HIGH YIELD PULPING OF DEPITHED BAGASSE BY MODIFIED MONOSULPHITE PROCESS

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SUMMARY

A study was carried out on high yield pulping of bagasse using mono sulphite process. The study included the effect of buffer, chemicals, cooking period, and temperature on pulp yields, Permanganate Number, pulp brightness, bleachability and strength properties of bleached pulps.

The depithed bagasse was presteamed at a temperature of 140°C for a period of 15 minutes. The presteamed material was digested using varying quantities of Sodium Sulphite solution and green liquor from Sulphate Mill calculated on the basis of total titratable alkali expressed as Na_2O. It was found that using 14% sodium sulphite solution on the basis of untreated depithed bagasse with 2% buffer at 165°C with a material liquor ratio of 1:4 for a total period of 3 hours gave an unbleached pulp yield of 64% with a pulp brightness of 46%. This pulp could be bleached to a brightness of 80% using the conventional multistage bleaching sequence of CEH, giving a pulp yield of 58%.

These mono sulphite pulps are characterized by easy processing, superior higher yield and superior pulp qualities compared to corresponding kraft pulps. The pulping of bagasse by mono-sulphite process should be an acceptable process for obtaining pulps with high yield and brighter pulps.

INTRODUCTION

Due to the expected further scarcity of the present raw materials in future, the paper technologists in India are rather compelled to divert their attention towards other raw materials such as agricultural residues etc. Sugarcane bagasse is one of them. It is receiving increasing attention as a raw material for the manufacture of paper pulps, due to the fact, that it contains about 70-75% holocellulose with suitable fibre length, slightly higher than that of hard woods i.e. about 1.4 mm.

Bagasse is a waste product of Sugar industries available in abundance. Sugar production in the country is said to be over 4 million tonnes. The sugar recovery ranges between 8 to 12 percent. Taking the average sugar recovery to be 10 percent of sugarcane, the sugarcane crushed for the production of 4 million tonnes of sugar, should be 40 million tonnes. This does not include the sugarcane used for Khandasari and Gur. The bagasse available from sugar industries would be about 8 million tonnes. It is recorded[1] that about 53 million tonnes of sugarcane is used for the production of Khandasari and Gur. The bagasse available from this source would be about 0 million tonnes. The total bagasse available would be 18 million tonnes. It is conceivable that if concerted efforts are made by way of better procurement, release of alternative fuel like coal or oil to the sugar mills, as well as the improving the boiler performance where bagasse is used as a fuel, the availability of bagasse could be significantly increased. By this way at least ¼th of the total i.e. about 5 million tonnes of bagasse could be made available. About 2-3 million tonnes of bamboo is available for papermaking. So it appears that the bagasse should be the second biggest resource for paper making[1].

It is a fact that primary job of sugar industries is to get maximum amount of juice, hence more sugar out of sugarcane. With this objective in view, the sugarcane is crushed thoroughly. While doing so the fibres are damaged to the extent of 40%[2]. If methods could be deviced so as to reduce this damage, maintaining the maximum extraction of sugar, then bagasse with more good fibres could be made available for papermaking. Better breeding of sugarcane also helps in giving more sugar production, at the same time sugarcanes will be having higher length and girth, producing bagasse of longer fibres of better quality to produce quality pulps and papers.

About 30 percent by weight of dry bagasse consists of short non-fibrous cells or pith cells. Pith can contribute little towards pulp quality; its presence, infact increases pulping and papermaking problems. Hence, it is advisible to remove pith from bagasse.[3] Depithing

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is done by two methods (1) Dry method, (2) Wet method Reitz disintegrator. After separation, pith can be put into use economically[4]. It can be used for (i) burning in boilers (ii) mixing with depithed fibre in various proportions to make grease proof papers (iii) making insulating boards (iv) mixing with molasses to produce cattle food and (v) can be mixed with soil in dry fields where water retention is required.

Quality of bagasse varies on many factors[2] chiefly (i) geographical source (ii) growing conditions (iii) growth cycle (iv) age of cane at cutting, (v) variety of cane (vi) type of depithing, etc. Particular bagasse has to be tested for finding out best process suitable for pulping and papermaking. Whole bagasse has been used for cheaper varieties of papers while for superior quality of paper depithed bagasse has been found useful. For depithed bagasse, Soda, kraft, Sulphite, and bisulphite processes, have been employed. The pulp yield ranges between 40 to 60%[5,6]. Using 12% Sodium Sulphite with 6% Sodium Carbonate or 3% Sodium hydroxide, under the conditions of 75 minutes cooking period and 170°C cooking temperature, had given a pulp yield of 63% (screened), 11 Permanganate Number and 48% brightness[6].

Bagasse appears to be quite sensitive to acid conditions as a result of its high pentosan content. Therefore acid pulping conditions should be avoided when producing papermaking pulps. High yield pulping of bamboo by modified Sulphite process in alkaline range is being carried out[7]. On the similar lines experiments were conducted using depithed bagasse. The study included the effect of buffer, chemicals, cooking period and cooking temperature on pulp yield, Permanganate Number, pulp brightness, bleachability and strength properties of bleached pulps. Some control kraft cooks were also carried out to compare with the monosulphite pulps.

EXPERIMENTAL

Depithed bagasse was obtained from Mandya National Paper Mills, Belagola, Mysore State. The original moisture content was between 35 to 40%. Before cooking the moisture content was reduced to about 10%.

The cooking liquor was prepared in Laboratory. Sulphurdioxide was passed through a solution of caustic soda of known strength, to a pH of 10. Then after shaking and keeping for some time, the sodium sulphite strength was determined.

TABLE I. CHEMICAL ANALYSIS OF DEPITHED BAGASSE AND BAMBOO

Particulars		Bagasse Indian	Bagasse (**) Hawaiian	Bamboo	Eucalyptus hybrid.
Ash,	%	1.77	0.71	3.10	0.44
Silica,	%	1.40	0.36	1.40	0.03
1% NaOH solubility,	%	30.23	—	28.30	13.4
Pentosans,	%	24.10	27.90	19.27	14.1
Alcohol benzene Extraction,	%	1.90	1.80	4.19	1.48
Lignin*	%	19.37	20.00	24.15	30.9
Holocellulose*	%	73.16	79.60	67.19	65.8
Alpha cellulose*	%	41.94	43.3	46.58	45.1

(*) correeted for ash.
(**) 38-2915 Hawaiian (2)

TABLE II. FIBRE DIMENSIONS OF DEPITHED BAGASSE AND BAMBOO

Particulars		Bagasse Indian	Bagasse** Hawaiian	Bamboo	Eucalyptus hybrid.
Fibre length, mm.	Max	2.90	2.72	4.3	1.04
	Min	0.30	—	0.59	0.39
Arithmatic Average mm.		1.00	0.92	2.02	0.80
Weighted average mm.		—	1.24	—	—
Fibre widh, mm	Max	0.03	—	0.034	0.016
	Min.	0.007	—	0.005	0.006
Arithmatic average		0.015	0.021	0.014	0.015
Length to width ratio, Arithmatic average		66.6	43.8	144.3	65
Weighted average		—	59.0	—	—

The chemical analysis (**Table No. I**) and fibre dimension (**Table No.II**) were carried out. The tests were carried out according to TAPPI standards except holocellulose which was determined by the method of Sengupta, Majumdar and Mac Millan[8].

Green liquor obtained from bamboo kraft mill was used as the buffer calculated on the basis of total titratable alkali empressed as Na_2O.

For all the trials 1 kg. of O.D. depithed bagasse was used.

Experiments were carried out in a rotating digester, electrically heated at a speed of 2 r.p.m. of 16 litres capacity.

Presteaming was carried out by passing steam through the bagasse for 15 minutes at 140°C and 3kg/cm² pressure and then the steam condensate along with the acids formed, were drained. Then the cooking was continued by adding varied quantity of hot sodium sulphite, with varied quantity of buffer for a specified time and temperature (**Table No. 1**). Then the cooked pulps were refined hot at 8% consistancy in one pass at a clearance of 250 microns in Sprout & Waldren disc refiner, washed in hydra extractor, squeezed to a consistancy of about 25% and then the yield was calculated by finding out the exact moisture content. Kraft cook was carried out with 16% chemicals as ($NaOH+Na_2S$), with 15 minutes presteaming and continuing the cooking at 165°C for one hour. After cooking the pulp was refined as mentioned above and the yield was calculated.

For bleaching, pulps were taken from the buffer and chemical variations experiments. (**Table No. IV & V**). Pulps were bleached with a multistage C.E.H. system to a brightness of about 78-80%. The following conditions were maintained during bleaching.

TABLE III PULPING

Particulars	Buffer, %							Sodium Sulphite, %				Cooking period, Mts.					Cooking Temp.°C				Kraft cook.
Cooking conditions																					
Sodium Sulphite, %	15.0	15.0	15.0	15.0	15.0	15.0	15.0	11.0	12.0	13.0	14.0	15.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	16.0
Buffer as Na_2O, %	0.0	1.0	1.0	2.0	3.0	4.0	5.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	Nil
Bath Ratio	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4
Presteaming: Time to 140°C, Minutes	7	Nil	9	10	8	10	7	8	5	6	7	10	7	8	8	7	10	7	8	10	8
Time at 140°C, Min.	15	Nil	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Time to 165°C, Min.	60	112	62	57	60	69	60	60	60	60	60	57	60	60	60	60	60	60	60	60	60
Time at 165°C, Min.	120	90	120	120	120	120	120	120	120	120	120	120	30	60	90	120	60	60	60	60	60
pH of spent liquor	6.0	6.7	7.0	8.5	8.8	9.1	9.3	6.0	7.8	8.6	8.5	8.5	8.0	8.6	8.4	8.5	8.1	8.3	8.6	8.4	—
Sodium Sulphite consumed, %	12.7	14.2	13.3	13.9	14.2	14.5	14.4	10.4	11.6	12.7	13.6	13.9	11.2	12.8	13.5	13.6	9.7	12.5	12.8	13.4	—
Refined yield, %	66.2	64.4	65.6	62.1	61.4	60.9	60.5	66.9	64.8	63.6	64.4	62.1	64.8	64.6	64.2	64.4	67.2	64.7	64.6	60.5	53.3
Permanganate Number	27.6	22.5	16.4	11.8	10.9	10.9	8.3	33.2	22.6	16.9	11.7	11.8	16.2	15.4	15.4	11,7	28.5	25.9	15.4	17.4	13.6
Brightness, %	39.0	32.0	47.0	48.0	47.0	44.0	45.0	28.0	37.0	43.5	46.0	48.0	43.0	42.0	42.0	46.0	35.0	40.0	42.0	43.0	29.0

*NaOH+Na2S

TABLE IV BLEACH CHARACTERISTICS & STRENGTH PROPERTIES CHEMICALS 15% and BUFFER VARIABLES 0-5%

Buffer as Na_2CO_3, %		0.0			1.0			2,0			3.0			4.0			5.0	
Sodium Sulphite %		15.0			15.0			15.0			15.0			15.0			15.0	
Permanganate Number,		27.6			16.4			11.8			10.9			10.9			8.3	
Brightness of unbleached, pulp %		39.0			47.5			48.0			47.0			44.0			45.5	
Bleach consumption,		11.28			7.85			5.31			5.30			4.9			4.5	
Bleached pulp yield, %		58.0			60.3			57.5			57.7			57.7			57.8	
Bleached pulp losses on unbleached pulp, %		12.5			8.1			6.97			6.07			4.89			4.18	
Brightness %		76.0			79.5			80.0			79.5			79:0			80.5	
Viscosity, cp (C. E. D.)		11.5			11.6			15.8			12.0			12.6			12.0	
Final freeness, °SR	30	40	50	30	40	50	30	40	50	30	40	50	30	40	50	30	40	50
																	Unbleached pulp.	
Basis wt, g/m²	59.3	62.0	62.0	64.9	60.5	62.5	62.3	62.8	62.5	61.8	59.5	59.2	62.5	61.2	61.7	61.9	61:2	58.7
Bulk, cc/gm	1.80	1.70	1.71	1.91	1.77	1.68	1 85	1.69	1.74	1.95	1.83	1.71	2.1	2.07	1.88	2.43	2.14	2.14
Breaking length Km	5.23	5.20	5.58	4.07	4.72	4.82	4.60	5.75	5.44	4,69	5.26	5.22	3.46	4.69	5.10	3.70	5.18	4.97
Stretch %	3.2	3.2	3.5	2.75	2.85	3:8	2.8	3.6	3.2	2 9	3.1	3.0	2.3	3.3	3 4	3.0	3.9	3.8
Tear factor	49.7	46.8	46.0	40.0	32.0	36.0	52.2	46.1	45.3	49.1	40.3	40.0	57.5	60.0	58.3	55.7	49.8	50.2
Burst factor	29.3	33.0	33.5	27.5	29.2	32 3	29.1	35.2	36.3	26.4	31:43	2.6	24.0	28.3	31.1	22.1	29.1	26.9
Folding endurance, Double folds,	6	7	9	17	19	21	6	11	10	3	3	4	7	6	7	2	2	3

Chlorination :— Consistancy — 4.0% ; temperature 27°-30°C ; Retention time— 1 hour ; chlorine added—70% of the total chlorine demand.

Alkali extraction :— Pulp washed after chlorination stage was used.

Consistancy— 5.0% ; temperature—50°C ; Alkali—2.0%, pH —9.5 to 10 and retention time—1 hour.

Hypochlorite :— Pulp washed after alkali extraction was used. Consistancy—5 0% ; temperature —40°C ; Hypo—30% of the total chlorine demand ; pH—8.5 —9.0 and retention time—½ hour to 1½ hour to a brightness of 78—80%.

Strength properties :— Standard sheets were prepared on Noble and Wood sheet making machine after beating in Hollander beater at a cy. of 1.55 to 1.57% to three freeness levels of 30, 40, 50°SR and after conditioning the sheets were tested according to TAPPI standard **(Table No. IV & V).**

TABLE V BLEACH CHARACTERISTICS & STRENGTH PROPERTIES—CHEMICAL VARIABLES 11-15% BUFFER 2%

Sodium Sulphite %		11.0			12.0			13.0			14.0			15.0			Kraft cook 16.0 (NaOH+Na2S	
Buffer as Na_2Co_3 %		2.0			2.0			2.0			2.0			2.0			Nil	
Permanganate No.		33.2			22.6			16.9			11.7			11.8			13.6	
Brightness of unbld. pulp%		28.0			37.0			43.5			46.0			48.0			29.0	
Bleached consumption %		15.85			9.8			7.6			5.5			5.31			6.5	
Bleached pulp yield %		55 0			55.6			56.5			58.1			57.5			47.5	
Bleached pulp losses on unbleached pulp %		17.5			14.2			11.0			9.0			7.0			10.8	
Brightness %		76.5			81.5			82.5			81.0			80.0			78.0	
Viscosity cp CED		10.5			12.4			16.2			15.8			15.8			12.0	
Final freeness °SR	30	40	50	30	40	50	30	40	50	30	40	50	30	40	50	30	40	50
Basis wt.g/m^e	60.1	61.0	60.0	62.4	59.5	59.3	62.0	60.1	59.6	56.1	61.5	61.5	62.3	62.8	62.5	61.3	60.6	61.0
Bulk cc/gm	1.88	1.90	1.78	2.16	1.81	1.97	1.83	1.80	1.77	2.01	1.78	1.87	1.85	1.69	1.74	2.05	1.95	1.85
Breaking length	4.67	4.58	5.27	4.35	5.32	5.44	5.65	5.73	5.78	4.87	5.69	5.78	4.60	5.75	5.43	4.62	4.76	5.00
Stretch %	2.7	2.6	2.7	2.5	2.5	2.5	3.1	2.5	2.5	2.5	2.9	2.7	2.8	3.6	3.2	2.2	2.4	2.9
Tear factor	44.6	43.9	42.0	50.5	47.0	47.2	54.8	49.9	47.0	53.5	45.7	48.8	52.2	46.1	45.3	42.3	46.1	39.3
Burst factor	29.4	27.1	29.1	24.7	32.1	31.5	33.0	33.1	36.8	32.6	38.7	35.6	29.1	35.2	36.3	30.1	31.3	29.7
Folding endurance, Double fold	3	3	2	2	3	3	5	4	5	5	7	5	6	11	10	2	2	3

DISCUSSION

I. Chemical analysis and fibre dimensions of depithed bagasse. **(Table No. I & II)** Holocellulose, pentosans are quite higher then that of bamboo and ucalyptus. Holocellulose is higher by 6 to 7% than bamboo. Pentosans are 5% higher than that of bamboo and eucalyptus. But lignin is less by 5% than bamboo and 11% less than eucalyptus. Fibre dimensions of bagasse show that it is equal or rather slightly more than that of hard woods, and the length to width ratio is slightly higher than eucalyptus. Naturally, it can be used for making quality papers with suitable processes. Pulps obtained without presteaming were darker and clean. But the presteamed bagasse gave pulps of better yield & better brightness.

II. Effect of buffer. The results are given in **Table No. III, Fig. No. 1.**

i) As the buffer increases from 0-2%, percentage refined yield is decreased from 66% to 62%, i.e. a fall of 4%. But percent yield was decreasedonly by about 1.6% for a change of buffer from 3 to 5%.

ii) Permanaganate Number falls sharply from 28 to 12 as the buffer increases from 0-2% whereas an increase from 2 to 5% buffer, Permanganate Number is decreased from 12 to 8 i.e. a fall of only 4 numbers.

iii) As the buffer is increased from 0 to 2%, pH of the spent liquor rises sharply from 6 to 8.5, but pH is increased only slightly i.e. from 8.5 to 9.3 when the buffer is increased from 3 to 5%.

iv) Chemical consumption is increased from 84 to 92% of the chemical added, when buffer changes from 0 to 2% i.e. 8% more Chemical is consumed. But from 3 to 5% buffer change, the chemical consumption is increased by about 4% from 92 to 96%.

v) Brightness of unbleached pulps seems rather unaffected by the change in the buffer additions.

III Effect of chemicals. The results are given in **Table No. I and Fig. No. 2.**

i) As the sodium sulphite is increased from 11 to 15%, pulp yield has dropped from 66.9% i.e. a drop of 4.8%.

(ii) Permanganate number falls sharply from 33.2 to 22.6 when the chemical is changed from 11 to 12%, but then onwards the fall is gradual. There is no difference virtually in Permanganate Number when chemical content is changed from 14 to 15%. i.e. major delignification takes place between 12. to 14% of chemicals. It also indicates that the concentration of the chemicals during cooking plays a role in the delignification. At a concentration of 28 gpl, Permanganate Number is high but at a concentration of 35 gpl Permanganate Number is low. i.e. higher concentration of liquor during cooking is essential.

(iii) As the chemical is changed from 11 to 12%, pH of spent liquor rises sharply from 6 to 8, but then it becomes almost constant from 13 to 15%, at 8.5-8.6.

(iv) As the chemical content is increased from 11 to 13%. the chemical consumption is increased from 94 to 97% of the total added, and then it drops fom there to 92%, when 15r% chemical is added. This also indicates that major delignification takes place between 13 to 14% chemicals added, and excess chemical added beyond this could not be utilized under the conditions of cooking used here.

(v) There is a distinct change in the brightness of unbleached pulps when percentage of chemicals added changes from 11 to 15%. Brightness increases from 28% at 11% chemicals to 48% at 15% chemicals.

IV Effect of cooking Period. The results are given in **Table No. I and Fig. No. 3**

(i) There is no appreciable change in yield when the cooking period is varied from 30 minutes to 120 minutes.

(ii) Permanganate Number though changes, the fall is not sharp and the difference is not appreciable at different times. Only at 30 minutes Permanganate Number is high (16.2) compared to other Permanganate Number at 60,90 and 120 minutes.

(iii) pH of the spent liquor does not change appreciably as cooking period is increased.

(iv) Chemical consumption makes an appreciable change at different periods of cooking. At 30 minutes it is only 80% of the total added and 97% at 120 minutes. At 60 minutes it is 93% and at 90 minutes it is 96%. It shows that major part of the chemicals added will be utilised between 60 and 90 minutes.

V Effect of cooking temperature. The results are given in **Table No. I and Fig. No. 4.**

Pulp obtained at 120°C was not cooked properly. It was shivy and coarse. At higher temperature yield falls to the minimum (60.5%). Though the yield at 142°C is maximum (67.2%), Permanganate Number also soars up to 28.5. At lower temperature brightness is low. pH of the spent liquor is not affected much by cooking temperature. Kraft cook of depithed bagasse has given a yield of 53.3%, 13.6 Permanganate Number and 29% brightness. These results are quite low compared to the best sulphite cook with 14% chemicals 2% buffer at a temperature of 165°C with total cooking period of 3 hours.

BLEACHING

VI. Effect of buffer. The results are given in **Table No. IV & Fig. No. 5.**

i) Bleached yield does not vary when the buffer is increased from 0-5%.

ii) Bleach losses and bleach consumption fall down rapidly when buffer is changed from Nil to 1-2% and then bleach losses and consumption decrease gradually but not appreciably. This indicates that buffer is essential in cooking bagasse which will give pulps with lower bleach requirements and with lower bleach losses.

VII. Effect of chemicals. The results are given in **Table No. V and Fig. No. 6.**

i) Bleached pulp yield is increased slightly in case of pulps cooked with chemicals varied between 11 to 14%. Then yield becomes constant with the pulp cooked using 15% chemicals.

ii) Bleach losses and Bleach consumption also are decreased from the pulps cooked with chemicals ranging between 11 and 15% for obvious reasons.

It appears that pulps cooked with 14% chemicals with 2% buffer are suitable for bleaching. Black specks were observed in bleached pulps which were found to be carbon particles and also other particles which obviously have come along with bagasse.

Kraft pulps of depithed bagasse was also bleached. It was not easily bleachable as that of monosulphite pulp, although the bleach comsumption and bleach losses are almost equal to that of monosulphite pulps.

STRENGTH PROPERTIES OF BLEACHED PULPS

The depithed bagasse bleached pulps can be beaten very easily. The beating period ranges between 3 to 5 minutes for. 40°SR which is about 1/7th of the beating period of bamboo pulps. This is due to the high pentosan contant and shorter fibres.

VIII. Effect of Buffer. The results are given in **Table No. V** and **Fig. No. 7**

i) Bulk shows little change when the buffer was varied between 0-5%. It varies between 1.75-2.0.

ii) Breaking length rises slightly with buffer addition from 0-2% and falls down between 2 to 5%. i.e. maximum breaking length is obtained with the bleached pulps, cooked using 2% buffer.

iii) Stretch rises slightly from 3 to 3.5% with the buffer variation between 0-2% and falls afterwards to 2.4% when the buffer is 5%. The tear factor falls from 0-1% buffer variation and then increases up to 5% buffer. Burst factor increases gradually from 32 to 35 between 0-2% buffer variation but falls rather steeply between 2-5% buffer variation to 26.5.

IX. Effect of chemicals. The results are given in **Table No. V** and **Fig. No. 8**.

i) Bulk remained almost constant when chemical 11 to 15% are used for digestion. Breaking length rises slightly up to 13% chemicals from then remains constant up to 15% chemicals. Strength remains constant up to 13% chemicals but then increases rather steeply up to 15% chemicals. Tear factor is increased slightly from 11 to 15% chemicals and shows a gradual decrease towards 15% chemicals. Burst factor shows upward trend from 11 to 15% chemicals. It ranges between 26 to 34. Strength properties of monosulphite bleached pulps are higher than that of kraft bleached pulps. The results show poor values of strength properties then those reported elsewhere. Obviously the bagasse used was having damaged fibres. Bagasse having least damaged fibres would give better properties then other pulp.

CONCLUSIONS

Holocellulose and pentosans of depithed bagasse are higher than that of bamboos and eucalyptus. Lignin in bagasse is 5% less than that of bamboo and 11% less than that of eucalyptus. Fibre dimensions are equal to hardwoods. For producing high yield, easily bleachable and high brightness pulps, presteaming followed by monosulphite cooking should be practiced. The optimum conditions work out to be presteaming at 140°C, & 3kg/cm² pressure for 15 minutes followed by cooking with material to liquor ratio 1 :4, temperature 165°C and time 90 to 120 minutes.

The modified monosulpoite process is an improved pulping method over kraft as much higher yields with superior strength characteristics could be realized.

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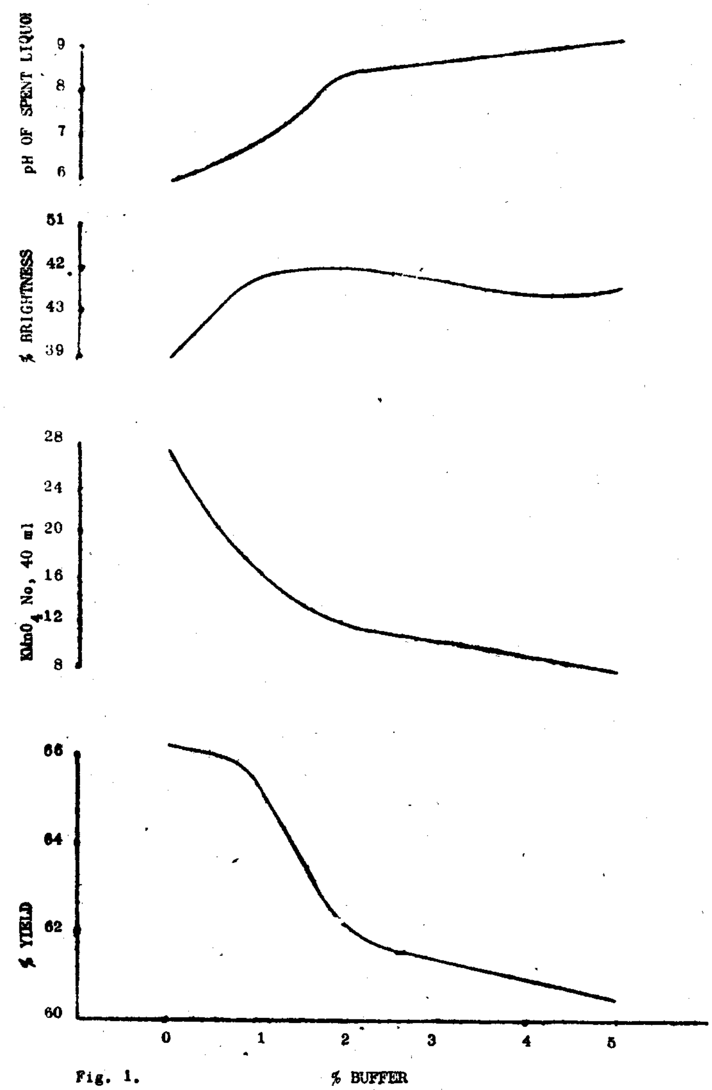

Fig. 1.

Cooking conditions : 15% chemicals; cooking period : (1+2) hours; Temperature 165°C
Material to liquer ratio : 1:4.

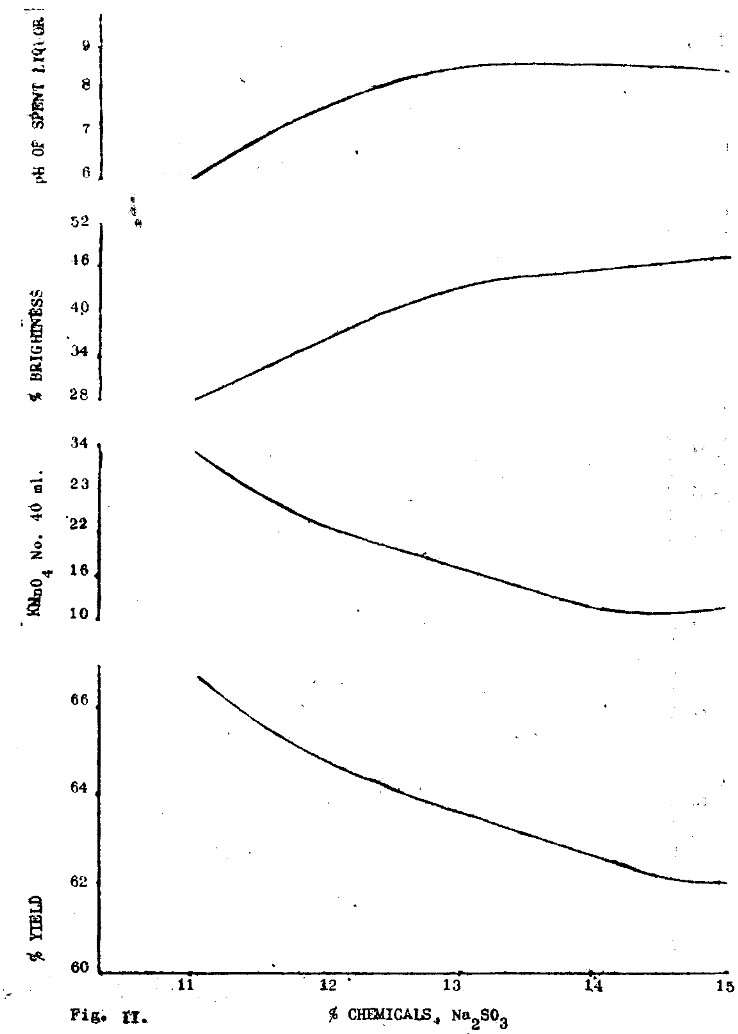

Fig. II.

Cooking conditions: Buffer 2%; Cooking period (1+2) hours; Temperature - 165°C.

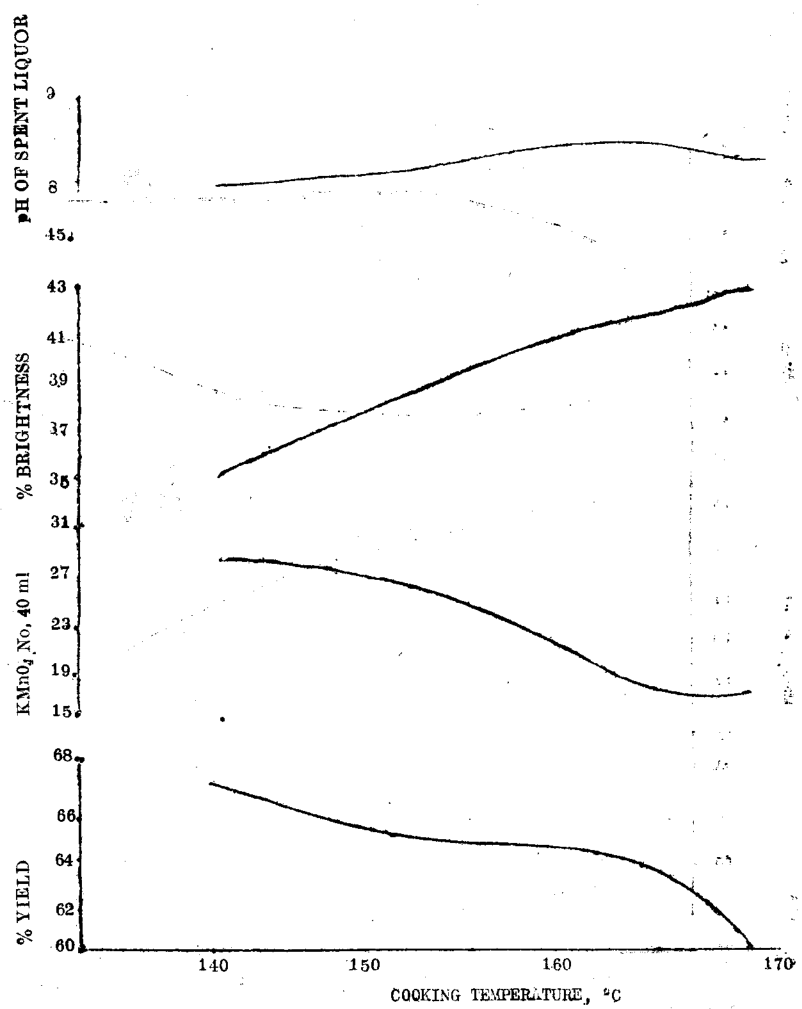

Fig. III. Cooking conditions: Chemicals: 14% ; Buffer: 2%

Cooking period : (1 + 1) hour.

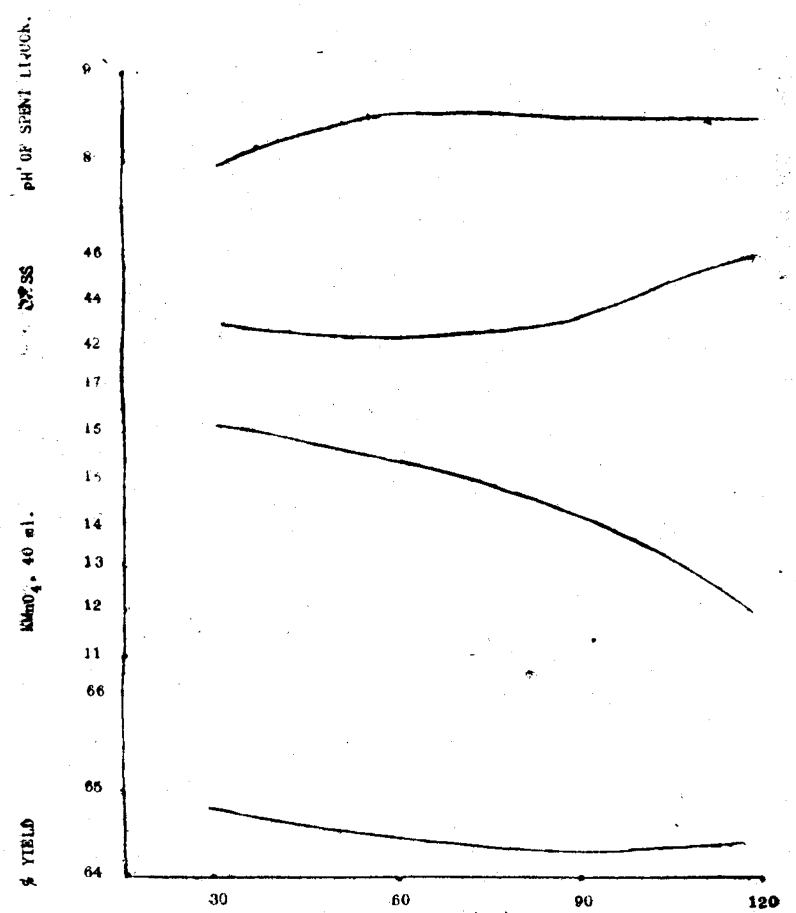

Fig. IV.

Cooking conditions: Chemicals: 14%; Buffer 2 %;
Cooking temperature 165°C.

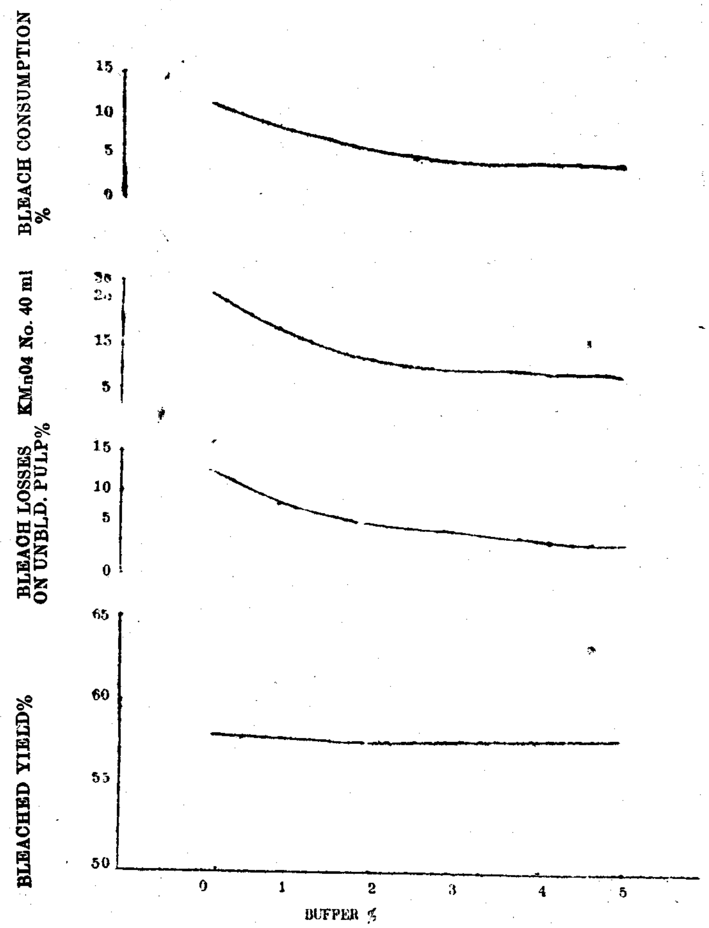

Fig. No. V.

Cooking condition: Chemicals 16%; Cooking period (1+2)hours
Temperature : 156°C.

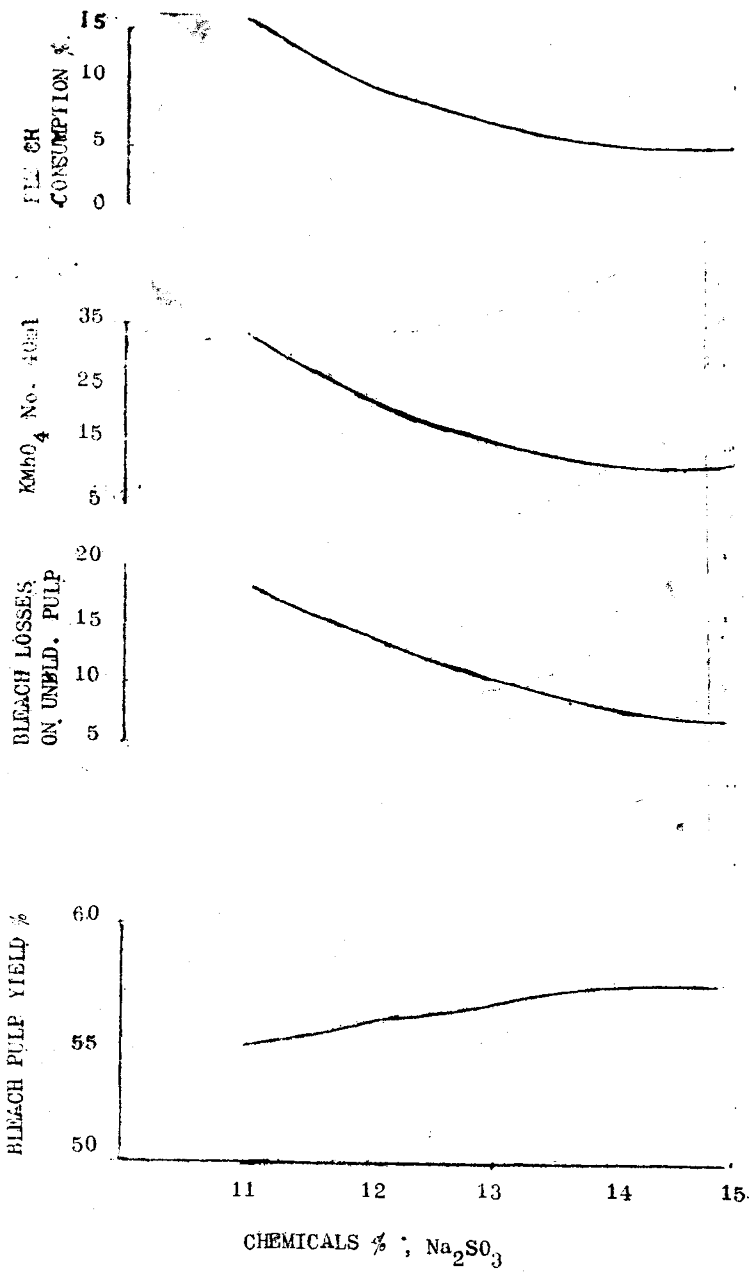

FIG. NO. VI.

Cooking conditions: Buffer 2%; Cooking period (1+2) hours; Temperature: 165°C.

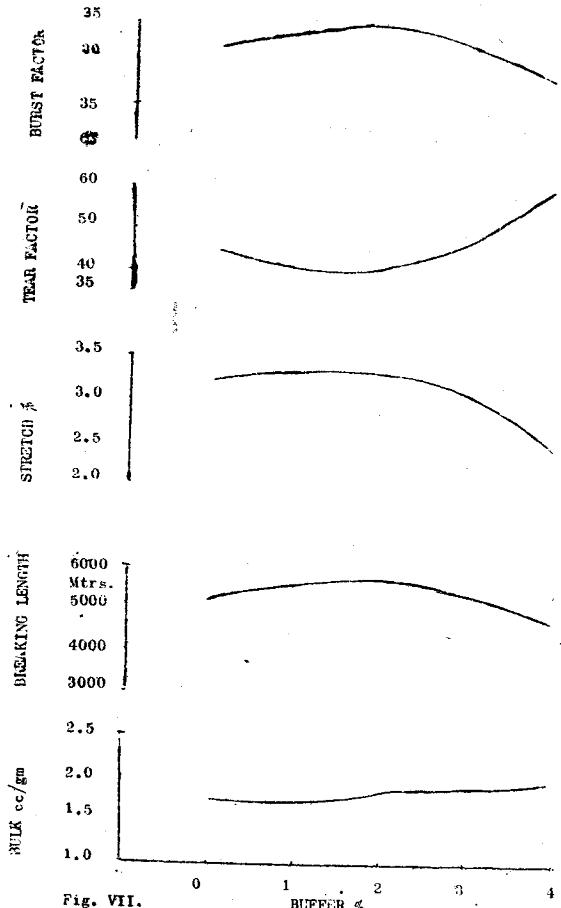

Fig. VII.

Cooking conditions: Chemicals: 15%; Cooking period: (1+2)hr

Temperature: 165°C.

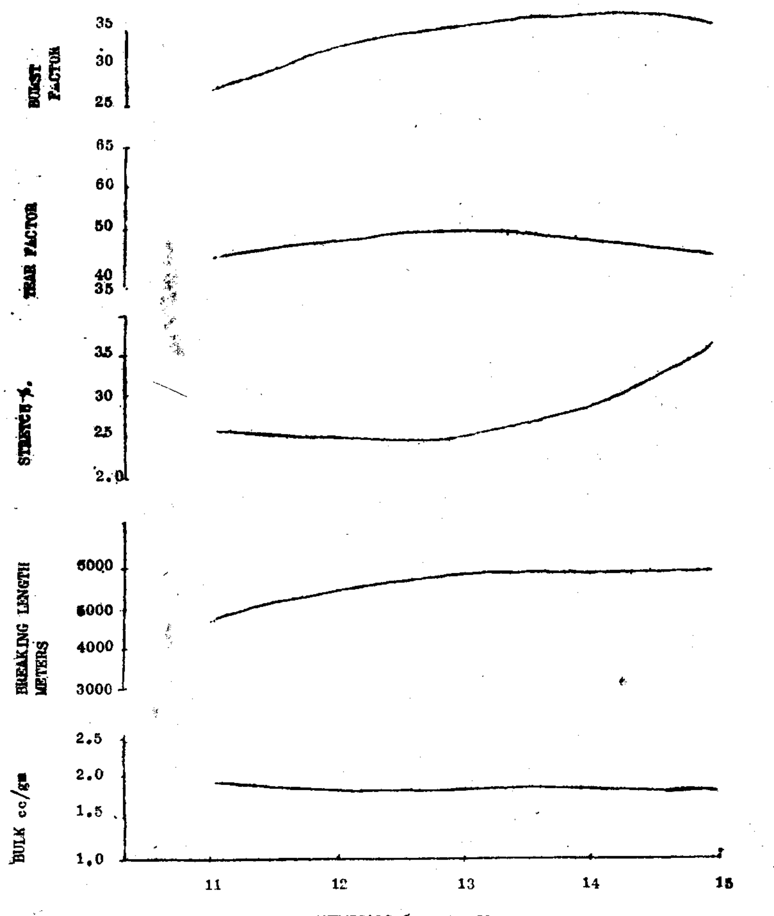

Fig. VIII Cooking conditions: Buffer 2%; Cooking period (1+2) hours
Temperature : 165°C.

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