTA>PA> Soda-AQ>Soda.

These results are supported with the relative viscosity of different pulps as mentioned before. Table 8 shows also the water retention values of different pulps which indicated to the fiber swellability in water. The water retention values for different bagasse pulps were calculated and from the results reported in Table 8 it can be obvious that the values of (WRV) of different bagasse pulps are in the order PA-EDTA>PA>Soda-AQ>Soda.

From all these results mentioned before and guided by Table 8 it can be concluded that, the addition of chelating agent (EDTA) to cooking liquor of alkaline peroxide pulping of bagasse enhances the efficiency of cooking liquor towards the delignification process and carbohydrate protection, where, it offer higher selectivity of delignification process and lower carbohydrate. Superior to both alkaline peroxide and Soda-AQ in each of the following: fiber length, water retention value, and relative viscosity.

CONCLUSION

- The major improvement in the pulping selectivity has been achieved at 0.3% EDTA results in a slight attack to carbohydrates lower than , ,roxide alkaline pulping liquor.
- At this value, the most favorable without EDTA. yield to kappa number relationship is observed.
- The decrease in alkali resistance values of (R_{10}) of peroxide alkaline. EDTA pulps is lower than the decrease of values of alkali peroxide pulps (without EDTA).
- Moreover, the peroxide alkaline EDTA process is superior in each pulp yield and R_{10} in the order PA-EDTA>PA>Soda AQ>Soda.
- Relative viscosity obtained with -Soda-AQ pulp, while the minimum viscosity obtained in the case of Soda pulp. The order in decrease the relative viscosity of different pulps is Soda<PA<PA-EDTA<Soda-AQ.
- Water retention value of different bagasse pulp are in the order PA-EDTA>PA>Soda AQ>Soda.
- The kappa number of different pulps is in the order PA DEDTA>PA>Soda-AQ<Soda process.
- The decrease in fiber lengths is in the order PA EDTA>PA>Soda AQ>Soda.

REFERENCES

1. Croonl & Andrews D H, *Tappi J* 54 (11) (1971) p 1893.
2. Kleppe P J, Eckert R C & Hou Min Chang, *Pulp Paper Mag.* Can. 73 (12) (1972) p 102.
3. Mita A, *Tappi* (Progress report No. 15) (1984) p35.
4. Dutt Dharm, Upadhyaya J S, Upadhyaya M K & Tiwary K N *IPPTA Converntion Issue*, (1993) P 95-107.
5. Lachenal D, de Choudens C & Monze P, *Tappi J* 63 (4) (1980) p 119.
6. Bouchard J, Nugent H M & Berry R M, *J Pulp Pap Sci* 21 (6) (1995) p J203.
7. Basta J, Holtinger L, Hermansson W & Lundgren P, *International Pulp Bleaching Conference*, Paper

Preorints, Tech. Sect, CPPA, Montreal (1094) p 29.

8. Jayme G, *Tappi J* 42 (2) (1958) p 178.

9. Jayme G & Karl Henz Rasentoct, *Das Papier* 11 (1957) p 77-82.

10. Lonnberg K B, *AICHE 1991. Forest products symposium proceedings*, Nov. 17-22, 1991, Los Angelos; Tappi Press (1992) p 45.

11. Macleod J M, Fleming B J, Kuber G J & Bolker H I, *Tappi J* 63 (1) (1980) p 57.

12. Gummeruo L, *Paperi Ja Puu* 64 (11) (1982) p 717.