COMPARISON OF BALSAM AND ASPEN POPLAR TREES IN ALBERTA

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N. Cyr and J.K. Laidler

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[1] 250 Karl Clark Road, Edmonton, Alberta T6N 1E4

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Forest Industry Development Division
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ABSTRACT

Balsam poplars are the second most abundant trees in Alberta but they are not used in waferboard mills since they cause problems in the waferizing stage by clogging the blades. In order to find the cause for this problem with balsam poplar, a preliminary comparative study of balsam and aspen poplars has been done. Extractable materials from each type of wood have been compared. From the findings, it has been suggested that the chemical nature of hemicellulose and lignin-like materials in balsam poplar possesses different thermal properties from those in aspen poplar. A confirmatory study of this finding with larger number of samples has been recommended.

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OBJECTIVES

To identify the chemical similarities and differences between balsam and aspen poplars by solvent extractions.

INTRODUCTION

Abundant aspen poplar (populus tremuloides Michx.) in Alberta has been successfully utilized for the production of waferboards. Balsam poplars (populus balsamifera L.) which is the second most abundant hardwood tree in Alberta is not currently used in these waferboard mills. Balsam poplars cause problems in the waferizing stage by clogging the blades.[1] This must be due to the different nature in the wood components of balsam poplar.

In this project, we made preliminary investigations on the chemical differences of wood components in balsam and aspen poplars by solvent extractions. The quantities of extractable materials from both species of wood have been determined and compared. The approximate nature of the extracted materials has also been identified. We hope to relate the cause of the problem encountered in the mills with balsam poplar to certain chemical components in wood.

Once the chemical components and their properties are identified, it may be possible to make modifications to the mill process to utilize balsam poplar. This will be a benefit to the economy of Alberta.

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[1] private communication with Dr. L. Bach

RESULTS AND DISCUSSIONS

General Properties

Aspen and balsam poplar wood samples were prepared according to the procedure described in the EXPERIMENTAL section. Some general properties of the samples from the two species are listed in Table 1.

Apparent densities, Klason lignin yields and ash contents of both trees are significantly different. Almost all the ash was found to be calcium carbonate ($CaCO_3$) and the ash content of balsam poplar was almost twice that of aspen poplar.

Extractions

Sawdust samples were extracted in various solvents in sequence. All the extractions were done in triplicate and the results were averaged. The quantities extracted in each solvent are tabulated (Table 2) and shown in Fig. 1 as bar diagrams for easy comparison. Percentages are based on original dry weights of sawdust.

As one can see from the figure, boiling water extracted almost twice as much material from balsam poplar as from aspen poplar and alkaline solutions extracted in total 4% more from aspen than balsam poplar.

Efforts have been made to identify the materials extracted from wood by various solvents. Both solution- and solid-states carbon-13 nmr and gel permeation chromatography were used. The nature of the extractables are described in Table 3.

Table 1

General Properties of Aspen and Balsam Poplar Samples

properties	aspen	balsam
apparent density	0.43	0.37
initial moisture content*1	47 %	54 %
Klason lignin yield	21 %	23 %
ash content	0.8	1.4
water re-absorptivity	8.1	8.7
pH*2	4.6	5.0

*1 The moisture content was measured when logs were received at Mill Woods.

*2 The pH of the water after the extraction.

Table 2

Percent of Weight Lost after Extraction

solvent	aspen	balsam
dichloromethane (CH_2Cl_2)	2.2 %	2.5 %
boiling water	3.0	5.7
ethyl alcohol	1.2	1.7
0.2 % NaOH solution	2.9	2.9
2 % " "	8.9	5.8
5 % " "	8.4	6.2
18 % " "	4.1	5.4
total	24.3 %	20.3 %

Table 3

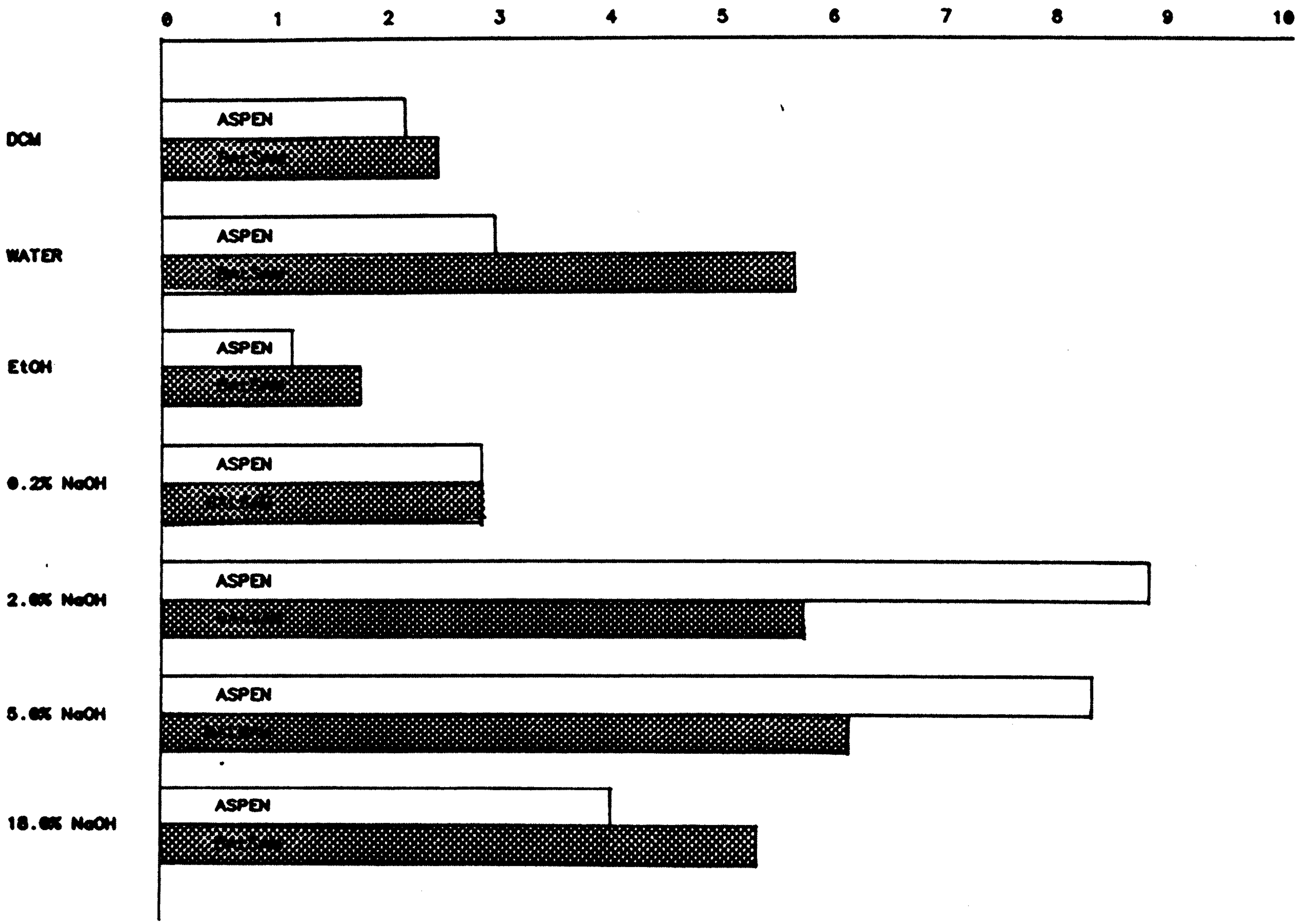
Description of Extracted Materials

solvent	Material Description
CH_2Cl_2	vegetable oil (mainly triglycerides of linoelic acid and palmitic acid)
boiling H_2O	$CaCO_3$, sucrose, acetylated xylan of small molecular weight
Ethyl alcohol	vegetable oil and small aromatic molecules
0.2 % NaOH	small xylan (D.P.=10-15) In aspen poplar, significant amount of lignin-like aromatic materials (see Fig. 2) were included where in balsam poplar this amount was much less.)
2 % and 5 % NaOH	Mainly deacetylated hemicellulose (xylan). From the GPC, the average M.W. of 5 % NaOH extracted xylan seemed to be much higher than those of 2 % NaOH.
18 % NaOH	The material is known to be deacetylated hemicellulose but the solid has not been recovered.

FIG. 1

ASPEN AND BALSAM EXTRACTIVES

PERCENT EXTRACTIVES[CORRECTED TO ORIGINAL DRY WEIGHT]



Soluble lignin-like materials

Klason lignin yields after extractions are shown in Table 4. From the yields of Klason lignins, the quantities of lignin-like materials which were extracted in various solvents can be estimated. These figures are also shown in Table 4.

The Klason lignin yield of the untreated wood was approximately 2 % higher for balsam than aspen.

After the extractions in CH_2Cl_2, H_2O and ethyl alcohol, totals of 3.4 and 3.7 % of lignin-like material were removed by the solvents. More lignin-like material was extracted from balsam poplar than from aspen poplar (7.1% v.s. 6.0%). The difference of 1 % may be significant enough to give balsam poplar different properties. This lignin-like material must be of small molecular weights and low melting points and thus soluble in various solvents.

Hemicellulose Content

The major differences between the extractable materials from aspen and balsam poplars were the amounts of xylan extracted in boiling water and alkaline solutions. The difference in the total amounts extracted between the two species was 4 % (aspen poplar lost more than balsam poplar) and this difference was consistent in all three experiments.

After the extraction in 18 % NaOH, the residual wood samples were completely hydrolyzed and the constituent sugars were analyzed to find the extent of hemicellulose extraction. The aspen poplar residue contained almost twice as much xylose as the balsam poplar residue. Therefore, it is concluded that although the water-soluble hemicellulose (xylose oligomers?) content of balsam was higher than that of aspen, the total hemicellulose content was considerably lower than that of aspen. The low molecular weight hemicellulose is likely to have a low phase transition (melting) temperature. Since the quantity of this material is almost twice as much in balsam poplar than in aspen, it is possible that this is the cause of the problem encountered in waferizing as this material would melt onto the blades and clog them.

Table 4

Klason Lignin Yields and Amount of Lignin Extracted
(%, based on original dry weight)

	aspen		balsam	
	yield	ext'd	yield	ext'd
untreated	21.1		23.3	
after EtOH extraction	17.7	3.4	19.6	3.7
after 2 % NaOH extraction	16.0	1.7	17.5	2.1
" 5 % " "	15.0	1.0	16.5	1.0
" 18 % " "	15.0	0.0	16.2	0.3
total extracted lignin		6.1		7.1

CONCLUSIONS

The major findings from this study were:

1. Balsam poplar contains more carbohydrate oligomers of low molecular weight (soluble in boiling water) than aspen poplar,

2. The Klason lignin yield was higher for balsam than aspen poplar and balsam poplar contained more easily soluble, lignin-like material than aspen poplar, and

3. The ash content of balsam poplar was significantly higher than aspen poplar.

Some wood components of balsam poplar seemed to be more easily accessible to extraction than aspen poplar. It was indicative that the molecular weights and the thermal properties of these components in balsam poplar were significantly different from those in aspen poplar. This may explain the previously described problems encountered in waferboard plants when balsam poplar was used.

EXPERIMENTAL

Samples

Two trees (one each of aspen and balsam poplar) were cut in the Slave Lake area on September 22, 1986 and sections from top and bottom portions of each tree were delivered to our laboratory soon after. These were kept frozen until used. Ground sawdust samples used in the experiments were the well mixed materials from both ends of each tree. The balsam poplar tree appeared to have decay in the center and this decayed portion was removed before the sample preparation. They were ground to 2 mm mesh.

Extractions

A series of extractions was done in order in the following solvents:

1. dichlormethane (CH_2Cl_2)
2. boiling water
3. ethyl alcohol
4. 0.2 % sodium hydroxide solution
5. 2 % " " "
6. 5 % " " "
7. 18 % " " "

All the extraction experiments were done in triplicate except for the last extraction in 18 % NaOH. Approximate quantities of the sawdust and the solvents used and the conditions are:

solvent	quantity sawdust	solvent	conditions
CH_2Cl_2	50g	500mL	refluxed for 3 hrs
water	45g	500mL	refluxed for 3 hrs
95% ethyl alcohol	40g	600mL	refluxed for 3 hrs
NaOH solutions	30-35g	600mL	stirred at room temp for 1hr

After every extraction, the mixture was filtered, the residue was dried overnight at 105°C and weighed to calculate the weight loss.

Klason Lignins and Sugars

Approximately 1 g of sample was stirred in 10 mL of 72 % H_2SO_4 for two hours at room temperature, diluted with 280 mL of water (to give a 2.5 % H_2SO_4 solution), and heated in a pressure cooker for 1 hour at 15 psi (~100 KPa). After cooling the solutions were filtered and the precipitates were washed with water until neutral and then dried at 105°C overnight. The filtrates were neutralized with $BaCO_3$ and analyzed by carbon-13 NMR.

RECOMMENDATIONS FOR FUTURE STUDIES

The findings described above were from samples of two trees in one area. The differences in the amount of material extracted by boiling water and alkali were significantly large but it must be confirmed with more samples.

Specifically:

1. The differences observed in this study must be confirmed for generality by experimenting with samples of more trees possibly from different clones and locations.

2. Data from trees cut during different seasons must also be confirmed.

3. Then the physical properties of materials extracted in boiling water must be studied to see if there is a correlations between properties of the materials and the cause of the problems encountered in the waferboard mills.

These studies can be done again in stages based on the results of the previous studies. Then it may be possible to develop modifications to the waferizing process so that the clogging of the blades will be avoided when balsam poplar is used.