

DECREASE IN EXTRACTIVES OF CHAIN-FLAIL RESIDUE

Branches, stem, bark, and the small diameter stem tops of whole-trees can be mechanically removed by chain-flail technology. The result is a near bark free stem for pulping industry and a mixed residue of wood, bark and needles. The study material composed of Scots pine whole-trees provided by UPM. The study was carried out at theon company terminal in Pietarsaari, Finland. The chain-flail technology was provided by Ari Hooli of Kemi, Finland. The gravimetric amount of extractives was halved during the first 4 weeks of storage. The biggest losses occur in the amount of acetone:water soluble extractives fraction.

INTRODUCTION

The forest industries use annually substantial volumes of wood resources in Finland and Sweden. As a result of this utilization the formation of harvesting and manufacturing by-products such as stumps, branches, and bark is significant.

Many initial extracts suitable for potential applications are either rather volatile or chemically unstable. The content of extractives starts to decrease immediately after tree felling and this degradation continues during storage (Alén 2000, Ekman 2000). This also means that the chemical composition of the extractives-based fraction changes gradually.

After felling the tree, the content of resin starts to decrease immediately and the chemical composition of this fraction changes (Alén 2000). Several factors determine the nature and rate of changes in the properties of wood resin (Ekman 2000). These factors include the particular type of harvesting, transportation, storage and inventory-control systems of the wood used at the mill. They also depend on the tree species available, time in storage, physical form of the wood, and the weather and other environmental conditions during all phases of the wood-handling process.

Living cells are contained in the bark, foliage, and wood when the tree is cut (Fuller 1985). These cells remain viable for long periods of time when the wood is stored in log form. When wood is chipped and placed in a pile, the living parenchyma cells respire in an attempt to heal the tree. Oxygen is consumed and heat is released. This heat generation provides good growth conditions for bacteria, which feed on the extractives in the wood. After a period of 7-14 days, it is not unusual that the temperature of the chip pile has reached already about 50 °C (Nurmi 1999). The rate of heating is influenced by the rate of pile construction and the freshness of the wood. Also wood species and season of the year affect the temperature build-up.

The major chemical changes in the resin during wood storage can be divided into three groups: (1) rapid hydrolysis of triglycerides accompanied by slower hydrolysis of waxes, especially steryl esters,

(2) oxidation/degradation/polymerization of resin acids, unsaturated fatty acids and to some extent other unsaturated compounds, and (3) evaporation of volatile terpenoids, especially monoterpenoids (Ekman 2000). It should be pointed out that these reactions are markedly faster when the wood is stored in the form of chips instead of logs (Alén 2000). Promberger et al. (2004) concluded in their research that the faster deterioration of compounds in wood chips is due to larger surface which makes substances more easily accessible. Increasing ventilation, and thereby increased access of air oxygen in the chip pile, further fastens evaporation and oxidation reactions (Ekman 2000). As an example, it has been reported that the degree of hydrolysis of triglycerides after eight weeks of outdoor chip storage was about the same as for roundwood storage for one year.

The present study focuses on changes in the chemical composition of chain-flailing residue during storage of 24 weeks.

EXPERIMENTAL SET-UP

The pine whole-trees were chain-flailed in a UPM terminal in Pietarsaari, Finland. The residue composed of branch and small diameter stem tops, bark and needles. A 150 m³ storage pile was piled. The sampling frequency was at the time of experiment initiation, 1, 2, 4, and 24 weeks of storage. Four different samples were taken at every sampling time, representing all areas of the pile. The samples were analyzed with respect to their extractives content. Subsequent Soxhlet extractions with two solvents (first with hexane and then with a mixture of acetone:water, 95:5 V:V) were conducted. The extractives in various groups were chromatographically (GC/FID) determined according to the method presented by Örså and Holmbom (1994).

RESULTS AND DISCUSSION

The gravimetric amount of extractives decreased significantly during storage (Fig. 1). The extractives amount is roughly halved during the first 4 weeks of storage. The biggest losses occur in the amount of acetone:water soluble, i.e. hydrophilic extractives fraction, although the amount of lipophilic extractives decreased as well.

In the case of chain-flailing residue, not only the amount of triglycerides decreased remarkably but also the amounts of free fatty acids decreased significantly (Fig. 2). The amount of resin acid fraction seemed to be fairly constant during 6 months of storage. It should be pointed out that after 24 weeks of storage there are no lignans left in this material.

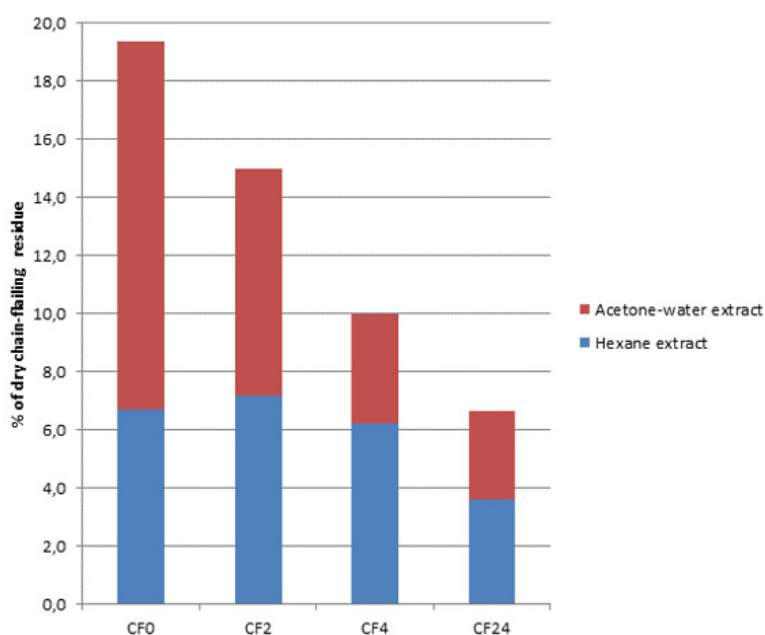
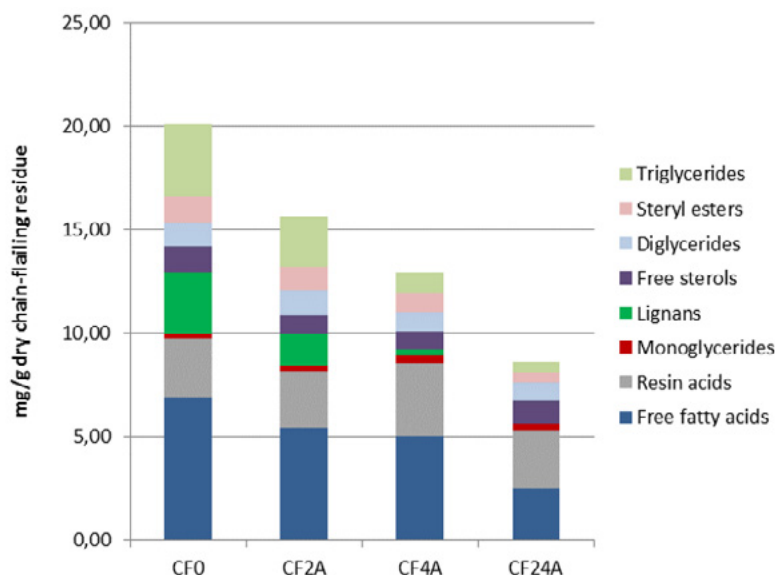


Figure 1. Gravimetric extractive amounts of uncompact chain-flailing residue. Key: CF0 = Chain-flailing residue sample taken before storage
CF1 = after 1 week
CF2 = after 2 weeks
CF4 = after 4 weeks
CF24 = after 24 weeks.

Based on the results of this storage study it can be concluded that the extractives content decreased notably during storage, already during the first 4 weeks. Also, the composition of this fraction changed during storage and valuable bioactive compounds were lost among others. Thus, the freshness of the feedstock and recovery logistics is of major importance in process concepts aiming at the recovery of extractives.

Figure 2. Extractives group analysis for softwood bark. Key:
 CF0 = Chain-flailing residue sample taken before storage
 CF2 = after 2 weeks
 CF4 = after 4 weeks
 CF24 = after 24 weeks
 A = one of the four sample positions, in the bottom of the pile



LITERATURE

1. Alén R (2000). Structure and chemical composition of wood. In P. Stenius (Ed.), Forest Products Chemistry). Fapet Oy: Helsinki, Finland, p. 12.
2. Ekman R (2000). Resin during storage and in biological treatment, In E.L. Back, (Ed.); Pitch Control, Wood Resin and Deresination, Tappi Press: Atlanta, USA, pp. 37-76.
3. Ekman, R. (2000) Resin during storage and in biological treatment, In Pitch Control, Wood Resin and Deresination, Back, E.L., Ed.; Tappi Press: Atlanta, USA, pp. 37-76.
4. Fuller, W.S. (1985). Chip pile storage – a review of practices to avoid deterioration and economic losses, The Journal of the Technical Association of the Pulp and Paper Industry, 68, pp. 48-52.
5. Nurmi, J. (1999). The storage of logging residue for fuel. Biomass and Bioenergy. 17:41-47.
6. Promberger, A., Weber, H. K., Stockinger, A., Sixta, H. Investigation of storage conditions on beech wood logs and chips and its influence on the production of dissolving sulfite pulp. Lenzinger Berichte, 2004, 83, pp. 17-23.
7. Örså F, Holmbom B (1994): A convenient method for the determination of wood extractives in papermaking process waters and effluents. J. Pulp Pap. Sci., 20:12, p. 361.

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