NOVEMBER 2018 | # 33

Extractives

Wood extractives provide a potential source for several types of high value platform and specialty chemicals, such as pharmaceutical or nutritional products, cosmetics, beverages, wood adhesives, paints, wood protection agents, plant-protective products and detergents.

WHAT ARE THE EXTRACTIVES?

Extractives can be broadly defined as the nonstructural constituents of wood which can be removed via extraction with neutral organic solvents or water. Thus, the extracted substances may be either lipophilic or hydrophilic.

Extractives occupy specific morphological sites in the wood structure. Despite normally being minor substituents of wood, the extractives are important factors influencing such properties of the wood as odor, color, light stability, decay and insect resistance, density, flammability, hygroscopicity, permeability, ease of pulping, density, paintability, etc. Extractives comprise an extraordinarily large number of diverse substances, i.e., several thousands of individual components, mainly with low molecular masses (table 1).

BIG VARIATION BETWEEN AND INSIDE SPECIES

The extractives content and composition varies between tree parts and tree species (table 2). This in turn has effects on the supply of raw materials, sampling and sorting if the aim is to procure raw materials containing specific extractives or to avoid certain extractives in the raw materials. There are considerable differences between extractives in softwoods and hardwoods, for example resin acids occur only in softwoods.

Even in a given species, the amount and composition of wood extractives may vary significantly between trees. Further variation can be observed, often systemically, within a single stem section from the base to the top and from the pith to the bark.

For example, Norway spruce stemwood doesn't contain any tannins whereas Norway spruce bark contains 10-13 % tannins. Another good example is stilbenes. The stemwood, or heartwood, of Norway spruce does not contain detectable amounts of stilbenes whereas the inner bark contains 5-15 % stilbenes. Both stilbenes and tannins have interesting bioactive properties and thus, potential to be used in high-value end products.

In addition, the age of a tree has effects on the extractives of the tree; for example, older trees contain more extractives in their heartwood than young trees.

EXAMPLE OF EXTRACTIVES IN SPRUCE BARK

Example of the extractives fractions in fresh spruce bark, coming from the BioHub storage study saw logs, can be seen in figure 1.

In literature, extractives are sometimes defined solely based on the lipophilic extractives a.k.a "resin" in common language. This definition however doesn't consider that most of the extractable material in wood (86 % in the example below) is hydrophilic in nature.

Table 1. Classification of extractives in woods (Alén 2000).

Aliphatic and alicyclic compounds	Phenolic compounds	Other compounds
Esters of fatty acids (fats and waxes)	Simple phenols	Sugars
Fatty acids and alcohols	Stilbenes	Cyclitols
Alkanes	Lignans	Tropolones
Terpenes and terpenoids (including resin acids and steroids)	Isoflavones	Amino acids
	Condensed tannins	Alkaloids
	Flavonoids	Coumarins
	Hydrolysable tannins	Quinones

Table 2. Proportion of extractives in different parts of common Nordic wood species according to different studies, as dry mass percentages [2].

	Picea abies	*Pinus sylvestris*	*Betula pendula*	*Betula pubescens*
Stemwood	**1.3-4.5**	**1-6.8**	**0.8-5**	**0.8-6.7**
Sapwood	1.7-2.7	3.1		
Heartwood	1.1-1.8	5.1-5.35		
Branchwood	**6.8-13.7**	**8.4-14.1**	**1.7-7.6**	**1.9-9.7**
Knots		24.6		
Stump	**1.9-3.6**	**6.5-18.7**	**3.6**	**5.8**
Rootwood	**2.4-6.5**	**4.2-6.4**	**5.8-12.1**	**7.9**
All bark	**23.5-28.3**	**16-25.9**	**8-30.7**	**10.9-33**
Inner bark	17.3-38.7	15.4-41.9	14.3-18.9	9.6-22.5
Outer bark	19.1-29.2	16.4-20.8	32.1-56.9	31.4-57.8
Foliage	**37.8-43.3**	**38.6-40.6**	**28.8-33.4**	**32.4-32.5**

From the developmental point of view, it is the hydrophilic extractives which harbor most of the potential for high-value products. In the example in figure 1, hexane and water ASE extractions were used for separating the lipophilic and hydrophilic extractives respectively.

The main lipophilic extractives groups were resin acids, fatty acids, triglyserides, sterols and diterpenoids, while the main hydrophilic extractives groups were sugars, organic acids, alcohols, stilbenes and lignans. The hydrophilic extractives are more reactive and degrade much faster during the storage of the wood.

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2018.11.12

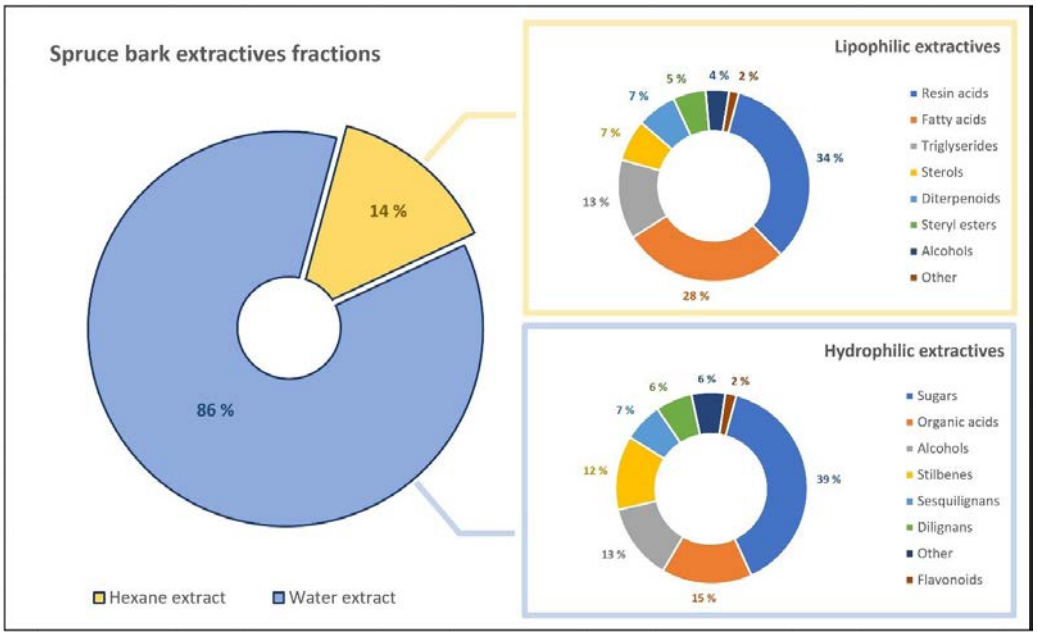

Figure 1. The extractives fractions of fresh spruce bark collected from the same sample using consecutive hexane and water ASE extractions. Lipophilic and hydrophilic extractives groups are displayed separately.

References:

[1] Alén, R. 2000. Structure and chemical composition of wood. In: Stenius, P. (ed.) Forest Products Chemistry: 11-57. Gummerus Printing. Jyväskylä, Finland.

[2] Routa, Brännström, Anttila and Mäkinen 2017. Wood extractives of Finnish pine, spruce and birch – availability and optimal sources of compounds - A literature review. Natural resources and bioeconomy studies 73/2017. Available in: http://jukuri.luke.fi/bitstream/handle/10024/540829/luke-luobio_73_2017.pdf.pdf?sequence=1

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