

Modification and characterization of European wood species as an alternative to Incense- cedar (*Calocedrus decurrens*) for pencil production

► Abstract

Caran d'Ache, the Swiss pencil manufacturer, intends to offer more sustainable product lines by replacing incense- cedar, an American wood species, with local wood in pencil production. Usually treated with a solution of dyes and wax, incense- cedar pencils present an excellent sharpening performance. The presented work aims to test wood modification procedures in six European wood species to improve their sharpening performance. The work comprised four parts: characterization of wood anatomy of the studied species, the validation of a method for assessing pencil sharpening effort, evaluation of wood impregnation of the different species with paraffin emulsion and testing of pencils from impregnated wood. The anatomical investigations indicated latewood width and early to latewood density ratio to be the most relevant features influencing pencil sharpening. The impregnation of wood was possible for most of the tested species and showed positive influence on reducing the needed force to sharpen the pencils.

► Experimental

Microscopy blades were prepared for observation in light microscope from each of the species and anatomical elements were measured.

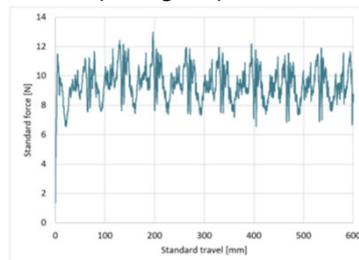
From a device constructed in BFH which, when attached to a testing machine, measures the force necessary to sharpen a pencil, preliminary testing rounds for validation of the method were carried out. The main variables of the testing setup that influence the sharpening results were identified and the analysis of the data for characterizing and comparing the sharpening effort of pencils was defined. The sharpening effort of standard Caran d'Ache pencils was quantified as a reference.

Pencil slats of the studied wood species were impregnated in autoclave with solutions of paraffin and dyes in four impregnation rounds.

Pencils from untreated wood and from the impregnated slats of the last two impregnation rounds were produced and evaluated regarding their sharpening properties.

latewood and annual ring width, and the proportion of cell wall/lumen in latewood and earlywood. Incense- cedar showed a particular combination of these features which was not similar in any of the other species.

The two most important dependent variables that characterize the sharpening effort of a pencil were concluded to be the average sharpening force and the sharpening amplitude.



Example of the resulting diagram from a run of pencil sharpening test.

Incense- cedar wood showed to be very easy to treat, in concordance to the literature. Other wood species, like silver fir, required more time in the autoclave for good penetration of the solution. Some others showed very small permeability, such that the desired concentration and solution distribution could not be reached.

Some wood species presented good sharpening properties even without impregnation. For others, homogeneous paraffin impregnation of around 1.5% final content in wood, showed to be effective in reducing the average sharpening effort of around 40%, obtaining values close to standard Caran d'Ache pencils.

the different wood species provided a better understanding of their behavior in the later steps of the study, as wood impregnation and pencil sharpening, but additional investigation of other wood properties is recommended.

The defined methodology of assessing pencil sharpening effort was suitable for comparing different types of pencils. Further research needs to be done to better understand test variables, noise data and repeatability.

Despite good results in average sharpening effort, paraffin impregnation was less effective regarding homogeneity in sharpening. Higher force peaks could be observed.



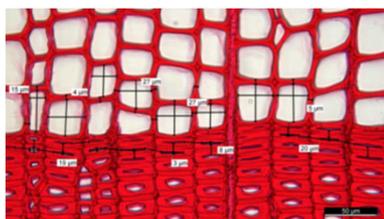
Evaluation of pencils produced with local wood impregnated with solution of paraffin and dyes.

The results of the present study showed that it is possible to achieve good sharpening properties in local wood species with a modification procedure with wax impregnation.

The adjustment of the procedure, quality sorting of the wood and evaluation of their performance in other aspects of pencil production are the next steps towards finding a viable alternative to the replacement of Incense- cedar in the pencil industry.

► Results

The most relevant features of the different softwood species were identified to be the ratio between



Measurement of tracheid cells at transverse plane 40x magnification.

► Conclusion

The anatomical investigation of



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