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Composition and Properties of Birch Sap and Syrup

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University of Turku

Non-Wood Forest Products
Health and Wellbeing
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Strategy of Natural Compounds Research
Food Chemistry and Food Development, UTU

Composition and chemical properties of bioactive natural compounds

Physiological and sensory properties of the bioactive compounds and components

Food-applicable raw materials

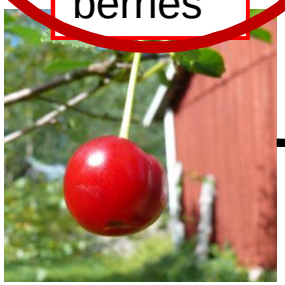
1. Seed oils by CO_2 extraction

2. Birch syrup by reverse osmosis

Development of foods with special properties

1. Common Strategies of Berry Processing

berries



Juice processing

other processes

press residue

partially pressed berries

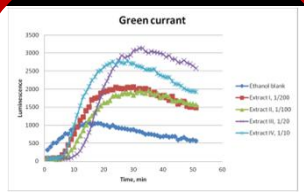
juice

Dried residue
Food fiber
Cutin for plastics
Phenolic extracts
Bakery products
Extrudates
Food color
Lecithin
?

Seed oil

pre-treatment, stabization, refining

oil extraction



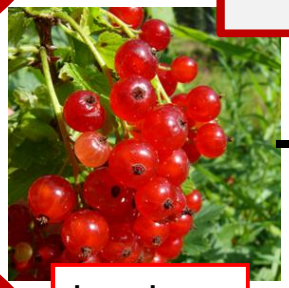
Antioxidant actvity ?

1. Common Strategies of Berry Processing

Dried residue
Food fiber
Cutin for plastics

From berries to seed oils by supercritical CO2 processing

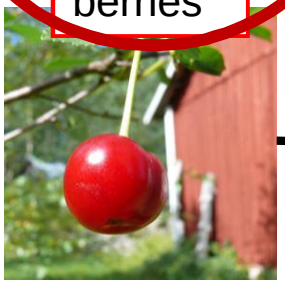
Seed oil



berries

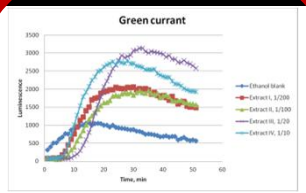
Lecithin

press residue



partially pressed berries

juice



Antioxidant actvity ?

pre-treatment, stabization, refining

oil extraction

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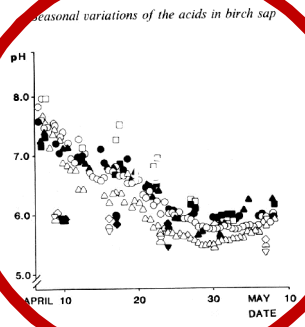
2. Common Strategy of Birch Syrup Processing

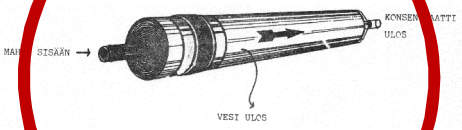
birch



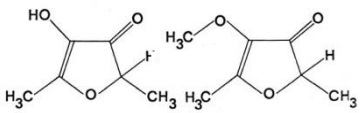
properties

products

marketing



technology



composition

design

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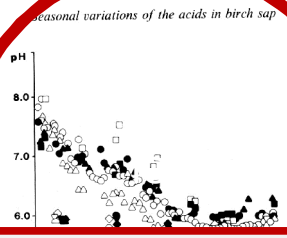
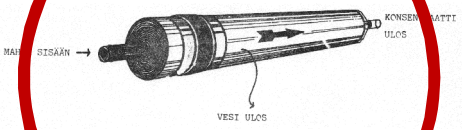
2. Common Strategy of Birch Syrup Processing



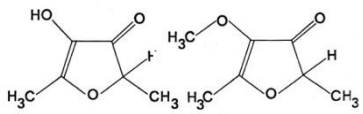
birch

From sap to syrup by reverse osmosis and vacuum evaporation

marketing



technology



composition

design

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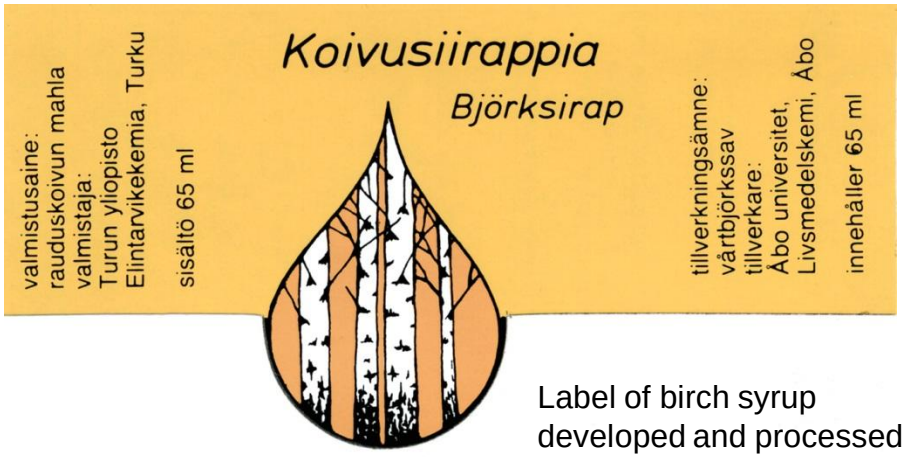
Why Birch Sap Research?

- A non-exploited natural resource
- In abundance in Finland
- Maple sap/syrup as a model
- Traditional use and folklore supports the endeavour
- Health claims in the air
- Technological and scientific interest
- New topics encouraged us



Label of birch syrup developed and processed at the University of Turku

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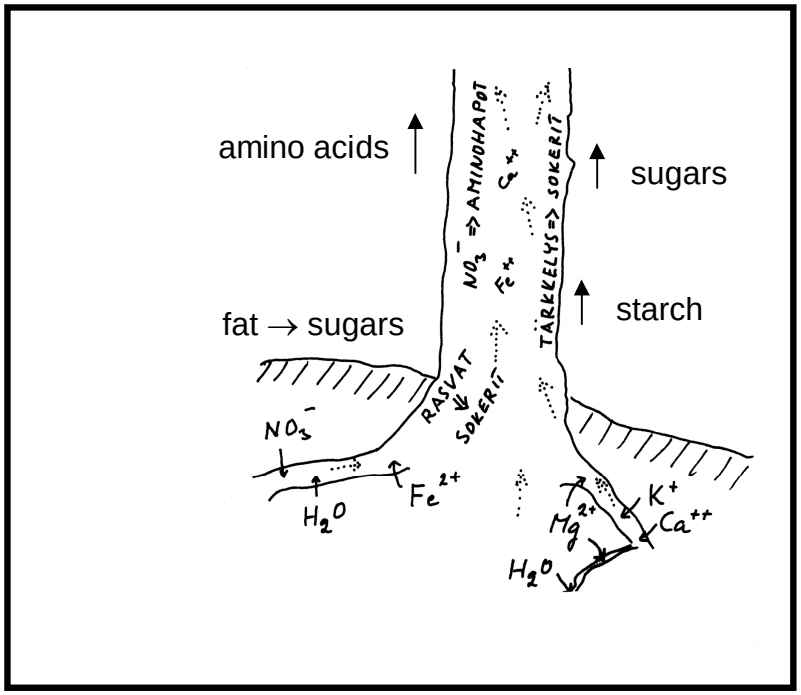
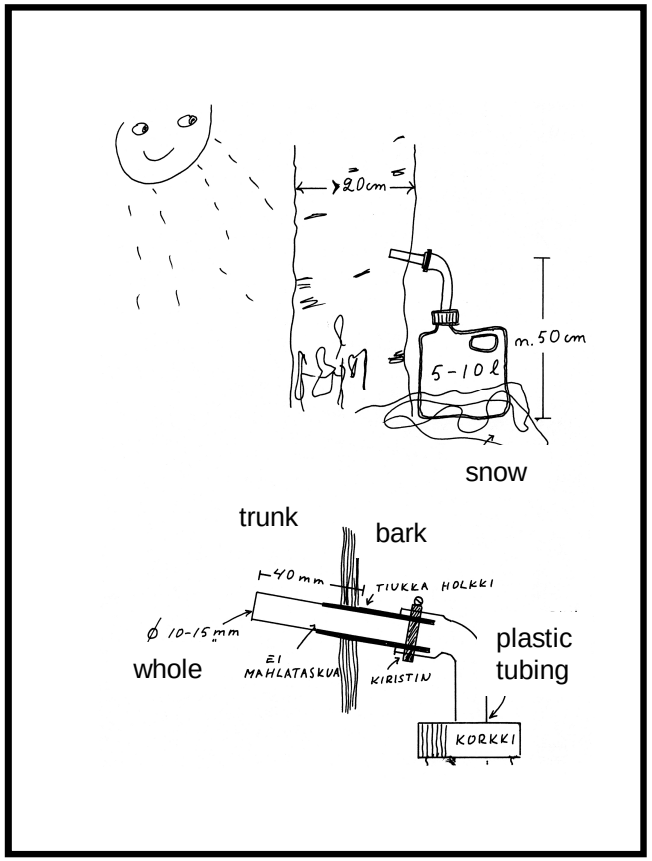
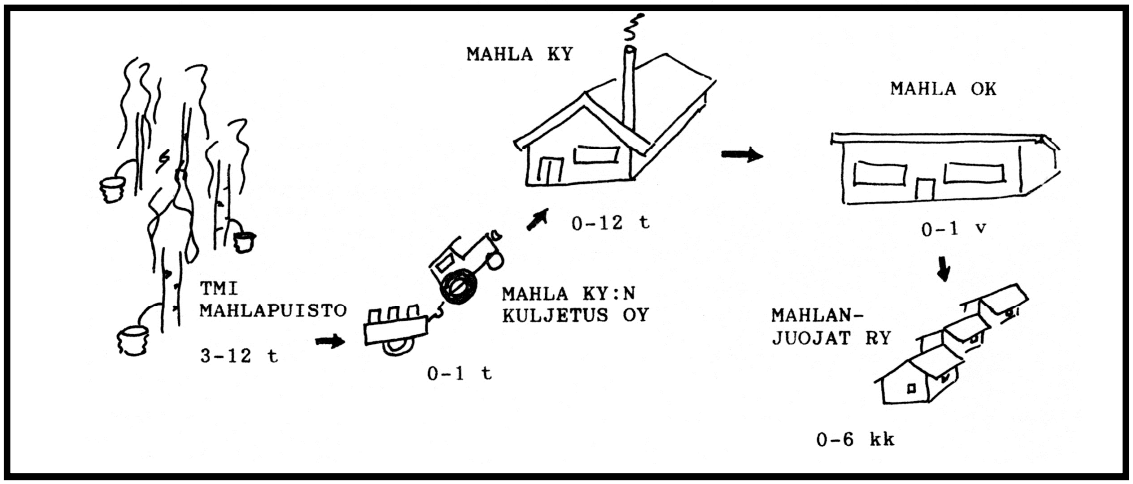
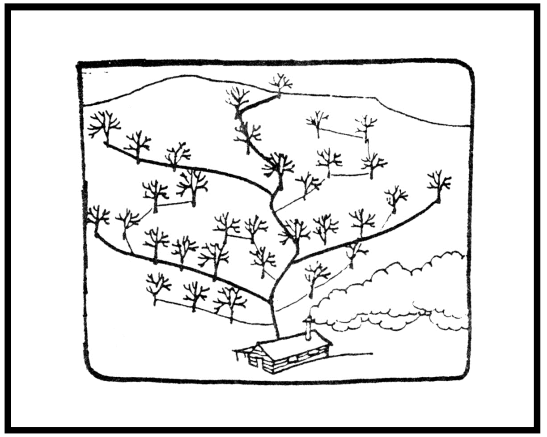
Sap collection









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What Are the Birch Sap and Syrup

- Sap in xylem under pressure in spring in birch tree
- Transports nutrients from the roots and trunk to the leaf buds
- A dilute solution (1 %) of important nutrients
- The energy stored in roots collected in the previous year
- Sap may be collected during one to two weeks
- The flow ends when the leaves are opening
- Sap sterile whilst in the tree
- Aseptic collecting *via* a drilled hole possible
- Easily spoiled by microbes
- 90 % of the dry matter sugars - sweet
- Syrup is concentrated and processed sap

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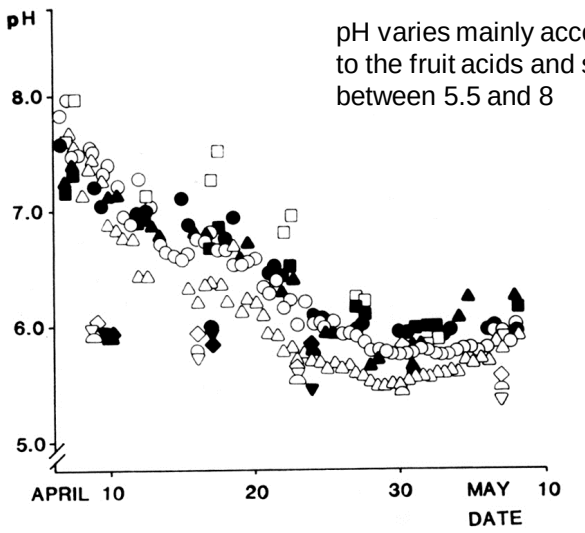
Composition of Birch Sap

- Soluble solids: 0.5 – 1.1 °Brix
- Sugars: glucose, fructose (low in sucrose, galactose?, inositol?)
- Minerals: K, Mg, Ca (low in Na)…
- Acids: malic acid, succinic (phosphoric, citric, fumaric)
- Free amino acids: citrulline, glutamine, asparagine…
- Proteins: A wide variety (enzymes)

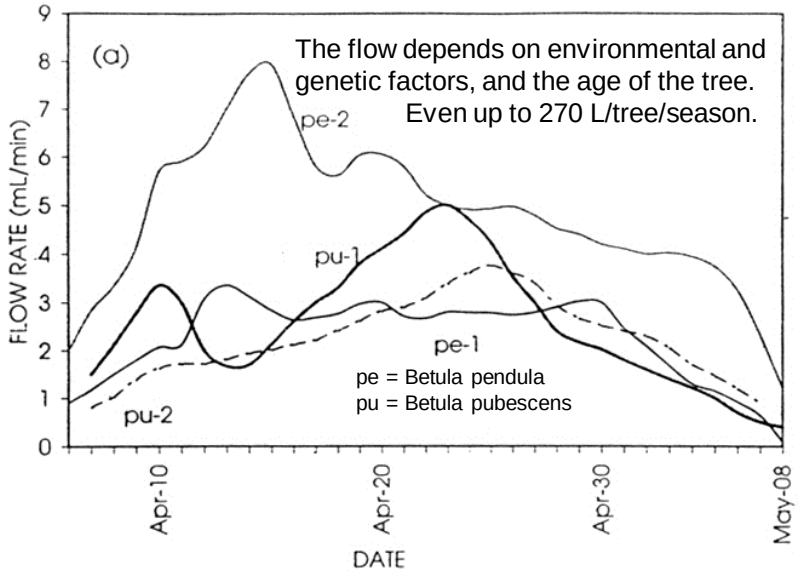
Titles in local newspapers at the moment of the research activity peak

Seasonal variations of pH in birch sap



pH varies mainly according to the fruit acids and salts between 5.5 and 8

Seasonal flow rates of birch sap



The flow depends on environmental and genetic factors, and the age of the tree. Even up to 270 L/tree/season.

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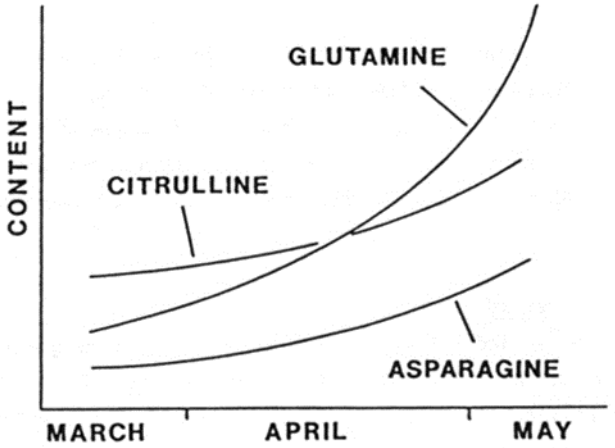
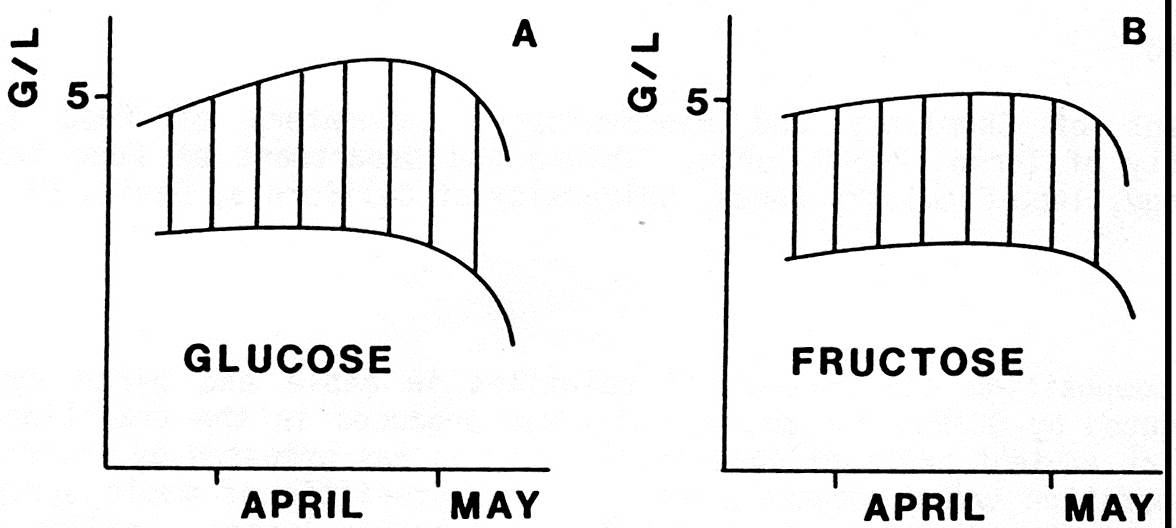
Kallio
Frontiers of Flavor
1987, 241-248.

Sugars, Fruit Acids and Amino Acids in Birch Sap

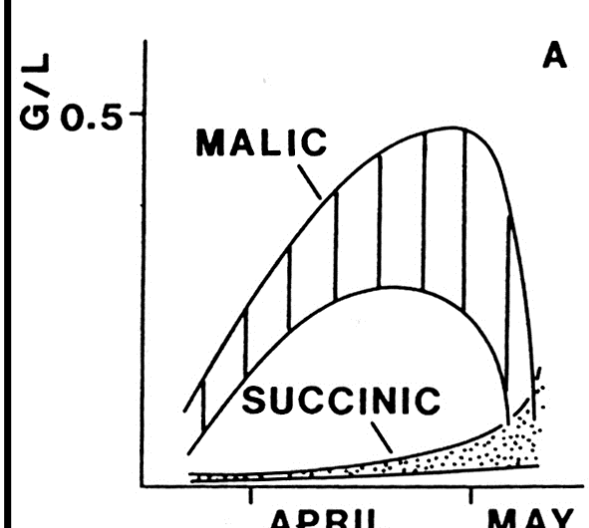
- The proportion of glucose of total sugars decreases during the season
- Low free amino acids expected



Typical changes of some amino acids



Typical changes of glucose and fructose in spring sap



Typical changes of malic and succinic acids

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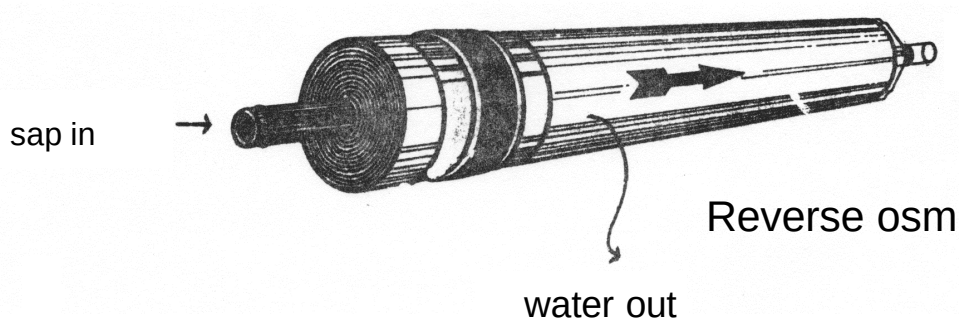
Birch syrup process

- High quality raw material (place of growth, time of season, microbiology)
- Processing of syrup = controlled removal of water
- A part of water may be removed by boiling
- Chemical reactions increase (color, flavor)
- **Reverse osmosis** instead of boiling (semi-permeable membrane)→ 10-20 %
- **Vacuum evaporation** (→ 70 %)
- May be **filtered** (precipitated proteins)
- Desired, optimized **thermal processing** (caramellization, Maillard reaction)



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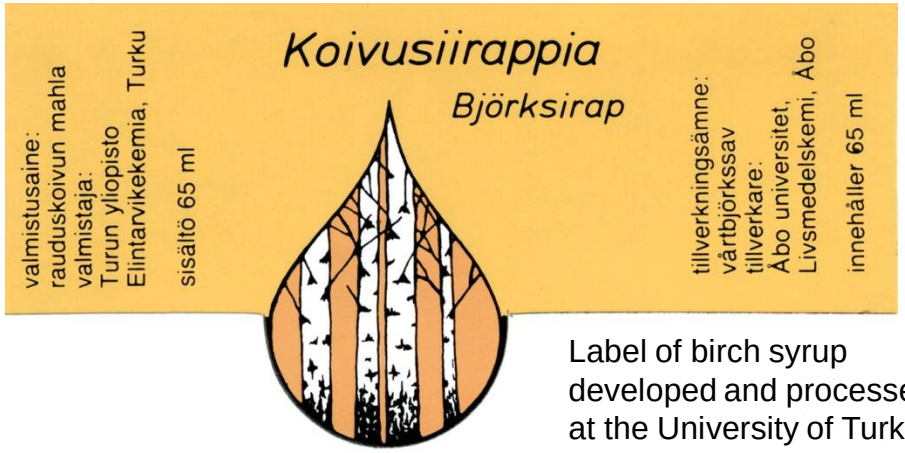
Birch syrup

- Dry matter higher than in maple syrup (difference in sugars)
- Glucose + fructose (invert sugar) susceptible for color and flavor formation
  - Maillard reaction (amino groups + reducing sugars)
  - Caramellisation (sugar reactions)
- Desired color/flavor with optimized heating process
- More acidic than maple syrup (lower sigar/acid ration)
- More salty then maple syrup (higher K, Ca, Mg)
- Susceptible for color/flavor changes during storage

Heatinig (0 to 10 min at 100 °C) of birch syrup reduced the aroma intensity of ”vanillin”, had no effect on ”furaneol” and increased ”burned aroma”. (*Food Chem.* **1987**, *24*, 287-299)

Moisture-temperature conditions are critical.



Label of birch syrup developed and processed at the University of Turku

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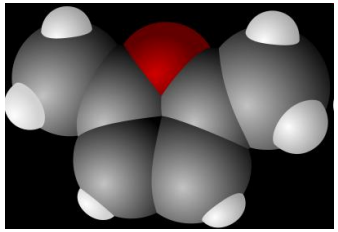
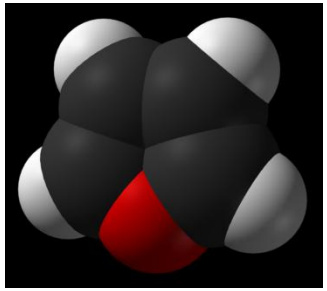
Some birch syrup aroma compounds

Volatile aroma compounds of birch syrup

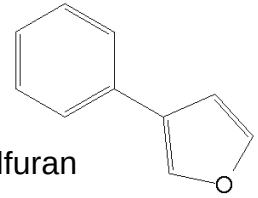
Furan
2-methylpropanal
2-methylfuran
3-methylbutanal
2-methylbutanal
2,5-dimethylfuran
2,3-pentanedione
Dimethyldisulphide
Octanal
Benzeneacetaldehyde
3-phenylfuran
2,5-dimethyl-4-hydroxy-3(2H)-furanone
Vanillin



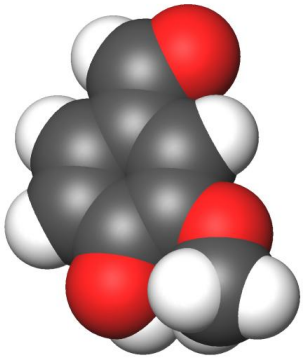
2,5-dimethylfuran



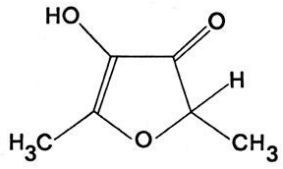
furan



3-phenylfuran



4-hydroxy-3-methoxybenzaldehyde = ”vanillin” (the most potent aroma compound of vanilla)



2,5-dimethyl-4-hydroxy-3(2H)-furanone = ”furaneol” © (A typical result of both caramellization and Maillard reaction. Common in roasted almonds, soy suce, roasted coffee, maple syrup…)

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History of Finnish Birch Sap and Syrup (UTU 1985-1995)

Kallio, H.; Lahdenoja, M-L.; Penttinen, R.; Electrophoretic profiles of birch sap proteins of *Betula pubescens*, *B. pendula* and *B. pendula* forma *carelica* in Finland with reference to overall composition of sap. The 1st International Symposium on Sap Utilization (ISSU) in Bifuka '95, Bifuka, Hokkaido, Japan, April 10-12, 1995, 13-21.

Kallio, H.; Aroma of birch syrup, *J. Agric. Food Chem.* **1989**, *37,* 1367-1371.

Kallio, H.; Ahtonen, S.; Identification and seasonal variation of amino acids in birch sap used for syrup production. *Food Chem.* **1989**, *33,* 125-132.

Kallio, H.; Teerinen, T.; Ahtonen, S.; Suihko, M.; Linko, R. R.; Composition and properties of birch syrup (Betula pubescens). *J. Agric. Food Chem.* **1989**, *37,* 51-54.

Kallio, H.; Comparison and characteristics of aroma compounds from maple and birch syrups. In: George Charalambous (Ed.), Proc. 5th Int. Flavor Confer., Porto Carras, Greece, July 1-3, 1987, Elsevier, Amsterdam, 1988, pp. 241-248.

Kallio, H.; Ahtonen, S.; Seasonal variations of the acids in birch sap. *Food Chem.* **1987**, *25,* 285-292.

Kallio, H.; Ahtonen, S.; Seasonal variations of the sugars in birch sap. *Food Chem.* **1987**, *25,* 293-304.

Kallio, H.; Rine, S.; Pangborn, R-M.; Jennings, W.; Effect of heating on the headspace volatiles of Finnish birch syrup. *Food Chem.* **1987**, *24,* 287-299.

Kallio, H.; Karppinen, T.; Holmbom,B.; Concentration of birch sap by reverse osmosis. *J. Food Sci.* **1985**, *50*, 1330-1332.

Kallio, H.; Ahtonen, S.; Raulo, J.; Linko, R. R.; Identification of the sugars and acids in birch sap. *J. Food Sci.* **1985**, *50* , 266-267, 269.