Application Natural and Modified Guar and Cassia Tora Seed Gum as Wet End Additive vis-a-vis Flocculant

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ABSTRACT

Various types of chemicals are used as wet end additives in the manufacture of paper and board world-wide. Among these, gums and mucilage obtained from guar(Cyamopsis tetragonolobus) and locust bean are commonly used. A general effect of gum addition is to achieve higher strength and reduce energy during beating. Natural and modified gums from Cassia tora seeds were evaluated inlaboratory on two pulps - (I) pulp consisting of bleached eucalyptus, bamboo and pine pulps and (II) consisting of bleached bagasse and softwood pulps. Laboratory studies have indicated that optimum dosage of gum was 0.5% on oven dry pulp basis to achieve optimum strength properties. Natural and modified gums increased the breaking length by 23% to 29% and double fold by 13% to 146% of both the pulps. Reasonably high folding strength 60% to 146% could be obtained by addition of modified Cassia tora seed gum in case of both the pulps. Cassia tora seed gum was found to be effective in improving the dry strength properties of paper. Tearing strength was not affected by the addition of thse gums.

Cassia tora gum modified with liquor ammonia was used as flocculant in paper machine back water and in sugar factories and its performance was compared with True floc and Deftech-706.

INRODUCTION:

Various gums and mucilage have been used as wet end additives in the manufacture of paper and paper board from many years. The most commonly gums and mucilage are locust bean gum, gaur gum, deacetylated karaya gum, Lycoid, latex, pectin, gelatin, etc. Among these gums and mucilage obtained from guar and locust beans are most widely used. During the past several years, numerous cultivated crops and forestry species have been investigated for thier galactomannan content to give a boost to many Indian Industry. These galactomannan are useful for many industrial purposes such as sizing, thickening and as stabilizing agent. Galactomannans from various sources having similar chemical structures with $\beta-1\rightarrow 4$ D-manose backbone are substituted to varying degree at the 6 position by single linked D- galactose residues, the extent of galactose substitution being a function of these source species.

Cassia tora Linn is a common herbaceous annual occuring as weed throughout India. The pods are

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15-22.5cm long and upt to 0.625 cm in diameter containing flattened dark seeds. The weight of 100 seeds is 2.40 gm. The seed contains a glycosidic and pleasant smelling fatty oil (5%). The seed is composed of hull (27%) endosperm (32%) and germ (41%). Endosperm consists of D-galactose, D-mannose, D-glucose and D-xylose in the ratio 2:7:2:1. Methylation studies showed that backbone of the polysaccharide consists of 1-4 linked D-mannopyranose and D-glucopyranose units. Galactomannan from endosperm of theCassia tora seed can find application on paper as dry strength improvement agent like guar gum.

Guar gum is derived from the seed of guar plant (Cyamopsis tetragonolobus) of the family Leguminosae. It is indigenously available in plenty. The guar seed is composed of endosperm (35-42%), germ (43-47%) and seed hull (14-17%). The effectiveness and desirable ingredients of the guar bean is the endosperm which is separated from the hull and germ. The flour of endosperm is a polymer galactomannan which on addition to pulp is responsible for strength development in paper. Guar gum has been found to be effective in improving the dry strength and folding endurance by the addition of small amounts of guar gum to pulp furnish. The molecular weight of these gums are in the order of $2x10^5$-$3x10^5$ Daltans. Commercially available guar has approximately a galactose mannose (G:M) ratio of 2, whereas locust bean gum from Certonia siliqua has approximately G:M ratio of about 3:5.

As celluose fibres are anionic in nature, by introducing cationic groups in gums attraction between the cellulose and gum could be increased resulting in retention and strength properties. Such modified gums contains cationic groups on the side chain of natural gum.

C. tora gum from the seeds were isolated as per the method described by Soni (1994) Modification of the C. tora and guar gums was carried out by subjectng endosperm to ammonia vapor in the closed vessel. Nitrogen content increased in Cassia tora (1.08%) and in guar gum (5.13%) was made flour (100 mesh) by mill cent flour mill (Soni1999) Effect of these gums on strength properties of paper was studied and compared with that of natural gums.

EXPERIMENTAL

Materials: Following pulps were used in laboratory for the study

(i) Bleached mill pulp consisting of Eucalyptus (80%) + Bamboo (12%) + pine pulp (8%)

(ii) Bagasse (80%) + Softwood bleached pulp (20%)

Beating/Refining of above Pulps (Method ISO 5364)

(i) Mill pulp was beaten to freeness level of 365 ml (CSF in PFI ml)

(ii) Softwood pulp was beaten in PFI mill to a freeness level of 405 ml CSF and

(iii) Bagasse pulp was used as such without beating, freeness (CSF) 430 ml

Unbeaten bagasse and softwood beaten pulp were blended in the proportion 80-20 prior to gum addition.

STOCK PREPARATION OF GUM SOLUTIONS

Cooking of natural and modified gums to be used in the stock preparation was as follows: 1% solution of guar was prepared by taking required quantity of gum in water and heatedto 60-70°C with continuous stirring for one hour.

TYPE OF THE PULPS EMPLOYED

Following pulps were used for this study.

1. bleached mill pulp consisting of approximately 80 percent eucalypt +12 percent bamboo +8 percent pine pulp having pulp brightness 74 percent.

2. Bagasse (80%) + softwood bleached pulpt (20%) having pulp brightness 81%

BEATING/RIFINING OF PULPS - METHOD ISO 5364

1. Mill pulp was beaten to a freeness level of 365 ml CSF in PFI mill.

2. Soft wood pulp was beaten in PFI mill to a freeness level of 405 ml CSF and

3. Bagasse pulp was used as such without beating, freeness (CSF) 430 ml.

Unbeaten bagasse and soft wood beaten pulp wee blended in the proportion 80:20 prior to gum addition.

ADDITION OF GUMS

20 gm OD pulps were diluted to 4% consistency and the pH of the pulp slurry was brought down to 4:8 using dilute sulfuric acid. After uniform mixing of pulp suspension gum solutions were added to it in varying quantities ranging from 0.25 to 0.75% on OD basis. One control sample was also made for comparison.

HANDSHEETS PREPARATION

The pulp after addition of gum was diluted to 0.3% consistency using water, adjuted to pH value 4.5 and freeness was measured using Canadian Standard Freeness Tester as per ISO, DP, 5269 method. The stock was further diluted to 0.12% consistency and hand sheets were made on a British sheet making machine as per ISO 5364 method, pressed and air dried.

TESTING OF PAPER HANDSHEETS

Hand sheets were tested after conditioning at 63+5% relative humidity and 27+1°C temperature as per the following standard methods.

Grammage	:	ISO 636
App. Density	:	ISO 534
Bursting strength	:	ISO 2758
Breaking length	:	ISO 1924
Double fold	:	ISO DIS 5626
Tearing strength	:	ISO 1974

RESULTS AND DISCUSSION

ZETA POTENTIAL

The zeta potential of Cassia tora gum was measured using lazer Zee Meter Model 501, Pen Ken Inc., USA. Pulp fibres, fillers and size particles carry negative charge, however, the zeta potential can be controlled for better formation of the sheet by the addition of cationic additive. Zeta potential of modified C. tora gum with respect to increase in nitrogen content is given in Table-1.

TABLE-1

Zeta potetial of modified Cassia tora gum (CTGM) at 0.25% concentration

Type of Gum	Nitrogen %	Zeta Potential (mu)
CTGN	0.76	- 16.4
CTGM - 1	0.91	- 20.7
CTGM - 5	1.02	-
CTGM - 10	1.06	- 21.26
CTGM - 15	1.07	- 22.5
CTGM - 20	1.08	- 28.61

TABLE-2

Effect of the concentration on the gel strength of C. tora gum

Gum concentration %	Gel strength (g/cm3)
2.5	56.3
3.0	234
3.5	431.5

RHEOLOGY

Viscosity of the Citora gum increased with the concentration of gum. It showed very low viscosity at lower concentration in comparison to the gums from other Cassia species (Tookey et al, 1963 and Khan et al, 1988). However rapid increase in the viscosity occurred in the high concentration and forms weak to moderately strong gel (Table II). Self geling property of tora gum may be due to its unique structure having a backbone of cellulose (17.6%) and mannan (82.4%) α–D-Xylopyranose and α–D-Galactopyranose units

TABLE-3

Effect of natural and modified Guar gum (GG) and Cassia tora (CTG) gums on strength properties of paper

Dosage of gum (%)	Particular of gum	Freeness CSF, ml	Apparent Density g/cm³	Burst factor	Bpreaking length km	Double fold Nos	Tear factor
Nil	Control	365	0.74	38	6340	46	61
0.25	GGN	315	0.74	44	6410	61	63
	GGM	305	0.74	49	6670	82	58
	CTGN	330	0.74	44	6580	49	62
	CTGM	310	0.74	48	6930	52	62
0.50	GGN	285	0.74	45	7850	139	60
	GGM	285	0.74	50	8160	106	57
	CTGN	325	0.74	47	7750	74	62
	CTGM	310	0.74	48	7850	75	61
0.75	GGN	280	0.74	45	6730	64	60
	GGM	285	0.74	50	6550	88	57
	CTGN	325	0.74	48	7240	71	62
	CTGM	265	0.74	51	7240	71	61

furnish composition : Eucalyptus bleached kraft pulp 80%, Bamboo bleached kraft pulp 12% and Pine bleached kraft pulp 8%.

are linked as side chain at 6 position of D-glucose and D- mannose of the backbone respectively. Thus tora gum structure is partly akin to both tamarind gum and locust bean gum.

EFFECT OF GUMS ON STRENGTH AND DRAINAGE PROPERTIES OF PAPER MADE FROM MILL PULP

The results presented in Table 3 indicated that freeness of pulps decreased by about 50-85 ml CSF by addition of natural and modified guar gums whereas less freeness drop was observed in the case of natural and modified Cassia tora gums.

Both guar and Cassia tora natural gum at 0.25%addition have shown more or less identical behavior (fig 1, table 3). Similarly modified gtums from guar and C tora also behaved in the same manner except for folding strength, which was increased to a greated degree i.e. by 78% for modified guar gum. Burst factor increased by 26%for both guar and C tora modified gum.

At 0.5% addition level modified guar gum gave better results, i.e., burst factor increased by 31% and breaking length by 28% and folding strength (fig 2, table 3). The remaining three gum have also shown increase in strength properties i.e. burst increased by 18-24% and breaking length increased by 24%. Natural guar gum substantially improved folding strenth i.e., 202% when compared to C tora gum whose values registered 63% increase. Tearing strenth remained constant for these gums.

Increasing the dosage of gums to 0.75% (fig 3, table 3) have shown negative influence on strength properties.

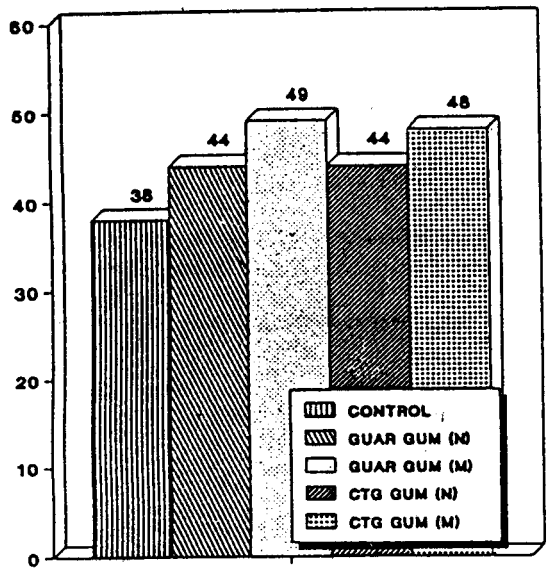

Fig. 1a. Burst Factor

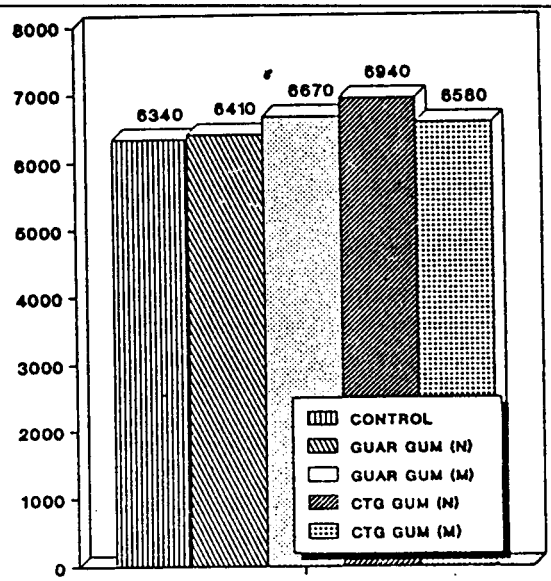

Fig. 1b. Breaking length, m

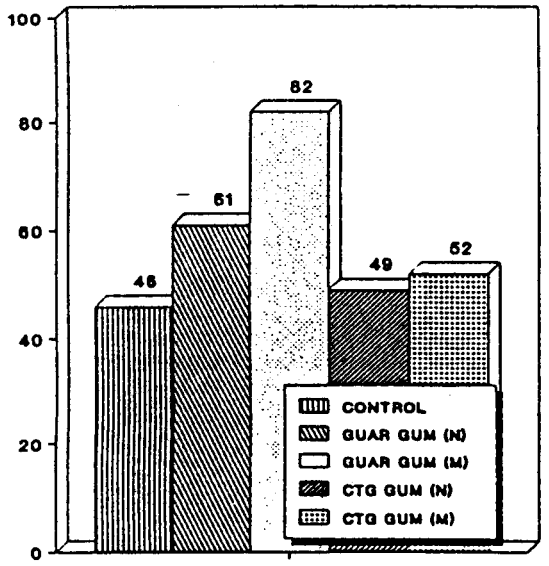

Fig. 1c Double fold, No's

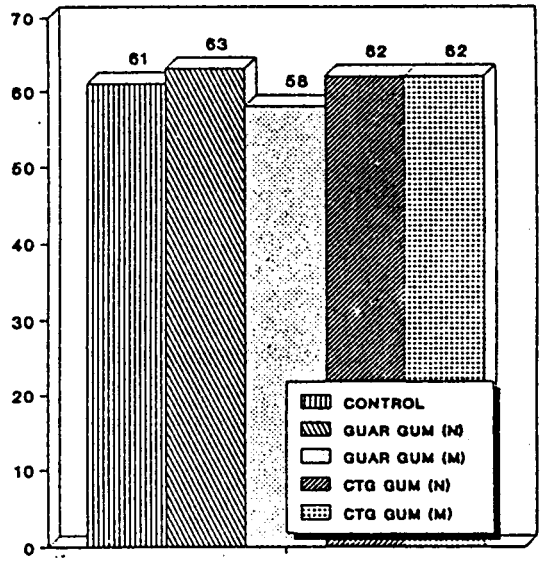

Fig. 1d Tear factor

FIG. 1 EFFECT OF VARIOUS GUMS ON STRENGTH PROPERTIES OF MILL PULP AT 0.25% ADDITION LEVEL

EFFECT OF GUM ON STRENGTH PROPERTIES OF PAPER MADE FROM 80 PERCENT BAGASSEAND 20% SOFTWOOD BLEEACHED PULPS

Results given in Table 4 indicate steep drop in Candian freeness value for pulps treated with natural and modified guar gum (4047%) and modified C. tora gum (34-37%) whereas only a marginal drop (13%) in freeness value for pulp treated with natural C. tora gum. The apparent density increased by 9-11% for natural and modified guar gums and by 7% for natural and modified C. tora gums. Decrease in freeness value followed by increase in apparent density could be due to retention of more fines by the addition of gums as bagasse pulp contains more fines when compared to wood, bamboo, and rag pulps.

Effect of addition of gum on strength properties at 0.25% addition level (fig. 4 Table 4) showed that natural guar and C. tora produced no appreciable rise in bursting strength, whereas 17% rise in bursting

strength could be obtained by the addition of modified guar and C. tora gums. Only marginal increase in breaking length could be observed whereas steep inrease in folding strength (35 to 37%) could be obtained by addition of these gums. Tearing strength remained more or less constant for these gums.

Increasing the dosage of gum to 0.5% could not produce any rise in bursting strength properties (fig5, Table 4). Breaking length w as increased by 20% for natural guar gum, 30% for modified guar gum, 26% for natural C. tora gum and 29% for modified C. tora gum.

Folding strength was increased quite drastically by addition of these gums. Natural guar and C. tora gums registered an increase on 98% and 84% respectively whereas an increase of 128% and 146% was obtained for modified guar and C. Tora gums. Tear strength remained more or less constant

Increasing the dosage of gum to 0.75% could not produce any further increase in strength properties.

TORA GUM FLOCCULANT

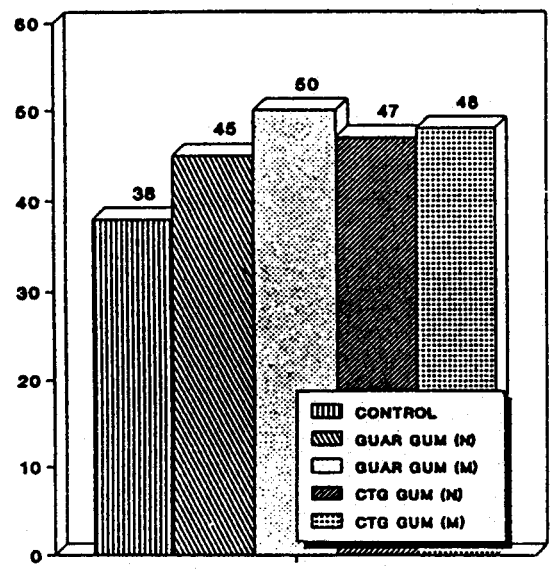

Fig. 2a. Burst Factor

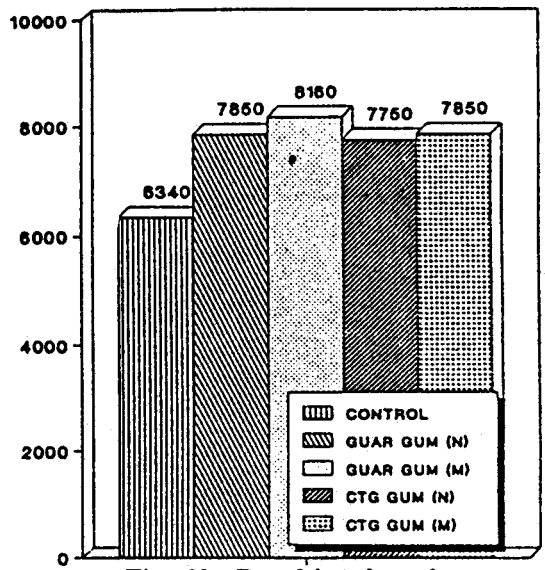

Fig. 2b. Breaking length, m

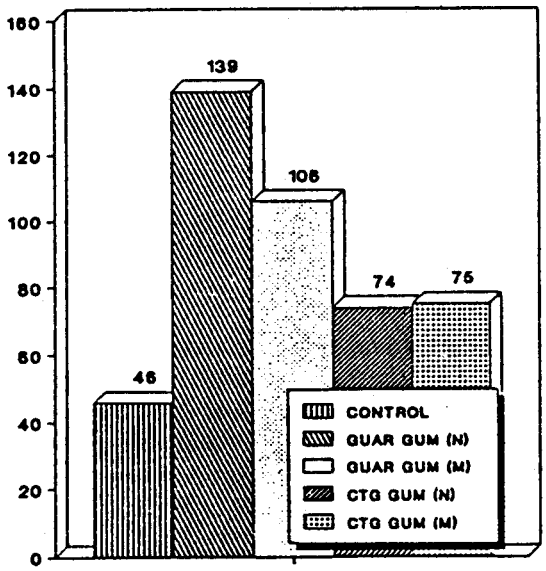

Fig. 2c Double fold, No's

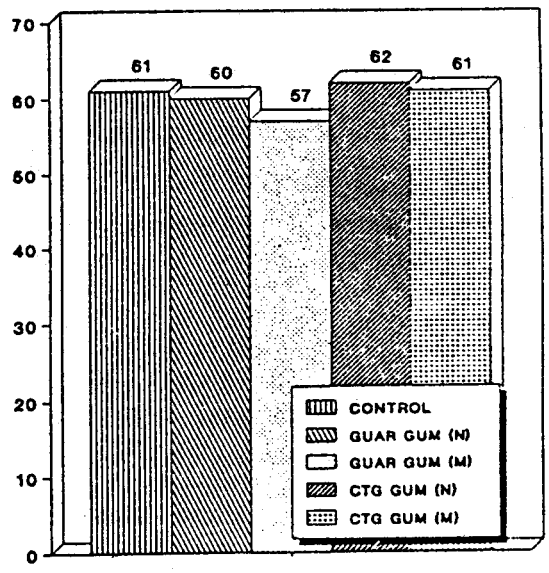

Fig. 2d Tear factor

FIG. 2 EFFECT OF VARIOUS GUMS ON STRENGTH PROPERTIES OF MILL PULP AT 0.50% ADDITION LEVEL

TABLE-4

Effect of natural and modified Cassia tora (CTG) and Guar gum (GG) gums on strength properties of paper

Dosage of gum (%)	Particular of gum	Freeness CSF, ml	Apparent Density g/cm³	Burst factor	Bpreaking length km	Double fold Nos	Tear factor
Nil	Control	405	0.76	34	5000	64	65
0.25	GGN	265	0.84	36	5800	101	67
	GGM	260	0.84	40	5800	87	59
	CTGN	360	0.81	44	5300	90	69
	CTGM	270	0.81	39	5610	99	64
0.50	GGN	235	0.84	36	6010	127	67
	GGM	260	0.83	40	6530	146	61
	CTGN	360	0.81	36	6320	118	64
	CTGM	265	0.81	39	6430	160	64
0.75	GGN	215	0.85	38	5830	95	65
	GGM	240	0.83	41	5800	137	60
	CTGN	345	0.81	35	5300	118	70
	CTGM	255	0.81	40	5710	153	63

Furnish composition : Bagasse bleached soda pulp 80% and softwood bleached kraft pulp 20%

TABLE-5

Back water (p H 5.5, suspended solid 3936 mg/l) treatment with flocculants

Flocculants	Back water initial volume (ml)	Dosage (mg/l)	Flocs settling time to 150 ml level (min)	Suspended solid (mg/l)	Settling %
True floc	500	4	1.30	50	98.7
Deftech-706	500	4	2.10	50	98.7
	500	6	1.50	25	99.36
CTM	500	4	3.30	13	99.6
	500	6	2.40	225	94.3
	500	8	3.05	275	93.0

In paper sheet formation, a suspension of solid particles of varied size. shape, and composition is caused to flow onto a forming screen. In addition to the more or less whole fibers present in the stock, there is present an appreciable quantity of pulp fines derived from small wood cells and fragments or debris torn from the fibers. The fibers in head box stock will be retained on a normal machine wire mesh (75 mm hole) merely as a result of their physical size; therefore, it is the pulp fines and mineral fillers that pass the wire and folllow the white water system. In a mill that has an efficient white water and broke recovery system,

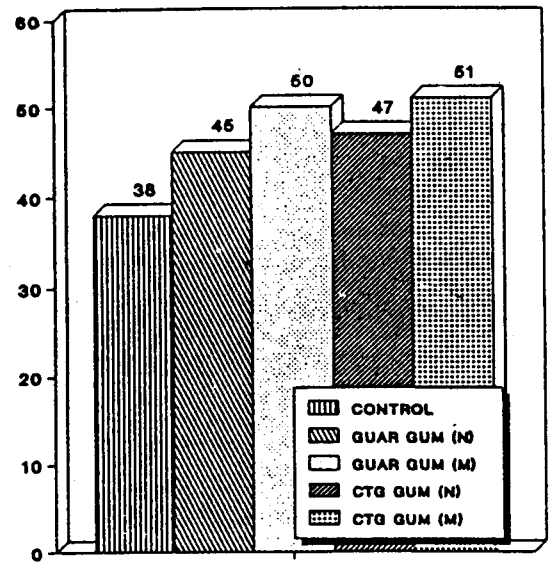

Fig. 3a. Burst Factor

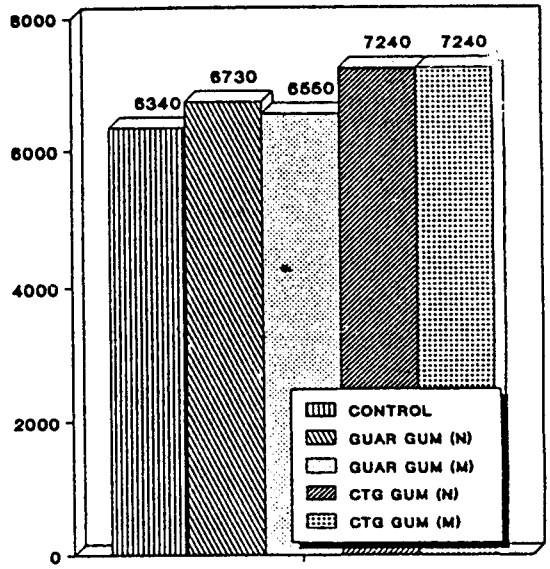

Fig. 3b. Breaking length, m

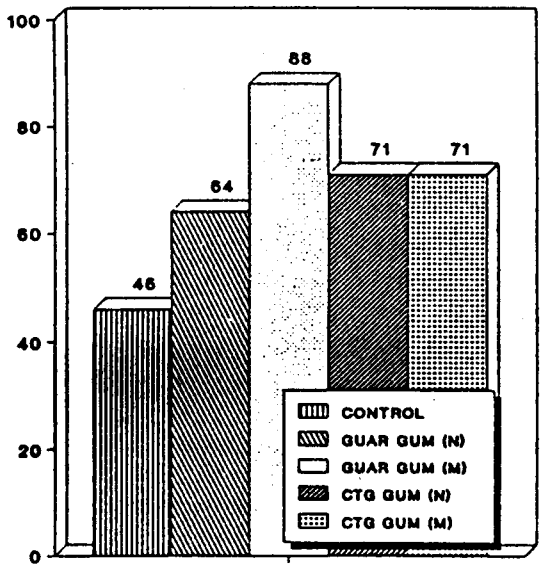

Fig. 3c Double fold, No's

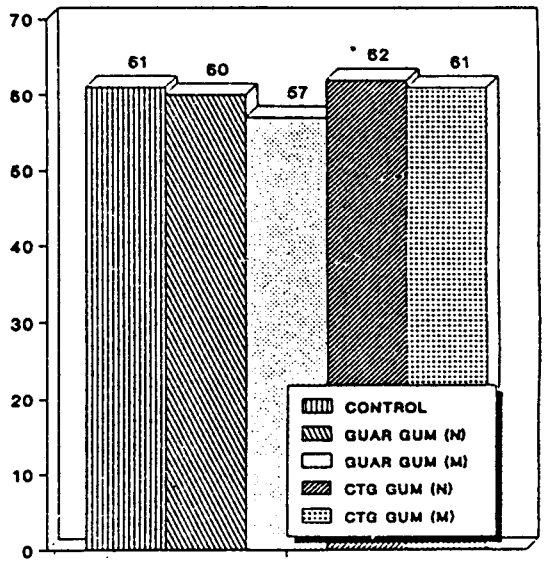

Fig. 3d Tear factor

FIG. 3 EFFECT OF VARIOUS GUMS ON STRENGTH PROPERTIES OF MILL PULP AT 0.75% ADDITION LEVEL

TABLE-6
Clarification of sulphited sugarcane juice by the addition of tora gum

Time (min)	Mud Volume (ml)			
	Tora gum	Guar gum	CMC	Mafloc
0	1000	1000	1000	1000
5	510	730	560	260
10	320	540	340	220
20	280	410	310	200

this should run above 95%. Synthetic polymers cationic in nature are normally used by mills to flocculate suspended fines in back water. C. tora gum modified (CTM) with ammonia vapour (10% weight increase) was used to treat the back water to recover the suspended fines and its performance compared with Trufloc and Deftech - 706. Performance of CTM and synthetic flocculant is shown in Table 5.

It can be noticed that CTM (4 ppm) takes 2 minute and 1.20 minutes more time for setting the floc in comparison to true floc and Deftech -706 respectively. However modified biolymer (CTM) allowed to retain 13 mg/l of suspended solids in back water in comparison to 50 mg/l of suspended solids on treatment with both synthetic flocculants. Thus CTM would give about 4 times more fibers for paper making and improve the economics of the mill.

In sugar factories, generally a flocculant is added to sulphited sugarcane juice to hasten the settling of mud. Performance of tora gum as a mud setting agent

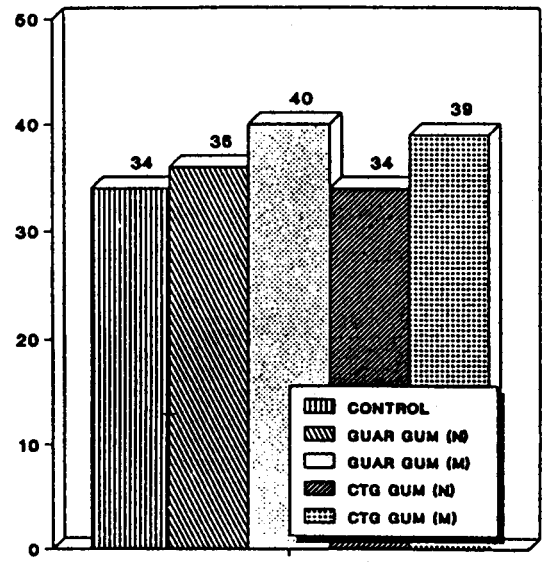

Fig. 4a. Burst Factor

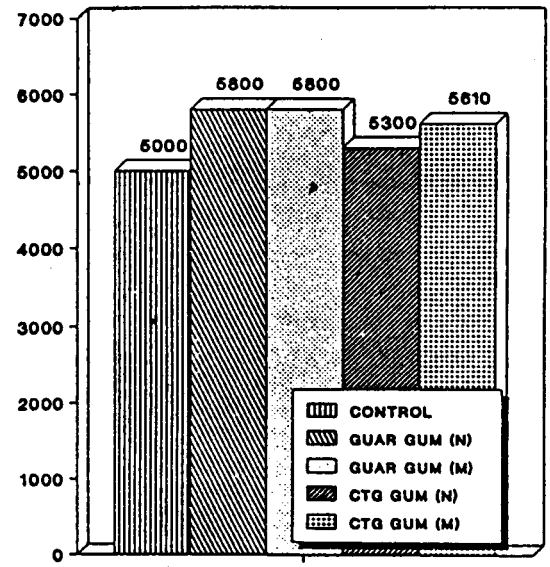

Fig. 4b. Breaking length, m

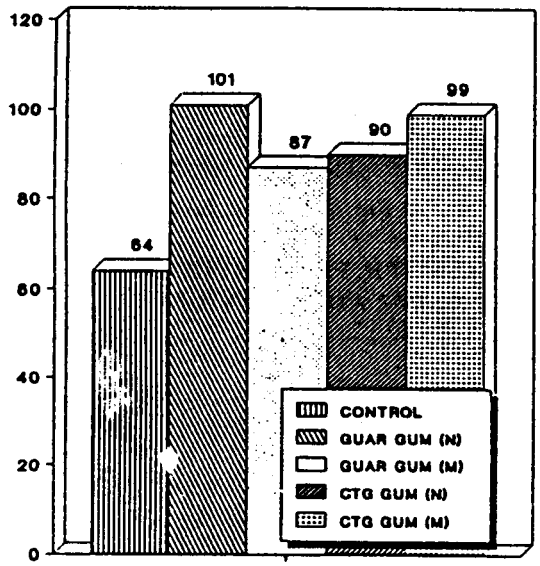

Fig. 4c Double fold, No's

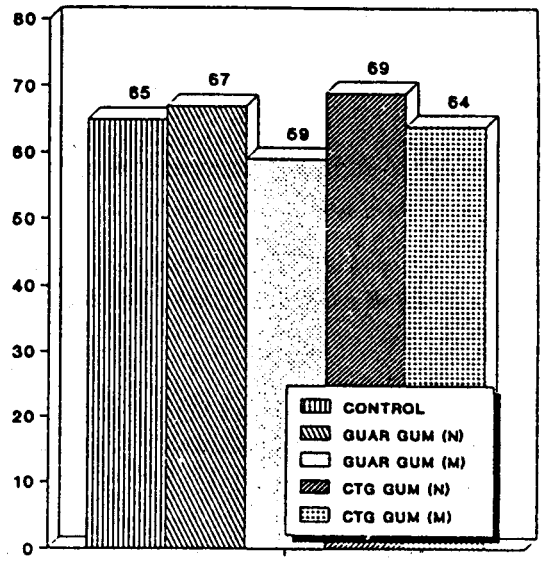

Fig. 4d Tear factor

FIG. 4 EFFECT OF VARIOUS GUMS ON STRENGTH PROPERTIES OF 80:20 BAGASSE/ SOFT WOOD BLD. PULP AT 0.75% ADDITION LEVEL

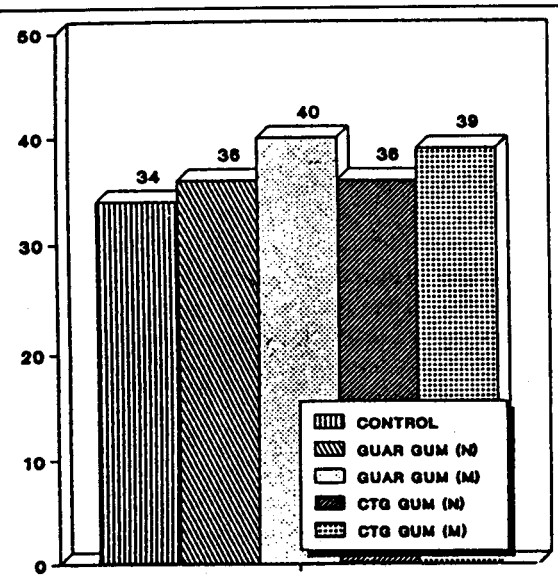

Fig. 5a. Burst Factor

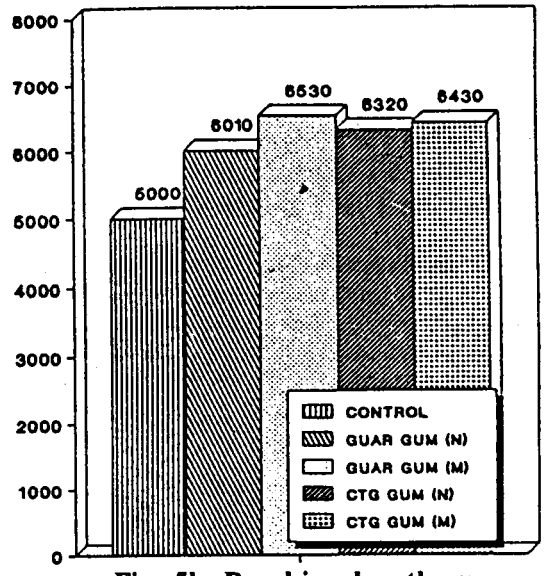

Fig. 5b. Breaking length, m

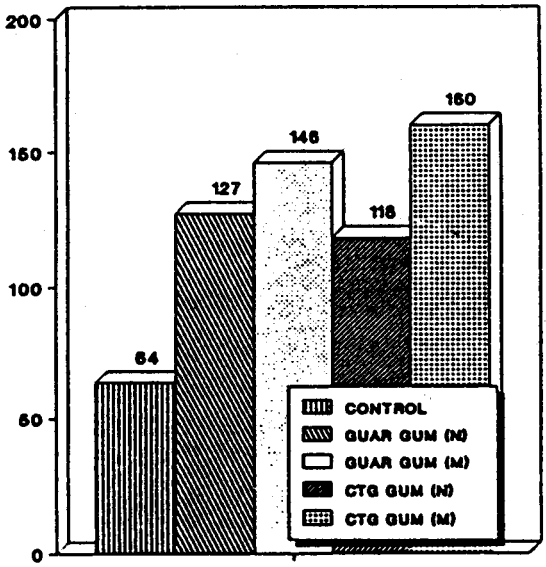

Fig. 5c Double fold, No's

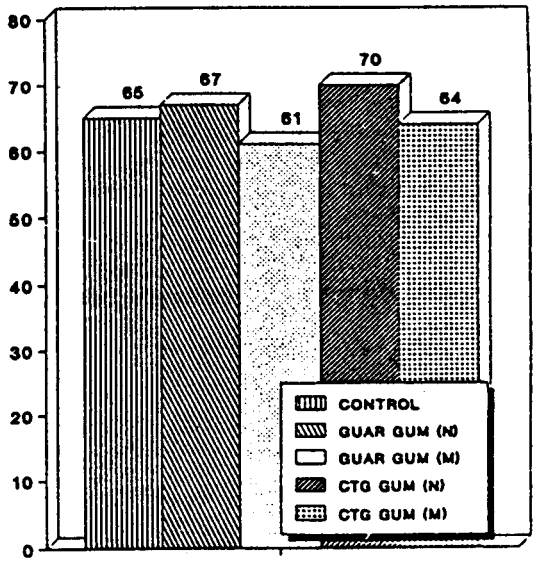

Fig. 5d Tear factor

FIG. 5 EFFECT OF VARIOUS GUMS ON STRENGTH PROPERTIES OF 80:20 BAGASSE/ SOFTWOOD BLD. PULP AT 0.50% ADDITION LEVEL

was compared with guar. CMC and Mafloc, a synthetic polyacrylamide compound. Mud settled by addition of these flocculants (3ppm) at different time intervals is shown in Table - 6.

It is evident from the above Table 6 that initial mud settling rate is quick on addition of Mafloc in comparison to other flocculants but at later stage tora gum settles the mud better than guar gum and CMC and little less than Mafloc.

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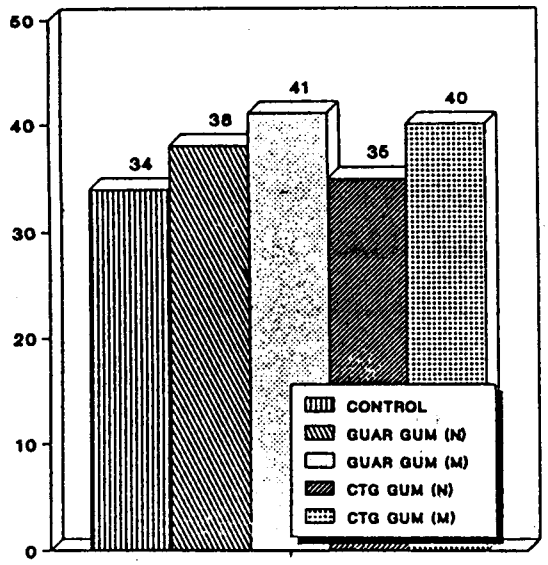

Fig. 6a. Burst Factor

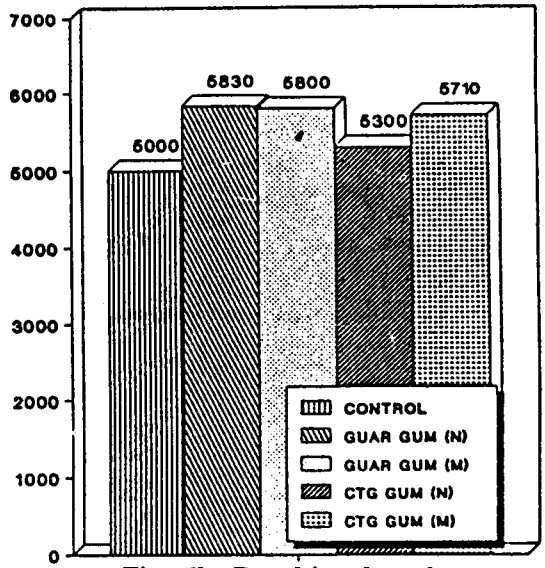

Fig. 6b. Breaking length, m

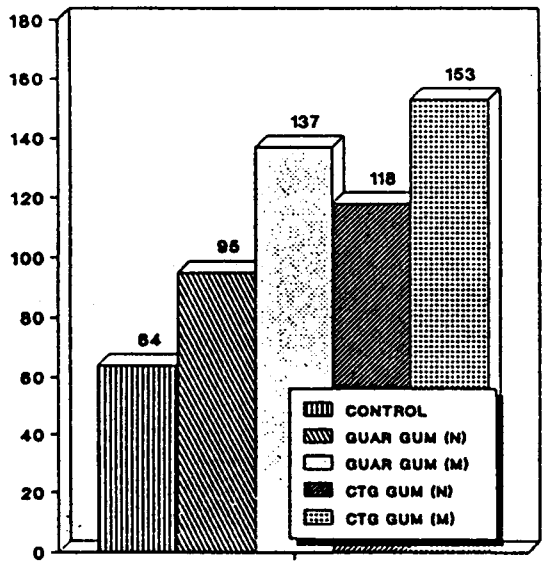

Fig. 6c Double fold, No's

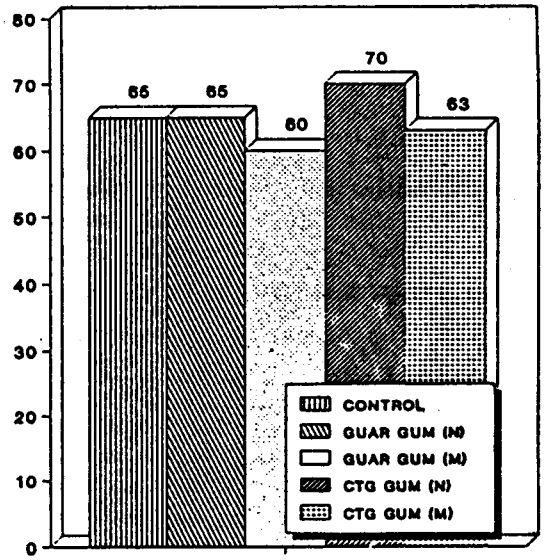

Fig. 6d Tear factor

FIG. 6 EFFECT OF VARIOUS GUMS ON STRENGTH PROPERTIES OF 80:20 BAGASSE / SOFT WOOD BLD. PULP AT 0.75% ADDITION LEVEL

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