Alteration in the content of xylan in eucalyptus pulp for tissue paper production

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Abstract

This paper summarizes our research findings over the effect of different xylan content in eucalyptus pulps on the quality of tissue papers thereof. Samples of unbleached kraft pulp from eucalyptus subjected to alkali treatment had their xylans values reduced gradually. The resulting samples were bleached by sequence $OD_{HT}(EP)D$, refined and evaluated as to their principal properties relevant to tissue paper. The pulps treated with different dosages of NaOH and reference showed levels of xylans varying from 5.9 to 15.6%. As a result of alkali treatment, the pulp showed high bleachability and low levels of HexA. Bleached pulps containing low levels of xylans showed higher values of bulk, Klemm capillarity, water absorption capacity, and lower values of tensile index, tear index and specific modulus than the pulp reference. The refining of the pulps indicated a higher energy consumption for the pulps with lower levels of xylans.

Keywords: xylan; tissue paper; eucalyptus; water absorption.

Introduction

Besides the extensive use of bleached eucalyptus pulp for printing and writing paper manufacturing, a significant portion is for the manufacture of *tissue* papers. Among the requirements of quality of pulps for eucalyptus *tissue* paper, their level of xylan stand out, which has been a controversial matter. Tissue paper can be defined as hygienic papers and napkins or tampons. They are produced through a paper-weight basis and predominantly composed of natural fibers of wood, which can be virgin or recycled. The term is used to describe products as toilet paper, hand towels, kitchen towels, napkins and handkerchiefs. From pulp to produce tissue paper seeks to intrinsic high softness, high bulk, good absorption and high drainability during the formation of roles. Another feature of fiber that is desirable for tissue paper production is the high drainability paper machine.

During the manufacture of tissue paper, the amount of hemicellulose contained in the slurry must be thoroughly evaluated. Fiber rich in hemicelluloses tend to produce paper of high density and lower specific volume, which is not interesting for tissue products and would harm the progress of the paper machines. The content of hemicelluloses in pulps can be altered by alkaline extraction under controlled conditions, since they are basically composed of xylans, in the case of eucalyptus wood, which are soluble in alkali.

This study aimed to develop techniques to obtain pulps with varying content of xylans from an unbleached kraft pulp from eucalyptus, to understand the influence of xylans in the properties of tissue papers.

Experimental

Unbleached kraft pulp sample from a variety of *Eucalyptus urograndis* were utilized. They were four alkali loads (10, 30, 50 and 70 g/L NaOH), while the other was fixed operating conditions alkaline hydrolysis (30 min, 30^{o}C, 10% consistency). These four samples of pulp, in addition to the reference pulp, were then subjected to analysis of viscosity, yield and content of xylans. The five pulp samples were bleached by the sequence $OD_{HT}(EP)D$. After bleaching the pulps were refined in accordance with standard TAPPI 248 om-00 [1]. The four levels of refining to the pulps ranged from 0 to 12,000 revolutions PFI, as the sample pulp. Handsheets were formed according to TAPPI 205 sp-02 [1] for the realization of physico-mechanical and specific roles. Measurements of bulk, tensile index, specific modulus, Klemm capillarity, water absorption capacity were performed according to TAPPI standards 220 sp-01, TAPPI 494 om-01, ISO 8787:86 and NBR 15004, respectively. The paper properties were listed and evaluated according to the level of xylans in the pulps.

Results and Discussion

Alkali treatment

Aiming to obtain brown pulps with different amounts of xylans and evaluate the influence of these carbohydrates in the pulp to producing tissue papers, the pulps were treated with different concentrations of NaOH solution. The results for levels of xylans, viscosity, kappa, HexA content, COD of the filtrate and yield are presented in Table 1.

Table 1. Results of alkaline treatments at various concentrations of NaOH solution.

Results	Concentration of NaOH, g/L				
	Ref.	**10**	**30**	**50**	**70**
Xylans (%)	15,6[a]	14,5[a]	10,8[b]	8,1[c]	5,9[d]
Yield (%)	-	98,5[a]	96,7[b]	89,2[c]	85,7[d]
Kappa number	16,1[a]	15,2[b]	13,3[c]	10,5[d]	7,9[e]
Viscosity (dm^3/kg)	1226[a]	1204[a]	1245[a]	1278[a]	1308[b]
COD filtrate (kg/t)	-	6,3[a]	66,3[b]	196,4[c]	206,6[d]
HexA (mmol/kg)	61,8[a]	61,4[a]	50,0[b]	34,7[c]	22,8[d]

The data shown in the "ref" are those obtained during the characterization of the sample received. A sample of unbleached pulp showed content xylans of 15.6%. As they increased the concentration of the alkaline solution, a higher percentage of xylans were removed from the cellulosic material, reaching 62% removal for treatment with 70 g/L NaOH solution. Such removal has a direct effect on reducing the content of HexA in the pulp and the yield of alkaline treatment. The HexA's are directly linked to the xylan chain, and thus removed together with these polymers. The fall in yields observed is mainly due to the loss of xylan. The reduction in kappa number of pulps demonstrates the removal of part of the lignin present in the samples. The results of the analysis of COD in the filtrate agree with the analysis of pulp discussed above, since there has been an increase in the COD of the filtrates as the alkaline extraction becomes more severe.

Bleaching sequence $OD_{HT}(EP)D$

All bleaching sequences were performed in conditions similar operationally to maintain a constant factor kappa of 0.16 in stage D_{HT} and varying the dosage of chlorine dioxide in the second stage of carbon dioxide in order to achieve the final brightness 90% ISO. The results of the bleaching sequence $D_{HT}(EP)D$ samples of pulp derived from alkali treatment of pulp and reference are presented in Table 2.

Table 2. Results of bleaching $OD_{HT}(EP)D$ pulp coming from the alkaline treatments.

Results	Xylans content, %				
	15,6	14,5	10,8	8,1	5,9
ClO_2 (% as Cl_2)	3,24	3,12	2,44	1,64	1,36
H_2O_2 (%)	0,3	0,3	0,3	0,3	0,3
NaOH (%)	1,12[a]	1,12[a]	0,97[b]	0,97[b]	0,97[b]
H_2SO_4 (%)	0,45[a]	0,83[b]	0,71[c]	0,70[c]	0,87[d]
ClO_2 (% as ClO_2)	1,23[a]	1,19[a]	0,93[b]	0,62[c]	0,52[d]
Total chlorine active [1/] (%)	3,87[a]	3,75[a]	3,07[b]	2,27[c]	1,99[d]
Bleachability (ud kappa/%Cl active)	2,8[a]	2,7[a]	2,9[a]	3,1[a]	2,7[a]
Brightness (%ISO)	89,8[a]	89,8[a]	89,9[a]	89,8[a]	90,1[a]
Brightness reversion (%ISO)	2,7[a]	2,6[a]	2,4[a]	2,5[a]	2,2[a]
Viscosity (dm^3/kg)	926[a]	911[a]	813[b]	-	767[c]
HexA's (mmol/kg)	6,6[a]	7,3[b]	7,3[b]	9,4[c]	5,5[d]

[1/] Total chlorine active = (ClO_2*2,63 + H_2O_2*2,09 + O_3*2,5).

The brightness reversion ranged from 2.2 to 2.7% ISO and was lower for pulps with lower levels of xylans. This can be explained by lower levels of HexA in those samples, because the HexA are largely responsible for brightness reversion [2]. For the sample containing 8.1% xylan, brightness reversion was slightly higher than the value of the reversion to other two samples (samples containing 10.8 and 5.9% xylan). Note that for this sample, the amount of HexA was higher than for the other samples (9.4 mmol/kg).

The viscosity of the samples ranged from 767 to 926 dm^3/kg, and the higher value for reference sample, and lowest for samples treated with higher doses of alkaline solution, confirming the role of xylans in protecting against cellulose chains degradation by oxidizing bleaching. Thus, with the removal of xylan the cellulose chains become susceptible to alkaline degradation.

Hygroscopic properties of bleached pulps

The hygroscopic properties of bleached pulps derived from the four treatments of alkaline hydrolysis and the references were evaluated and compared. Special attention was given to those properties of interest in the manufacture of paper tissue, such as water absorption capacity and capillarity Klemm.

The results for the absorption capacity of water (Wa) for samples of refined and bleached pulps at different levels are given in Table 3.

Table 3. Absorption capacity of water (Wa) of the samples treated with different dosages of NaOH, at different levels of refining.

Sample (% xylan)	**Levels of refinement**			
	Level 1*	Level 2	Level 3	Level 4
15,6%	5,4	3,6	2,9	2,6
14,5%	5,4	2,8	3,2	2,7
10,8%	7,1	3,6	3,0	2,7
8,1%	9,0	3,5	3,1	3,0
5,9%	11,5	3,2	3,5	3,0

* No refined pulps (zero revolutions PFI).

It may be noted that the refined pulps showed higher absorption capacity, which was expected since the refining of the fibers causes swelling and improves the ability to link interfiber [3], thereby impeding the penetration of water molecules on the cellulose fibers. The influence of refining is very significant when comparing the samples before (level 1 - no refining) and after the refinement levels (2, 3 and 4). After refining, the water absorption capacity of the fiber is not significantly altered.

Figure 1 shows the absorption capacity of water for pulp refined to 20 °SR, depending on the content of xylan in the pulp. It is proven here that pulps with lower levels of xylan at 20 °SR have a greater capacity for water absorption, the fundamental property of tissue products, which require high absorption of fluids during their use. The presence of xylan in the pulp causes difficulty in movement of water molecules in the fibers of the paper, preventing a good absorption of water by it.

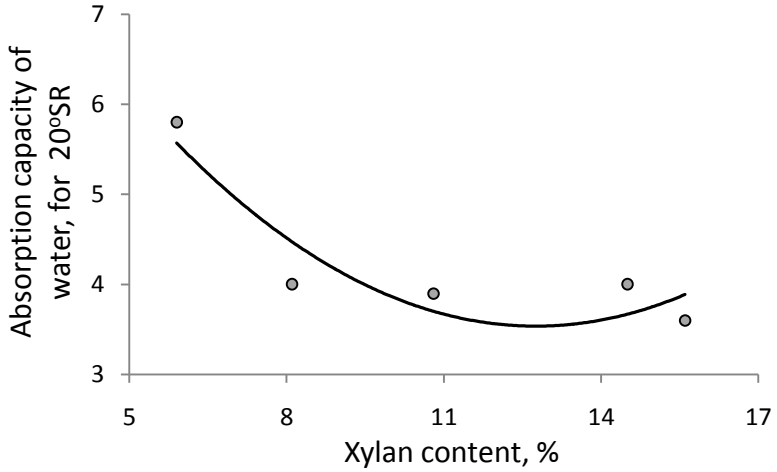

Figure 1. Absorption capacity of water (Wa) at 20 °SR according to the content of xylan present in the pulp.

The capillary Klemm is a test that measures the rate of absorption of liquids and it is very important in testing for tissue papers. Papers that present higher Klemm capillary fibers tend to have less united and greater amounts of empty spaces. Klemm capillary values tend to decrease with increasing intensity of refining due to the increasing number of interfiber.

Can be seen from Figure 2 that the decrease in xylan content of the pulp through the intensification of alkali treatment increases the capillarity of the paper produced Klemm, ie, increases the distance the water travels in the paper structure, the range of test time. One explanation for this is that water to move through the paper structure interacts with the hemi in greater intensity than with cellulose, hemicellulose due to having more amorphous regions (the region where the polymer molecules are disordered) difficulty in providing a displacement of water by the structure of the paper. Thus, papers made from pulps with lower levels of xylans are highly favorable for the production of tissue paper, just because they have good absorption of liquids.

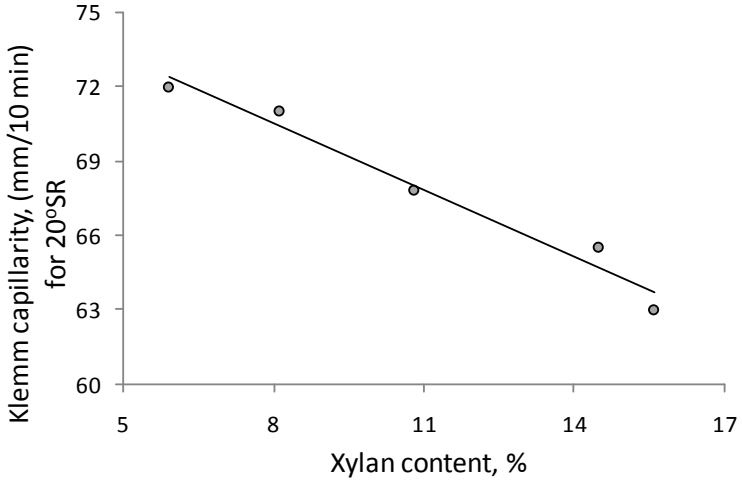

Figure 2. Capillarity Klemm for paper produced, according to the content of xylan present in the pulp.

Physico-mechanical properties

The various physico-mechanical of bleaching pulp derived from four treatments of alkaline hydrolysis and the references were evaluated and compared. The bleached pulps with

varying content of xylans were refined and produced their roles were evaluated for their properties tensile index, bulk and specific modulus.

It is hoped that the tissue papers have minimum tensile strength, since high values of indices are bad traction in the softness of tissue paper. Therefore, it is observed from Figure 3 that the xylans have significant influence on tensile index of paper produced, and pulps with lower levels of xylans, show lower levels of traction due to its greater fragility in the face of reagents used during the bleaching. Again, it was proven that pulps with lower content of xylans are more favorable for the production of papers for the segment of tissue.

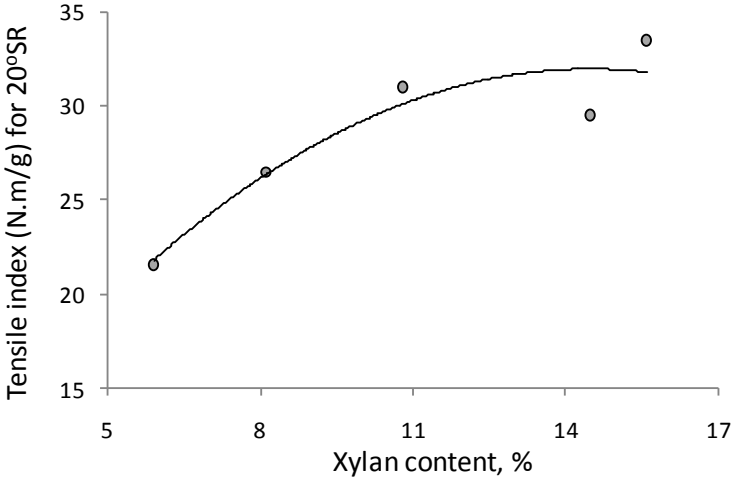

Figure 3. Tensile index at 20 °SR for paper produced according to the content of xylan in the pulp.

Figure 4 shows the specific modulus (MOE) calculated for 20 °SR according to the content of xylan present in the pulp, which shows that lower levels of xylans imply lower the MOE. According to Karlsson [4], the modulus is a mechanical property that relates inversely with the softness of the paper, so they are desirable in tissue paper low values of MOE, which makes the papers obtained from pulps bleached with about 6 and 8 % of xylans quite interesting to tissue paper segment, resulting in low by the MOE.

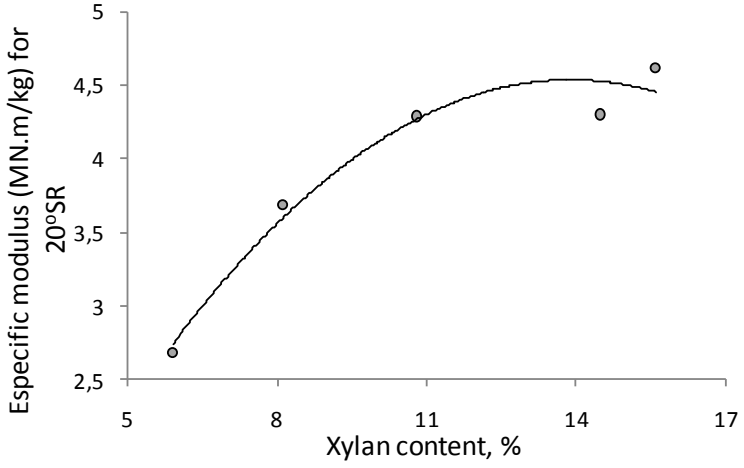

Figure 4. Specific modulus (MOE) at 20 °SR according to the content of xylan in the pulp.

The specific volume, also known as *bulk* is obtained by dividing the thickness (μm) of the paper by its weight (g/m^2). The structural characteristics of the fibers also influence the

determination of this property. Stiffer fibers contribute to the collapse with the increase in specific volume of the papers because they are less able conformation [5].

Figure 5 shows the apparent specific volume (bulk) was calculated for a Schopper-Riegler degree of 20 °SR, depending on the content of xylan present in the pulp. It is observed that the bulk is higher for pulps with lower amounts of xylan, which can be explained by the high load of soda applied during the alkali treatment, which caused swelling of the fiber and thus its increase in volume, a fact which makes them very interesting segment in tissue, due to their high bulk and low in hemicellulose.

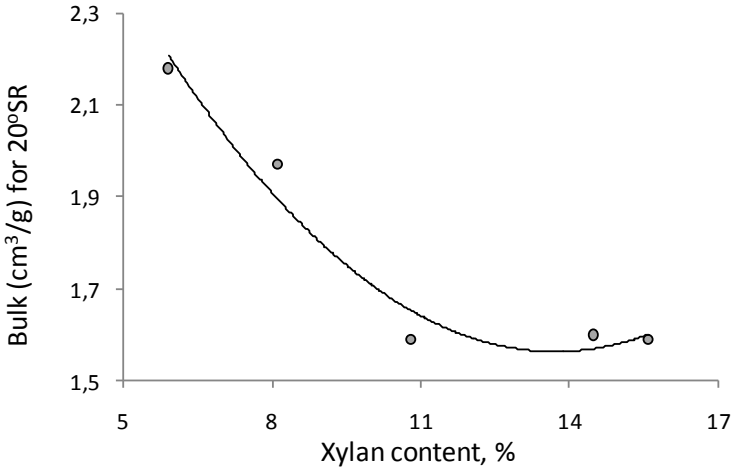

Figure 5. Apparent specific volume (bulk) to 20 °SR according to the content of xylan in the pulp.

Conclusion

The removal of xylan from the pulp by alkali treatment significantly reduced the demand for chlorine for pulp production with 90% ISO brightness by sequence OD_{HT}(EP)D, by reducing pulp kappa, but the flesh was bleachability influenced by the removal of xylan.

The capacity of water absorption of the samples was positively and significantly influenced by the removal of xylans in the pulp slurry not refined. In refined pulps, the effect of the concentration of xylan was insignificant. The action reduced the refining capacity to absorb water from the pulp. The capillary Klemm increases with the removal of xylan from the pulp and decreases with the action of refining.

The removal of xylan increased the properties of bulk and decreased the index properties and tensile modulus.

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