GALACTAN IN WESTERN LARCH WOOD

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GALACTAN IN WESTERN LARCH WOOD[1]

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Abstract

A quantitative determination was made by the U. S. Forest Products Laboratory of the galactan in western larch woods and sawmill refuse. This work was done to obtain data useful to those contemplating commercial ventures designed to produce and market various materials made of galactan.

Galactan in the lateral roots of virgin trees ranged from approximately 11 to 23 percent, based on the weight of the oven-dry wood. The galactan content of slabwood from virgin-growth butt logs was found to be about 14 percent; from the middle logs, 4.2 to 10 percent; and from the top logs, about 5 percent. Butt logs from fire-killed virgin trees contained approximately 9 to 16 percent of galactan; the middle logs, 6.6 to 12.1 percent; and the top logs, 6.6 to 7.8 percent. Butt logs of stand thinnings contained from 3.8 to 5.3 percent of galactan; the middle logs, 2.1 to 3.5 percent; and the top logs, 2.2 to 3.1 percent.

Introduction

Western larch differs from most other species of wood in that it contains appreciable quantities of galactan in the form of a hot-water-soluble polymer of arabinose and galactose (4, 7).[3] This form of galactan has a re-occurring building unit which consists of one molecule of arabinose and

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[1] This work was done in cooperation with the Forest Utilization Service unit of the Northern Rocky Mountain Forest and Range Experiment Station, Missoula, Mont.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Underlined numbers in parentheses refer to Literature Cited at end of this report.

six molecules of galactose (5, 6, 7). It is thus an arabogalactan polymer rather than galactan, as commonly designated. Borgin (1) found that galactan from western larch consists of two components having molecular weights of 100,000 and 16,000, respectively.

The arabogalactan, on hydrolysis with acid, can be converted to arabinose and galactose. In turn, the arabinose portion can, under more drastic conditions, be changed by means of acid to furfural. The galactose portion is oxidizable by means of nitric acid to mucic acid, which is insoluble in water or aqueous solutions of nitric acid. This is the basis for the quantitative determination of galactose in the material commonly designated galactan.

Mucic acid finds uses in the manufacture of intermediate organic chemical products; among them are baking powder, effervescent salts, artificial yeast, an accelerator of yeast growth, a component of esters and salts for pharmaceuticals, in disinfectants, in acidulants, an ingredient of soft drinks, a component in electroplating baths, and mordants for dyeing textiles. Most of these uses require no large tonnages of mucic acid. Accordingly, new uses would have to be developed before large-scale production of mucic acid would be economically feasible.

Virgin-growth western larch heartwood appears reddish brown in color on the cross-sectional surface of the stump and butt log. If the galactan content is high, the reddish-brown color is tinged with blue. On exposure of the cut to summer heat and sunlight, the galactan accumulates in the form of a white powder on the surface of the stump and the cross-sectional face of the butt log. High concentrations of galactan are generally associated with ring shake and rot in the butt log of western larch (2). The presence of these two defects led to the practice of loggers to place the top cut for the long butt sufficiently high up the tree so as to eliminate physical indications of the shake and rot. In recent years, loggers have developed uses for the less intense ring-shake stock and, as a result, the discarded butts are becoming shorter and less frequent.

Previously the U. S. Forest Products Laboratory showed that a limited number of samples of wood from the butt log of virgin-growth western larch had an average of 17.9 percent of galactan, and samples of wood from the top log of the tree had an average of 5.9 percent of galactan. In contrast, samples of wood from the butt log of second-growth western larch had an average of only 5.6 percent galactan.

The object of the present work was to determine the percentage of galactan in western larch wood discarded during log-harvesting and lumber-cutting operations in Montana, Idaho, and Washington as a source of information for anyone who might consider exploring the feasibility of utilizing the material.

Wood Types Tested

Samples of western larch wood that were analyzed consisted of (a) roots; (b) cross sections from the butt, middle, and top parts of fire-killed trees; and (c) cross sections from the butt, middle, and top part of trees removed in thinning operations, and (d) samples of slabwood from different heights of the trees. The wood samples were collected and shipped to the Forest Products Laboratory in December 1948 by the Forest Utilization Service of the Northern Rocky Mountain Forest and Range Experiment Station, Missoula, Mont.

The root samples were collected along a highway constructed in 1948, north of Seeley Lake on the Lolo National Forest. They were from one of the largest virgin larch stands in the Northern Region. Many of the trees in this stand ranged from 300 to 400 years in age. The sampling was confined to lateral roots as it was impossible to remove the main roots of the stumps. Three root samples which differed in surface appearance as grayish, bark-covered, and black, respectively were analyzed.

The slabwood samples were obtained at a sawmill near the place at which the root specimens were collected and represented the same type of virgin western larch as the roots. The test samples analyzed were cut from the slabs at 0, 6, 16, 32, and 64 feet above the stump of the tree.

Samples of fire-killed virgin-growth trees were collected on the Colville National Forest in northeastern Washington. They were taken from an estimated area of 250,000 acres, which was burned over in 1929. The fire-killed trees were still in a relatively good state of preservation, as shown by visual examination of the samples, and constitute a major utilization project of the region. Samples from three trees designated as Nos. 3, 4, and 6 were analyzed.

Samples from thinning operations were taken from second-growth stands of western larch 60 to 80 years of age on the Cabinet National Forest near Noxon, Mont. This area is located on the eastern fringe of the western white pine stands and is considered one of the best western larch sites in the region. It is representative of the type of stand on which thinning would be advantageous. The average diameter of the trees was approximately 6 inches at breast height and their height was approximately 70 feet. Samples from three trees designated Nos. 1, 9, and 13 were analyzed.

The wood samples were reduced to sawdust and the coarse particles eliminated by means of a 20-mesh screen.

Methods and Results of Tests

Galactan in the wood was quantitatively determined by Schorger's method (3). It involves treating a given weight of air-dry unextracted wood sawdust of known moisture content with boiling 3 percent nitric acid, filtering, washing the residue with boiling water, adding the washings to the original acid filtrate, concentrating the filtrate, oxidizing the galactose in the concentrated filtrate to mucic acid by means of 25 percent nitric acid; concentrating the mixture, adding a known weight of mucic acid to start crystallization of the mucic acid in the filtrate, and allowing to stand 48 hours. The mucic acid was filtered off, washed, dried and weighed. A correction was made for the mucic acid added and the remainder was multiplied by the factor 1.2 for conversion to galactan.

Analytical data for the root and slabwood samples are recorded in table 1. Yields of galactan from the root samples Nos. 1, 2, and 3 were 23.0, 10.7, and 16.9 percent, respectively. Yields of galactan from the slabwood at 0 feet height were 14.1 percent and gradually decreased to 4.7 percent at 64 feet above the stump. Being slabwood, the samples contained considerable sapwood which has less galactan than heartwood. The concentration of the galactan decreased with height above the stump and confirmed the results of previous analysis of virgin western larch wood.

Galactan yields of the butts of the three fire-killed trees were 13.5, 15.7, and 9.2 percent, respectively, as shown in table 2; those of the samples taken from the middle of the corresponding trees were 9.3, 12.1, and 6.6 percent; and those from the top of the corresponding trees were 7.8, 7.1, and 6.6 percent.

Galactan yields from the butts of the three thinning trees ranged from 3.8 to 5.8 percent; those from the middle ranged from 2.1 to 3.5; and those from the top ranged from 2.2 to 3.1 percent.

Radial distribution of the galactan in a tree was also determined. To do this cross sections were cut from the butt, middle, and top of the fire-killed western larch tree No. 3 for the analytical work. Sectors removed from the cross sections were divided, parallel to the boundary between the annual growth rings, into outside and inside parts. The radial dimensions of the two parts are shown in table 3 in connection with the analytical data. Galactan content was 15.1, 10.0, and 9.5 percent in the outside part of the sectors from the butt, middle, and top, respectively; it was 8.3, 6.0, and 5.5 percent in the inside part of the corresponding sectors.

Obviously, the roots, the slabwood from the lower 6 feet of the butt log, and the butt logs of virgin western larch trees are rich in galactan. The stumpwood, which is located between the roots and butt log, presumably also contains galactan in yields ranging from about 10 to 23 percent. On the other hand, trees removed by thinning operations are a poor source for galactan. Killing of the trees by forest fire appears to have had little if any effect on the galactan content of the wood.

On the basis of present information, the maximum yield of mucic acid derivable from western larch would be roughly 83 percent of the galactan values reported.

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Table 1.--Percentage of galactan in western larch root sections and slabwood[1]

Type of material	Number of sample	Galactan	Type of material	Height of sample in tree	Galactan
		Percent		Feet	Percent
Root sections	1	23.0	Slabwood	0	14.1
	2	10.7		6	10.1
	3	16.9		16	4.2
				32	6.6
				64	4.7

[1]Based on weight of oven-dry wood.

Table 2.--Percentage of galactan in fire-killed western larch and thinnings from second-growth[1]

Type of material	Number of tree and location of sample	Galactan	Type of material	Number of tree and location of sample	Galactan
		Percent			Percent
Fire-killed trees ...	3		Thinnings from second-growth stand	1	
	Butt	13.5		Butt	5.5
	Middle	9.3		Middle	2.1
	Top	7.8		Top	2.2
	4			9	
	Butt	15.7		Butt	3.8
	Middle	12.1		Middle	2.3
	Top	7.1		Top	2.5
	6			13	
	Butt	9.2		Butt	5.8
	Middle	6.6		Middle	3.5
	Top	6.6		Top	3.1

[1]Based on weight of oven-dry wood.

Table 3.--Percentage of galactan according to radial location in sections of fire-killed western larch[1]

Section of tree	Location of sample[2]	Radial dimension of sample	Galactan
		Inches	Percent
Butt	Outside	5	15.1
	Inside	4	8.3
Middle	Outside	3	10.0
	Inside	5	6.0
Top	Outside	2	9.5
	Inside	3	5.5

[1]Based on weight of oven-dry wood.

[2]Each section was wedge-shaped and divided into inner and outer samples with respect to radial direction.