

POTENTIAL NEW WOOD SPECIES FOR THE FURNITURE INDUSTRY

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Link to this article: <https://doi.org/10.11118/978-80-7701-044-3-0035>

Abstract

The effects of climate change, which are becoming more pronounced today, mean that unconventional wood species must be used in the wood industry, of which the furniture industry is an important integral part. Less used wood species for furniture are poplar and robinia. Poplar is unsuitable as a surface component because of its low density, hardness, etc. This can be improved by compression, which would significantly increase the usability of this species, which is found in large quantities worldwide. The Brinell-Mörath surface hardness can be improved up to 22 MPa. Robinia already has interior, furniture and outdoor furniture applications, but its difficult machinability and variable colouration, especially in the case of so-called „black stripe“ discolouration, are major limiting factors. The latter can be improved by various thermal treatments. For this purpose, dry thermal-treatment was considered to be a better solution than steaming in water vapour.

Keywords: black stripe, colour, cielab, hardness, thermal treatment, steaming

INTRODUCTION

Uncountable wood species may be available for further uses, for example as furniture or at least as furniture parts. The woodworking industry is slow to accept new wood species and raw materials, so good preparation is needed before a new material is introduced. At the same time, there is time and opportunity to think through and study the possibilities in depth. There are many species of wood found in large quantities throughout Europe, including Hungary, which have limited use. In addition to rethinking the methods of use, this can be helped by the improvement (modification) of wood, for which there are a number of methods already in operation or under development. In this study, two such options are discussed.

Poplar Top Layer for Furnitures

The aim of our research is to use poplar as a raw material to make more valuable furniture and interior design products. To achieve this, the possibilities of modifying the physical and mechanical properties and the aesthetic appearance of the wood have been explored. The aim of this research is to establish the scientific basis for a thermo-mechanical refinement method that will allow the combined improvement

of the hardness, strength and aesthetic appearance of the thin cell-walled, low-density poplars.

Colour Variations in Robinia

We obtain a large part of our information by sight, so visual perception and its effects on us are of paramount importance. Nowadays, in addition to the technical properties and durability of wood, aesthetics and appearance are of very important, too. In many cases, the colour of the material is the determining factor for the use. The already rich variety in colour of black locust wood or robinia wood (*Robinia pseudoacacia* L.) is even more true for fast-growing hybrids (e.g. Shipmast locust, „Obelisk“, „Turbo“). These newer cultivars have different anatomical structure (growth ring width, earlywood to latewood ratio) due to their rapid growth. Previous mechanical and physical studies suggest that the cultivars could become important industrial raw materials, but the colour variation thus raises important additional issues (e.g. computer optimisation, surface treatment) that require instrumental, objective colour determination and solutions.



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Homogenisation of the Abnormal Discolouration of Robinia

One of the characteristic wood defects of black locust (*Robinia pseudoacacia* L.) is „black stripe“ discolouration, which is increasingly occurring according to feedbacks from the wood industry. This is the dark discolouration of some growth rings, which significantly affects the market value of the robinia wood. Our research team has carried out preliminary research to explain this phenomenon to find out what causes this wood defect and how it modifies wood properties. Using a stereo microscope, we found vessels with red-coloured tyloses and high levels of yellow deposits (robinetin), as well as vessels with no visible tylose and red-coloured wall. The tylose has probably collapsed and deposited on the vessel wall. Liquid chromatography measurements were used to determine the extract material content and an increase of about 15% was observed compared to the control sample without black stripes. In all cases, the amount of robinetin increased significantly (by 23–70%). It is likely that the wood is protecting itself against biological degradations.

The colour of the wood is a very important characteristic for users, so in this part of the study we tried to remove or decrease the existing discolouration caused by black stripes by water vapour steam and dry thermal treatments. Steaming is not only justified by its beneficial colour-changing effect, but also by its influence on the mechanical properties of the hard robinia wood (e.g. machinability) in a way that is favourable to the user.

The two most important factors affecting colour change during treatments are the temperature applied and the treatment time. The role of temperature is the greater, but above 220 °C does not happen further colour change [1]. The medium used also affects the extent of colour change, with greater change (darker wood) in the presence of air than in inert atmospheres (e.g. water vapour steam, nitrogen) [2]. Steaming between 80–130 °C can reduce large colour differences of turkey oak, robinia or beech with falseheart, as examples [3].

It is clearly visible to the naked eye that thermal treatment significantly reduces the clarity of the wood. Its colour shifts towards red and loses its yellow content. In the case of dry thermal treatment at higher temperatures, the thermal treatment resulted in a more uniform colour (with a significant loss of brightness), but here the pattern formed by the different sheaths is already blurred, which is not advantageous, as the pattern of the wood is an important aesthetic factor.

MATERIALS AND METHODS

Poplar Top Layer for Furnitures

For the tests, we used Pannonia poplar timber (*Populus × euramericana* cv. Pannónia), which after

drying was sawn into lamellae. The lamellae were compressed at temperatures of 160, 180 and 200 °C with compressed ratios of 15, 30 and 45%. During compression, the materials were kept in the press for 10, 20 and 30 minutes, taking care to maintain constant temperature and pressure. After compression, the thickness of the lamellae was 20 mm, so the initial lamellae thicknesses were 25.0, 28.5, 33.3 mm. After the treatment, the changes in colour, density, shrinkage properties, surface hardness (Brinell-Mörath), bending strength, bending modulus of elasticity and compression ratio of the lamellae as a function of initial thickness were investigated.

Colour Variations in Robinia

30 logs from different trees, coming from six different growing areas in Eastern Hungary were analysed for colour. In addition to the black locust (*Robinia pseudoacacia* L.) used as a control, several cultivated varieties were included in the samples. A disc was taken from each log at a height of one meter. One specimen was prepared from each disc passing through the pith. Colour measurements were taken on specimens with air-dry moisture content using a Konica-Minolta CM - 2600d spectrophotometer at centimetre intervals from the pith to the sapwood.

Homogenisation of the Abnormal Discolouration of Robinia

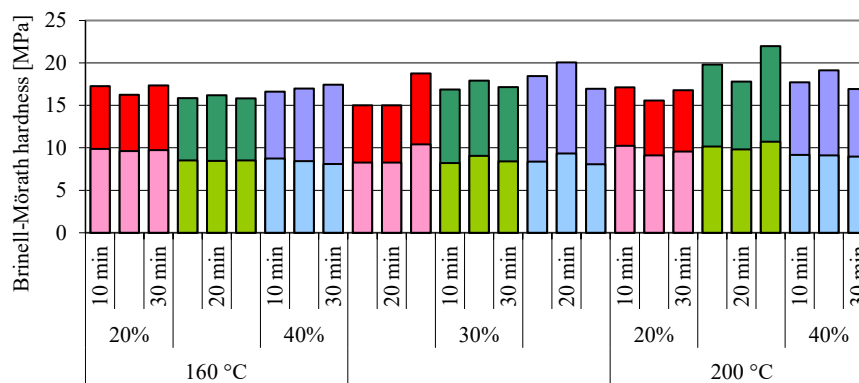
Selected black locust (*Robinia pseudoacacia* L.) wood specimens were used containing black stripes. Colour measurements were performed as described previously on samples conditioned in normal climate. Thermal treatments were carried out at 160 °C for 1 hour and 180 °C for 3 hours in air atmosphere, as well as in water vapour at 110 °C for 20 hours and 120 °C for 120 hours.

RESULTS

Poplar Top Layer for Furnitures

Looking at the overall colour difference, the change is noticeable to the naked eye, as $\Delta E^* > 3$ [4]. The extent of the differences is highly dependent on the treatment parameters. Since the change was similar for all three colour coordinates (a^* , b^* , L^*), the overall colour difference is also most affected by the temperature applied (the highest values are obtained with the parameters 200 °C, 30%, 30 min). The pressing time has a smaller effect, with no difference visible to the naked eye for elements pressed at 160 and 180 °C for 10, 20 and 30 min at the same density. No correlation between the total colour difference and the compression ratio can be detected.

One of the main aims of the experiment was to increase the surface hardness. The initial average Brinell-Mörath hardness of the lamellae ranged from 8 to 11 MPa, while after compression these values were between 15 and 22 MPa. These



1: Changes in surface hardness as a function of treatments

values clearly show that in all cases the surface hardness increased significantly as a result of the treatment. Looking at Fig. 1 (the lighter part is the value before compression, the darker is the value after compression), it can be seen that varying the compression parameters results in different degrees of hardness. The change in hardness is most strongly determined by the ratio of compression, the more the material was compressed, the higher the surface hardness became. There is no clear correlation with the change in hardness for compression temperature and time.

The average bending strength (*MoR*) of the control sample was 79.85 MPa, while after compression these values were between 87 and 116 MPa. The average bending modulus of elasticity (*MoE*) of the control sample was 8.2 GPa, while after compression these values were between 9.3 and 13.3 GPa. In all cases, the *MOR* and *MOE* increased as a result of the treatment. However, no clear correlation between the treatment parameters and the increase in *MOR* and *MOE* was observed. One reason for this may be that many specimens were sheared during bending test, resulting in a high variance (sometimes 20–25%).

During the shrinkage test, three linear shrinkage values were measured, in the direction of fibre, in the direction of compression and perpendicular to the compression. No change in shrinkage properties was observed in the fiber direction or perpendicular to the compression direction. In the direction of compression, the shrinkage values increased and

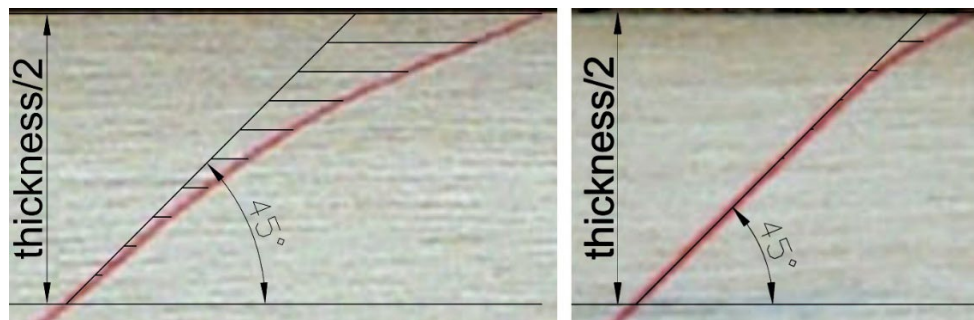
the increase was closely related to the ratio of compression, which indicates the presence of the memory-effect.

Looking at the absolute dry density, the increase in density increased with the degree of compression, so the extent of this was determined only by the initial density of the lamellae. However, compression is not uniform as a function of thickness.

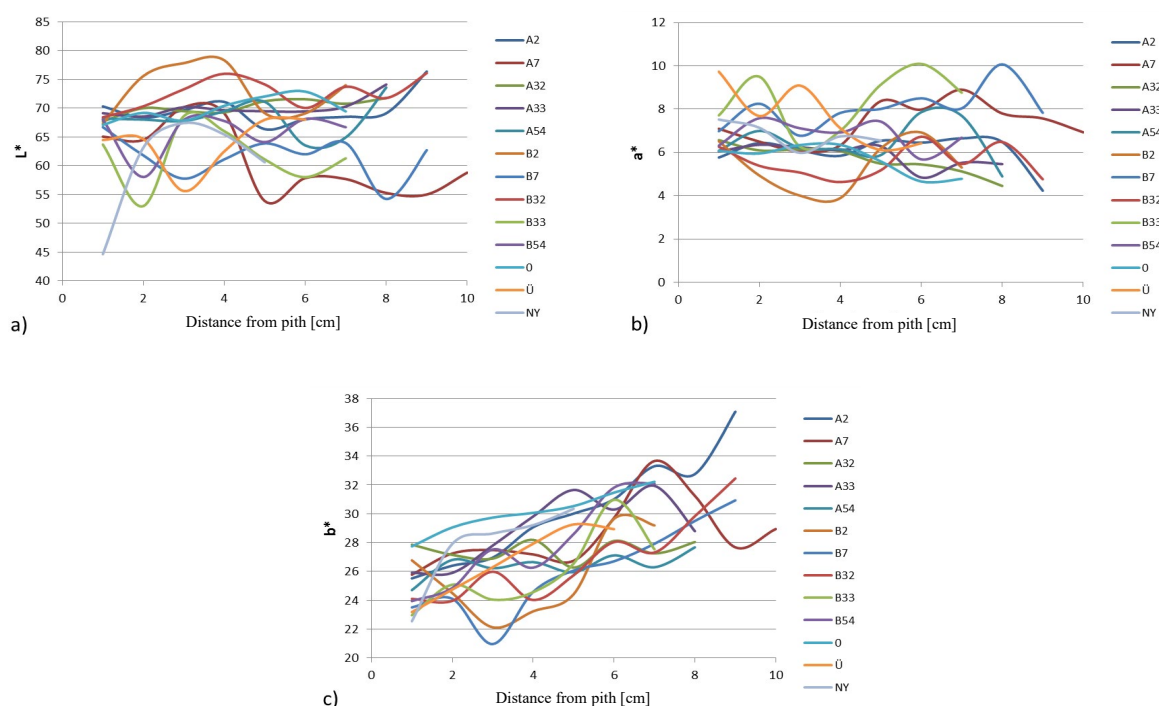
When examining the degree of compression, it was found that materials with different compression levels compressed differently (Fig. 2). At 20% compression, the top 1/3 layer compressed at around 40%, while the inner parts compressed at a low rate of around 0–10%. At 30% compression, the top 1/3 layer compresses around 45–50%, the middle 1/3 layer around 30%, and the inner 1/3 layer around 10–15%. At 40% compression, the top 1/3 layer compresses around 50–55%, the middle 1/3 layer around 30–40% and the inner 1/3 layer around 20–25%.

Colour Variations in Robinia

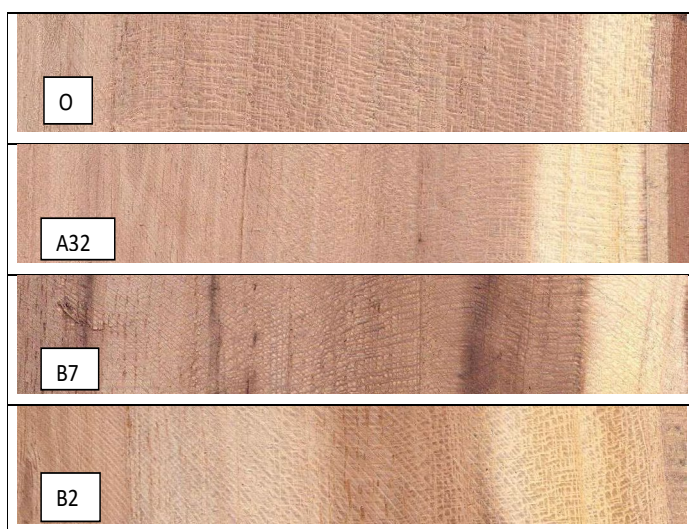
Looking at the average values of L^* and a^* colour components along the radius from the pith to the sapwood, no clear trend can be observed for either the fast-growing varieties or the control. In contrast, when looking at the variation of the colour coordinate b^* , there is a clear increasing trend from the pith to the sapwood. Relatively high variability appears in case of all colour components (Fig. 3).



2: Measuring the degree of compression for 40% (left) and 20% (right) specimens



3: Results of the measurements of colour coordinate L^* (lightness of the colour; a), a^* (colour position between green and red; b), b^* (colour position between blue and yellow; c)

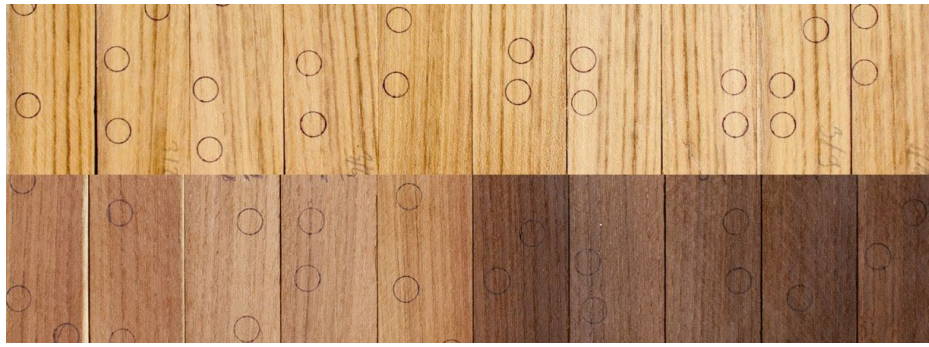


4: Typical appearance of a control (0), a fast-growing variety with low colour variation (A32), and two fast-growing varieties with high colour variation (B7 and B2)

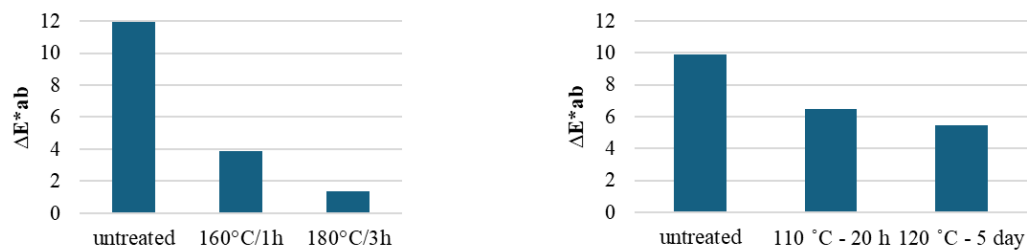
The darker, brownish staining visible to the naked eye on the wood (Fig. 4) is not reflected in the results of the colour measurement. No significant differences between the species were found when the mean values of the colour characteristics of heartwood and sapwood were examined. Accordingly, the average colour properties do not allow to determine the aesthetic usability of robinia wood, and it is necessary to investigate the variance of the colour components to reveal the colour variability.

Homogenisation of the Abnormal Discolouration of Robinia

Colour homogenisation was observed in the experiments at all temperatures and treatments tested (Fig. 5, 6). It is also observed that the homogenizing effect of steaming is smaller. The decrease in differences between colour components was mainly due to an overall decrease in lightness (L^*), with a slower darkening of the originally dark parts. The colour differences of the thermal-treated specimens remained below that of the steamed



5: Comparison of untreated (top) and thermal-treated (160°C - 1h bottom left, 180°C - 3h bottom right) specimens



6: Colour homogenisation by dry thermal treatment (left) and by water vapour steaming (right)

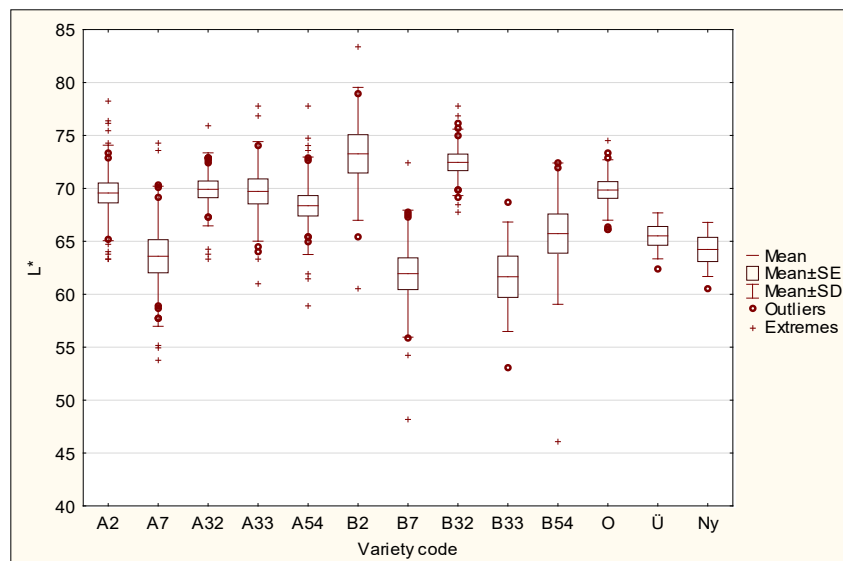


Fig. 7 Basic statistics for the colour coordinate L^* (lightness factor)

specimens even when the steamed specimens were finally darker. This phenomenon may be related to the increased extractive content of the black stripe, that is important for darkening, and reacts differently in dry and vapour atmospheres.

DISCUSSION

Colour Variations in Robinia

The standard deviations of the colour components are generally higher for the tested fast-growing robinia cultivars, and there is a high proportion

of outliers and extremes compared to the controls (Fig. 7). The exception was one fast-growing cultivar (A32), for which the standard deviation of no colour components exceeds that of the control. However, there is no correlation between the average annual ring width and the standard deviation of the colour components. Thus, the increase in colour variation is not primarily due to an increase in the growth rate. Compared with the colour data of varieties from the same growing area, it can be stated that the degree of colour variation, i.e. the variance of colour components, can be considered a genetic trait of the cultivars.

CONCLUSION

This paper explores the potential of less used wood species in the furniture industry today. The low hardness of poplar (*Populus* spp.) is the most significant limiting factor, while the highly variable colour of robinia wood (*Robinia* spp.) also causes problems.

Pannonia poplar (*Populus* × *euramericana* cv. Pannónia) specimens were compressed perpendicular to the grain using different compression ratios, temperatures and times. The initial average Brinell-Mörath hardness of the lamellae ranged from 8 to 11 MPa, while after compression these values were between 15 and 22 MPa. The change in hardness is most strongly determined by the ratio of compression. There is no clear correlation with the change in hardness for compression temperature and time. In the direction of compression, the shrinkage values increased and the increase was closely related to the ratio of compression. Shrinkage remained the same in the other directions. Bending modulus of rupture increased between 9 and 45%, while modulus of elasticity increased by 13–62%.

The rich variety in colour of *Robinia pseudoacacia* L. is even more pronounced for fast-growing cultivars. Using CIELAB colour measurement, L* and a* colour components between the pith and the sapwood, do not show clear trend for either the fast-growing varieties or the control robinia. In contrast, when looking at the colour coordinate b*, there is a clear increasing trend from the pith to the sapwood. The variability of the colour components is always high.

Colour homogenisation of *Robinia pseudoacacia* L. was observed in the experiments at all temperatures and treatments tested (thermal treatment at atmospheric pressure and steaming in water vapour). This may be necessary due to the increasing appearance of so-called 'black stripes'. The homogenising effect of steam treatment is weaker. The reduction in the differences between colour components was mainly due to an overall decrease in lightness (L*), with a slower darkening of the originally dark parts.

Acknowledgements

This article was made in frame of the project TKP2021-NKTA-43 which has been implemented with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the TKP2021-NKTA funding scheme.

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