The Manufacture of Bleached Straw Pulp with Korean Straw

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韓國産 짚類를 原料로 한 漂白 짚팔프 製造에 關한 硏究

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The paper consumption in Korea, about 70.000 tons in 1959, is steadily increasing. Although the paper production in Korea also increased from 20.000 tons in 1957 to 40.000 tons in 1959, the lack of forest resources for pulp manufacture is a vital problem in the Korean paper industry. Fortunately various straws, annual quantity of 4.5 million tons are available. Among them 3.3 million tons are rice straws, and the rest are wheat and barley straws. These straws are utilized for various purposes such as bag making, roofing, cattle feeds, fertilizer and fuel, but about 800.000 tons, rice straws 600.000 tons, barley straw 130.000 tons, eat straw 50.000 tons, can be utilized for pulp manufacture.

We have examined the pulp preparation since 1960 from straws by soda-chlorine process, which can be obtained from common salt(annual production 450.000 tons) in Korea. Conditions for straw pulp process have been investigated and it was shown that the straw pulp can be mixed with wood pulp for various papers.

1. Composition of Straw [1,2,6]

Straw samples were taken from farms near Seoul; rice and barley straws from Poongsan Yi, Dong Boo Myun, Kwang joo Goon, Kyunggi-do and wheat straws from Myunmek-dong in Seoul.

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a) Proportions of Straws

For the examination of difference of physical proportions of straws 200 gr. of each of the three kinds of straws were taken. The head, stem and leaf including sheath were divided, their weights proportion were determined and the results were shown in Table 1.

Table 1 Proportions of straws (weight %)

Straws	Stem Part	Leaf Part	Head Part
Rice	27.68	66.97	5.35
Wheat	67.39	32.61	—
Barley	64.49	35.51	—

The Table indicates that the leaf part in the rice straw is about 65%, but in case of the wheat and barley straws the leaf portion is only 32-36% and for the stem portion the case is reversed. In the pulping process this result should be taken into account.

b) The Length and Width of the Fibre

Each straw was divided into stem, leaf and head parts. Each sample was put into 50% HNO_3 solution saturated with $KClO_3$ and heated 5 min. at 45-50°C accordance with Schulzes method. The separated fibrous parts were examined with micrometer under 50 times magnifications. Table 2 shows the mean value of 20 measurements for the fibres of perfect shape.

Table 2 Fiber length and width of straws (unit m/m)

		Fiber Length			Fiber Width			
		Maxim. Value	Minim. Value	Average Value	Maxim. Value	Minim. Value	Average Value	L/W*
Rice Straw	Stem	1.575	0.406	0.991	0.011	0.004	0.007	141.6
	Leaf	1.654	0.394	1.024	0.012	0.004	0.008	138.0
	Head	1.293	0.228	0.761	0.011	0.005	0.008	95.1
Wheat Straw	Stem	1.502	0.474	0.988	0.015	0.007	0.021	82.8
	Leaf	0.979	0.400	0.719	0.012	0.007	0.010	71.9
Barley Straw	Stem	1.142	0.454	0.798	0.016	0.007	0.012	66.5
	Leaf	1.192	0.429	0.811	0.013	0.004	0.011	90.1

* L/W above Length/Width.

There is no significant difference on their shapes between fibres by three parts in the same kind of straw. The fibre of rice straw, is longer than those of wheat and barley straws, and the ratio of length over width in rice straw fibre is higher than those of barley and wheat straws.

c) Chemical Compositions

Each kind of straw was divided into stem, leaf and head, and pulverized to 40-60 meshes. Each part was analyzed in accordance with TAPPI standard methed.[5,7]

Table 3 Chemical composition of straws (wt %)

	Rice Straw				Wheat Straw			Barley Straw		
	Whole	Stem	Leaf	Head	Whole	Stem	Leaf	Whole	Stem	Leaf
Water	9.2	7.8	8.2	6.3	8.8	9.4	8.7	8.8	8.8	8.8
Ashes	14.6	10.4	16.5	9.2	4.2	2.7	7.6	9.3	5.9	10.0
1% NaOH Extract	48.2	53.6	46.1	48.7	34.2	29.3	37.0	39.5	35.4	44.6
Alcohol-Benzol Ext.	4.4	5.5	4.1	4.8	3.9	4.0	3.3	3.5	3.6	3.4
Pentosan	21.5	14.8	27.6	21.7	24.5	28.5	22.9	22.8	27.1	20.6
Lignin Ash Free	17.6	13.9	16.7	20.7	20.1	22.9	18.3	18.9	24.6	12.8
Total Cellulose (C-B Cellulose)	46.4	41.3	49.5	46.3	52.0	53.3	45.0	57.8	59.1	52.2

This indicates that rice straw contains more ashes, cold water extract, hot water extracts, 1% NaOH extract and alcohol-benzene extract and contains less cellulose, pentosan and lignin than wheat and barley straws. But there is no significant difference in composition between stem, leaf and head of the same kind of straw. These results substantially agree with the results of Celdercor Co. United Kingdom.[3,4]

2. Manufacture of Straw pulp [3,8]

As mentioned above, the object of this experiment consists in finding out fundamental data to treat Korean straws with soda-chlorine process, which is composed of alkali cooking, chlorine treatment, alkali treatment, screening and bleaching.

a) Alkali Cooking

NaOH solution, which is prepared with NaOH corresponding to 9% of charged straw, and water three times of straw weight, is poured into the 2 l-autoclave containing 300 g of whole straw. After covering, heating is started and within 60 minutes temperature is reached to 110°C. The temperature of the content is maintained at this temperature for 90 minutes. Then the autoclave is cooled to the room temperature and the pulp is filtered and washed with water.

b) Treatment with Chlorine

The cooked pulp is concentrated up to 22.5% and granulated in bean size. Then exposed on chlorine gas in a closed vessel for 60 minutes at 15-20°C. After the unreacted gas is measured,

the pulp is completely washed and weighed.

c) Alkali treatment and Screening

The chlorine-treated pulp is diluted to 5%, and 5 parts of NaOH with respect to 100 parts of the pulp weight is added to the solution and the mixture is heated for 30 minutes at 70°C then washed.

d) Bleaching

The pulp is bleached with bleaching powder. The screened pulp is made up to 5% pulp concentration and treated with bleaching powder solution, having 2.5% available chlorine with respect to the pulp, for 5 hours at 30-35°C under constant agitation. The bleached pulp is washed with water and dried.

e) Summarized Results

The pulp yield in each treating is summarized in Table 4.

Table 4 Yield of straw pulp after treatment (wt %)

	Rice Straw			Wheat Straw			Barley Straw		
	Whole	Stem	Leaf	Whole	Stem	Leaf	Whole	Stem	Leaf
Alkali cooking treatment	56.2	51.2	58.3	58.2	61.7	54.2	58.1	62.3	55.2
Chlorine treatment	106.0	105.4	104.7	107.8	103.8	107.6	109.2	107.4	107.8
Alkali extract treatment	85.6	83.8	86.7	83.5	82.2	82.3	84.0	82.8	83.4
Screening	96.1	97.4	95.9	95.3	95.6	97.6	96.3	93.2	96.2
Bleaching treatment	95.6	97.0	96.3	96.1	94.8	95.5	95.5	95.2	94.4
Bleached pulp yield	43.9	40.4	46.6	44.4	46.2	41.5	44.6	46.4	41.8

There is a great difference in the composition of the three kinds of the straws, but little difference in the pulp yields which is about 44%. The pulp yield in this experiment is somewhat higher than that of the Celdecor's results.

It was observed that the consuming quantities of Cl_2 gas and NaOH are less in case of rice straw than wheat and barley straw, and this can be expected from the fact of higher content of lignin in wheat and barley straws than in rice straw.

3. Paper making and Physical properties of Prepared paper

In the paper making with the bleached straw pulp mixed with wood pulp, the beating conditions of pulp are as follows.

Concentration of pulp	3%
Beating period	1 hr. for straw pulp
	2 hr. for wood pulp
Beater	Hollander type
Beating temperature	15-20°C
Beating degrees	50 degrees S.R.

In paper making, Small Sheet Former, made by the Frank Company in West Germany, was used under 1 kg/m² water pressure for 20 minutes at 110°C and 60 g/m² round sheet paper having 20 cm diameter was made. No seizing and adding of fillers were made.

The mixing ratios of pulps in shown in Table 5 and the physical properties of those paper samples are summarized in Table 6.

Table 5 Mixing ratio of wood pulp and straw pulp (wt %)

Straw Pulp	100	90	80	70	60	50	40	30	20	10	0
Wood Pulp	0	10	20	30	40	50	60	70	80	90	100

Table 6 physical properties of straw papers

Props ratio & mixing	Weight g/m²	Thickness m/m	Density	Bulk CBS	Ash %	Brightness G.E.%	Bursting strength kg/cm²	Burst factor %	Tensile strength kg/cm²	Breaking length km	Strect %	Tearing strength gr.	Folding endurance
S.P.— 100 %	58.4	0.08	0.73	2.15	11.0	90.0	1.9	3.25	2.79	3.83	2.2	50	482
R.P.— 100 %	58.4	0.08	0.73	2.15	9.2	84.7	1.9	3.25	2.65	3.63	2.9	40	421
R.P.— 90 % S.P.— 10 %	58.4	0.08	0.73	2.13	9.4	84.0	2.2	3.77	2.60	3.56	2.9	45	454
R.P.— 80 % S.P.— 20 %	58.4	0.08	0.73	2.14	9.5	85.0	2.4	4.11	2.98	3.98	3.1	62	403
R.P.— 70 % S.P.— 30 %	58.4	0.08	0.73	2.14	9.6	85.5	2.4	4.11	3.32	4.54	3.1	49	351
R.P.— 60 % S.P.— 40 %	58.4	0.08	0.73	2.14	9.9	86.0	2.5	4.28	3.53	4.82	3.2	40	218
R.P.— 50 % S.P.— 50 %	58.4	0.08	0.73	2.14	10.1	87.0	2.6	4.45	3.61	4.94	3.2	34	196
R.P.— 40 % S.P.— 60 %	58.4	0.08	0.73	2.14	10.2	87.5	2.7	4.61	3.05	4.18	2.6	28	153
R.P.— 30 % S.P.— 70 %	58.4	0.08	0.73	2.14	10.4	88.0	2.4	4.11	3.18	4.35	2.5	22	110
R.P.— 20 % S.P.— 80 %	58.4	0.08	0.73	2.15	10.8	88.5	2.1	3.60	2.78	3.81	2.4	20	63
R.P.— 10 % S.P.— 90 %	58.4	0.08	0.78	2.15	10.8	89.0	2.0	3.43	2.56	3.49	2.1	15	53
B.P.— 100 %	58.4	0.08	0.73	2.07	1.8	82.0	2.8	4.80	3.48	4.77	3.0	36	368
B.P.— 90 % S.P.— 10 %	58.4	0.08	0.73	2.07	2.4	82.5	2.5	4.28	3.53	4.84	3.0	39	371
B.P.— 80 % S.P.— 20 %	58.4	0.08	0.73	2.0	3.28	83.0	2.3	4.51	3.76	5.15	3.3	42	362
B.P.— 70 % S.P.— 30 %	58.4	0.08	0.73	2.1	4.26	83.0	2.2	4.96	4.13	5.66	3.2	71	327
B.P.— 60 % S.P.— 40 %	58.4	0.08	0.73	2.1	5.34	84.0	2.0	4.82	4.02	5.50	2.9	62	265
B.P.— 50 % S.P.— 50 %	58.4	0.08	0.73	2.1	6.26	84.5	1.8	4.61	3.84	5.26	2.8	49	231
B.P.— 40 % S.P.— 60 %	58.4	0.08	0.73	2.1	7.18	85.0	1.6	4.49	3.73	5.13	2.5	34	149
B.P.— 30 % S.P.— 70 %	58.4	0.08	0.73	2.1	8.13	86.0	1.5	4.03	3.36	4.60	2.4	26	97
B.P.— 20 % S.P.— 80 %	58.4	0.08	0.73	2.1	9.18	86.5	1.5	3.83	3.20	4.38	2.4	18	56
B.P.— 10 % S.P.— 90 %	58.4	0.08	0.73	2.1	9.9	86.7	1.5	3.80	3.17	4.34	2.3	17	49
W.P.— 100 %	58.4	0.08	0.73	2.0	3.81	83.0	2.6	3.61	3.01	4.12	3.4	35	312
W.P.— 90 % S.P.— 10 %	58.4	0.08	0.70	2.1	4.16	84.0	2.6	3.41	2.83	3.89	3.5	42	329
W.P.— 80 % S.P.— 20 %	58.4	0.08	0.73	2.1	4.93	84.5	2.7	3.37	2.81	3.85	3.5	46	351
W.P.— 70 % S.P.— 30 %	58.4	0.08	0.73	2.1	5.88	85.0	2.7	3.37	2.81	3.85	3.0	51	349
W.P.— 60 % S.P.— 40 %	58.4	0.08	0.73	2.1	6.48	85.5	2.7	3.43	2.96	3.92	2.7	69	326
W.P.— 50 % S.P.— 50 %	58.4	0.08	0.73	2.1	7.26	86.0	2.6	3.66	3.05	4.18	2.7	50	378
W.P.— 40 % S.P.— 60 %	58.4	0.08	0.73	2.1	7.96	86.5	2.6	4.21	3.51	4.81	2.5	39	249
W.P.— 30 % S.P.— 70 %	58.4	0.08	0.73	2.1	8.78	87.0	2.6	4.16	3.47	4.75	2.4	28	195
W.P.— 20 % S.P.— 80 %	58.4	0.08	0.73	2.1	9.46	87.5	2.5	4.15	3.46	4.74	2.3	17	130
W.P.— 10 % S.P.— 90 %	58.4	0.08	0.73	2.1	9.99	88.0	2.4	4.14	3.45	4.73	2.1	9	76

Ashes and lusters of the paper increase, and folding endurance and tearing strength decrease as wood pulp content is increased, but the bursting strength, shearing strength, tensile strength and elongation of 100% straw paper are increased to certain extent by mixing with wood pulp, the optimum content of which are different with the kind of straw, and then are decreased with the larger content of wood pulp. Elongation strength and length show reasonably good values when 30-50% of wood pulp is mixed with rice straw pulp and in case of wheat straw pulp and barley straw pulp 50-70% of wood pulp and 30% of wood pulp are optimum values respectively. The bursting strength of the barley straw paper is gradually decreased as the content of wood pulp is increased and the bursting strength of the wheat straw paper does not change great deal by mixing of the wood pulp, but the rice straw pulp mixed with 50-70% wood pulp shows worse bursting strength value than pure rice straw pulp or pure wood pulp.

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