Hop

Introduction

Hop (*Humulus lupulus L.*) is a perennial dioecious climber of the Cannabaceae family, which produces clusters of either female or male flowers. Female inflorescences possess numerous glands with volatile oils that produce the characteristic flavors. They are mainly used to impart bitterness, flavor and preservation properties in beer production and herbal medicine. Wild hops are widely distributed throughout the Northern Hemisphere i.e. Europe, Asia and North America. Hop belongs to the same family (Cannabaceae) and genus (Cannabis) as hemp.

Fiber extraction

Two different methods for fiber extraction were examined. The first method that was used was chemical fiber extraction, where dried and non-retted hop stems were boiled in 0.5 N NaOH for 30 min with a material to solution ratio of 1:10. Afterwards the stems were thoroughly washed first in warm water of 60°C and neutralized in dilute acetic acid solution of 1% to remove any remaining alkali. After the rinsing process the fibers were manually extracted from the wet stems and air dried. Water retting was the second method used. Dried and non-retted hop stems were soaked for 2 weeks in a water bath of 20°C, followed by a manual extraction of the fibers from the wet stems and air dried. After the extraction process the dried fibers were mechanically carded to refine the fibers.

Fiber composition and properties

The composition of the hop stem fibers in terms of cellulose, lignin and ash content was determined by Reddy & Yang (2009) using standard test methods. It was found that hop stems contain cellulose fibers with properties similar to hemp. The hop stem fibers have a high cellulose content and a relatively low lignin content whereas single cells in hop stem fibers are much shorter and wider than cotton and hemp.

	Hop fibers	Cotton	Hemp
Cellulose %	84 ± 1.6	84 ± 1.6	55–72
Lignin %	6.0 ± 0.2	0.7–1.6	2–5
Ash %	2.0 ± 0.1	0.8–2.0	1

Fibers obtained from hop stems were coarser than cotton and hemp. The average length of hop stem fibers is much higher than that of cotton and in the range of lengths reported for various bast fibers including hemp. Breaking tenacity of the hop stem fibers was higher than that of cotton and close to that of the hemp fibers. Elongation of the hop stem fibers is lower than that of cotton but higher than the elongation of hemp fibers. Moisture regain of hop stem fibers is similar to that of cotton and slightly lower than that of hemp.

Fiber properties	Hop stem fibers	Cotton	Hemp
Fineness (denier)	48±1.9	3-8	-
Length (cm)	11.5±2.9	1.5-5.6	-
Strength (g/den)	4.1±1.9	2.7-3.5	5.2-6.8
Elongation (%)	3.3±1.2	6-9	1.7-2.6
Moisture regain (%)	8.3±0.4	7.5-8	12

Reddy et al. 2015

The length and the mechanical properties of the fibers which were obtained in the SUSTEX project by chemical and water retting are shown in the table below and compared with the results that are given in literature (Reddy et al. 2009).

	Mean+ STDEV		Reddy et al. 2009
	chemical retting	water retting	
Fineness (tex)	5,9 ± 2,6	11,6 ± 6,2	5,3 ± 2,1
Lenght (mm)	58,2 ± 9,1	47,9 ± 8,6	115 ± 29
Tenacity (cN/tex)	13,5 ± 7,5	9,5 ± 4,1	36,3 ± 16,8
Elongation (%)	2,8 ± 1,9	2,1 ± 1,2	3,3 ± 1,2

Fineness and elongation of the chemical retted fibers were comparable to those in literature (also chemically retted) whereas the water retted fibers were coarser and stiffer. The fiber length and tenacity of both chemical and water retted fibers were much lower than the results found in literature. This may be caused by e.g. difference in treatment, difference in growth of the plants, difference between male and female plants used, etc.

Conclusion and outlook

- Hop stem fibers were used centuries ago to produce coarse cloth
- Properties of the hop are placed it between hemp and cotton
- Results in SUSTEX are generally comparable to the literature. Limited amount of material was tested, the reproducibility has to be confirmed
- Optimization of the extraction procedure needed to envisage fibers suitable for textile applications.