Applications of Molecular Beam Mass Spectrometry and Computer Assisted X-ray Tomography to Forest Tree Improvement

Gerald Tuskan[1], Darrell West[1], Mark Davis[2], H.D. Toby Bradshaw[3], David Neale[4], Mitchell Sewell[4], Nick Wheeler[5], Ron Dinus[6]

[1]*Oak Ridge National Laboratory, Environmental Sciences Div., Oak Ridge TN 37831*
[2]*National Renewable Energy Laboratory, 1617 Cole Blvd., Golden, CO 80401*
[3]*Center for Urban Horticulture, University of Washington, Seattle, WA 98195*
[4]*The Institute for Forest Genetics, U.S. Forest Service, Environmental Horticulture Department, University of California, Davis, CA, 95616*
[5]*Weyerhaeuser Forestry Research Center, Centralia, WA, 98531*
[6]*Consultant, 2490 Goshen Road, Bellingham, WA 98226*

gtk@ornl.gov

Traditional methods of determining wood properties are time consuming and expensive, and as a result, have contributed relatively little to progress in improved product quality. We have developed two rapid assays, pyrolysis molecular beam mass spectroscopy for cell wall chemical composition and computer-assisted tomography x-ray densitometry for wood specific gravity, annual ring boundaries and within-ring specific gravity for loblolly pine and *Populus*. These techniques 1) can be completed in a fraction of the time (~1-2 minutes per sample) typically required for traditional analytical methods and 2) utilize small subsamples or are non-destructive. Using these techniques, we have detected nine quantitative trait loci (QTLs) in loblolly pine for wood specific gravity (explaining 34% of variance). QTLs for wood specific gravity appear to be either early- or latewood specific. Twelve unique QTLs influencing cell wall chemistry were detected using the one-QTL model and most QTLs (75%) were verified by analyses of multiple peak values. Four additional cell wall chemistry QTLs were detected using the two-QTL model. Significant differences in chemical contents were observed among the populations from NC vs. OK, suggesting that QTLs interact with environmental location. In *Populus*, we have determined lignin content (averaging 24.8% on a dry weight basis) and syringyl to guaiacyl ratios (averaging 1.9) across 310 full-sib progeny. Glucan content, including fractions from cellulose and some subcomponents of hemicellulose, averaged 45.4%. Estimates of mannan, arabinan and xylan averaged 2.7%, 0.5% and 17.0%, respectively. Mean specific gravity was 0.34 and ranged from 0.24 to 0.48. Glucan and xylan content are negatively correlated (r = -0.91), as were arabinan and extractive content (r = -0.76) and arabinan content and syringyl to guaiacyl ratio (r = -0.73). There were no detectable correlations between lignin and arabinan content, lignin and extractives content, extractives and mannan content, and glucan and extractives content. The genetic analysis indicated that there are multiple alleles contributed by each grandparental genotype. These techniques and others like them will have little impact on improved product value until feedstock composition and product quality are more closely aligned by all participants in the product chain. Integration of such techniques into traditional tree improvement efforts, product manufacturing and final product value will be discussed.