Phenolic Compounds in Stem Wood of Scots Pine from Different North-South Regions in Finland

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Background

It is a well-known fact that the suitability of wood for many of its applications is to a large extent influenced by its chemical composition. It was earlier noted that the differences in wood quality which may affect its processing and subsequently the final products may be influenced by the existence or non-existence of some extractive compounds. Although this observation was made in relation to wood utilisation in pulp and paper industries, it is also applicable to other present day and future wood uses in which extractives are likely to take centre stage in the exploitation of wood for value added products. Therefore, knowledge of both the concentration and type of extractive compounds in the available wood raw material is vital when assessing its utilisation options. Scots pine the dominant tree species and most abundant source of forest biomass in Finland. It is envisaged that now and in the near future, forest lignocellulosic biomass will be the main feedstock for the production of bio-materials, bio-chemicals, bio-fuels, and other novel bio-refinery products. The goal of the biorefinery concept is to get more value out of the biomass resources. Some wood non-structure extractive components like phenolic compounds, have the potential of truly high value due to their bioactivity such as antioxidant, antimicrobial and other protective properties.

Objectives

The objectives of this study were:

1. To characterise the phenolic compounds in stem wood of Scots pine (*P. sylvestris*) stem wood from final cutting and first thinning harvest tree samples from north-south regions in Finland.
2. Study the difference in composition and concentration of phenolic compounds between mature sapwood and heartwood samples.
3. Study the difference in the concentrations of compounds between final cutting and first thinning harvest sapwood samples.
4. Study the effect of geographic region and forest type on the concentration of individual phenolic compounds in all the sample categories.

This data was required for the project “Northern range and raw materials, characteristics and uses of wood-based thermal liquids (NORPYRO)”.

Materials and Methods

The samples consisted of Scots pine stem wood obtained from seventy final cutting harvest trees (93 years mean tree age) and seventy first thinning harvest trees (48 years mean tree age). We selected four sampling regions for the forests (Lapland north & south, middle and southern Finland) (Figure 1). We got sapwood and heartwood samples from mature trees while only the sapwood samples from young trees. Milled dry-air dried wood samples were extracted by the ball mill extraction method with 100 % cold methanol as an extraction solvent. The extraction procedure was done according to a standard protocol described by Nybakken et al. 2012. Dissolved extracts were analysed by the High Performance Liquid Chromatography (HPLC) for identification and quantification of phenolic compounds.

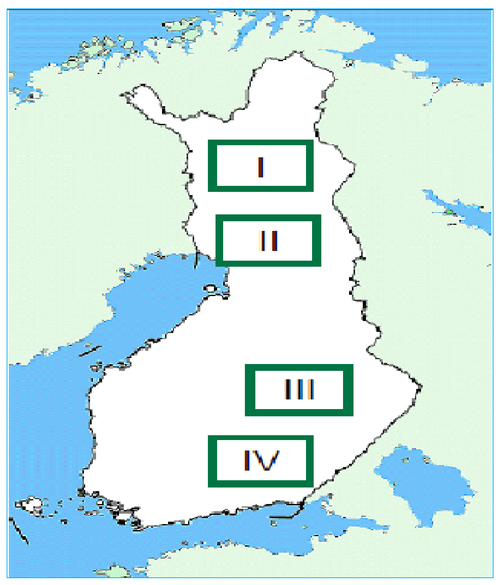

Figure 1: Sampling geographic regions. Lapland North (I), Lapland South (II), Middle Finland (III) and Southern Finland (IV)

Selected Results

Geographic region had a significant effect on the concentration of all the three compounds in young sapwood and vanillic acid in mature sapwood and heartwood samples. The concentration of PSMME and pinosylvin in sapwood increased with increasing tree age while the concentration of vanillic acid was not affected by tree age of the samples (Figures 2-4). The mean concentrations and standard deviations of the phenolic compounds which were identified and quantified in all the three sample categories are presented in Tables 1 and 2.

Table 1. Twelve phenolic compounds identified and quantified in stem heartwood from final cutting harvest Scots pine tree samples.

Compound Name	RT (min)	Mean Conc. (µg/mg)	Number of Samples (N)	Std. Dev	Std. Error
Pinosylvin	34.7	2.5543	69	1.2602	0.1517
PSMME	46.9	4.8806	69	2.1704	0.2613
PS Glycoside	32.9	0.0611	69	0.0351	0.0042
PSMME Glycoside	45.4	0.0907	69	0.0645	0.0078
Vanillic Acid	8.5	0.0067	69	0.0027	0.0003
Piceatannol	22.1	0.0067	69	0.0057	0.0007
Eriodictyol	39.3	0.1226	69	0.0693	0.0083
Lignan 1	7.1	0.0962	69	0.0267	0.0032
Lignan 2	14.3	0.0771	69	0.0500	0.0060
Lignan 3	24.3	0.0726	69	0.0289	0.0035
Neolignan 1	17.3	0.3031	69	0.2055	0.0247
Neolignan 2	20.7	0.1656	69	0.1774	0.0214

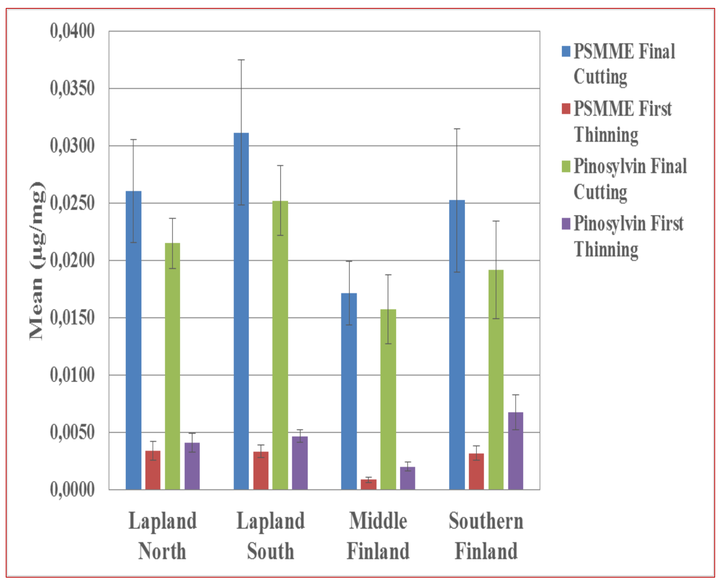

Figure 2. Mean plots for the effect of region and tree age on the concentration of pinosylvin and pinosylvin monomethylether (PSMME) in mature and young Scots pine stem sapwood samples. Error bars = standard errors of mean.

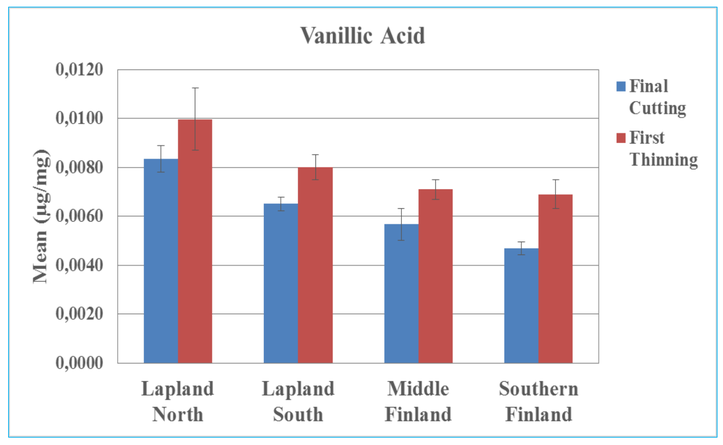

Figure 3. Mean plots for the effect of region and tree age on the concentration of vanillic acid in mature and young Scots pine stem sapwood samples. Error bars = standard errors of mean.

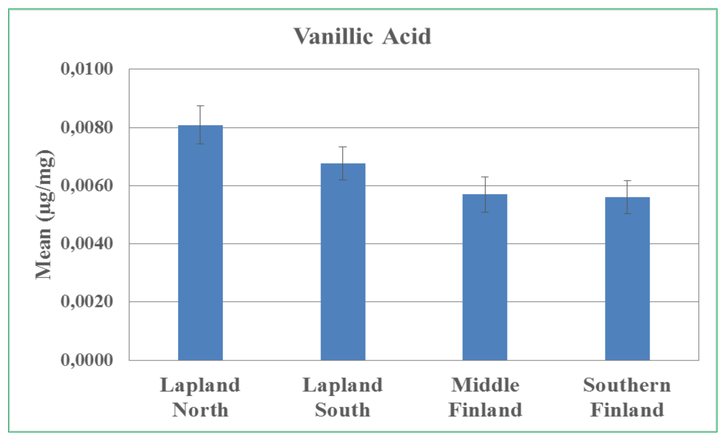

Figure 4. Mean plots for the effect of region on the concentration of vanillic acid in mature Scots pine stem heartwood samples. Error bars = standard errors of mean.

Conclusion

Twelve compounds were identified in heartwood while only three compounds were present in sapwood samples. The study confirmed with results from other studies that stilbenes (pinosylvin monomethylether and pinosylvin) are the dominant phenolic compounds in Scots pine stem wood. However, we got lower yields compared to what has been reported in literature. In sapwood, the concentrations of pinosylvin and PSMME were significantly higher in final cutting than in first thinning harvest samples. The concentration of vanillic acid seemed not to be affected by neither tree age nor type of wood (sapwood / heartwood) but it was rather affected by other factors like climatic conditions due to different regions. Its concentration increased in poor growth conditions.

Acknowledgements

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Table 2. Three phenolic compounds identified and quantified in stem sapwood from first thinning and final cutting harvest Scots pine tree samples.

Sample Type	Compound Name	RT (min)	Mean Conc. (µg/mg)	Number of Samples (N)	Std. Dev	Std. Error
Young Pine	Pinosylvin	34.7	0.0048	69	0.0046	0.0005
	PSMME	46.9	0.0030	69	0.0029	0.0003
	Vanillic Acid	8.5	0.0082	69	0.0038	0.0005
Mature Pine	Pinosylvin	34.7	0.0211	66	0.0135	0.0017
	PSMME	46.9	0.0261	66	0.0233	0.0029
	Vanillic Acid	8.5	0.0065	66	0.0022	0.0003

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