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COLOR HOMOGENISATION OF CHERRYWOOD (*CERASUS AVIUM L.*) AND BLACK LOCUST (*ROBINIA PSEUDOACCACIA L.*) DURING STEAMING

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ABSTRACT

Hydrothermal treatment of wood, especially steaming, is often used to achieve a more intensive and homogenous color of wood or to change its hue. Color homogenisation of cherry wood (*Cerasus avium L.*) and Black Locust (*Robinia pseudoaccacia L.*) was investigated. We obtained this with steaming in steaming chambers. Temperatures of 95°C and 110°C were used. The samples were removed from chamber in time period (1, 2, 4, 7 and10 days). The results were evaluated with color co–ordinate system CIE L*, a*, b*.

With rising temperature the color homogenization was faster and less time was needed. Values of lightness L* of cherry wood became stabilized in the same time (the 5.th day) regardless of steaming temperature. Wood steamed at higher temperature had less red hue in the end of steaming process. Values of yellow hue were not changed a lot. The lightness L* of black locust decreased during steaming. Red hue was changed greatly in the first days and the decrease of yellow hue was very variable. The decrease of this value was regular and stronger in the first days. It can be due to faster color homogenization when using higher temperature.

The results could have a practical value in the application of color measurement during hydrothermal procedures aimed at the obtaining of desired color.

KEY WORDS: cherry wood (*Cerasus avium L.*), black locust (*Robinia pseudoaccacia L.*), steaming, color of wood, colorimetry, CIE L*, a*, b* system

INTRODUCTION

Wood is an excellent material to absorb and reflect light and the interaction of its physical properties causes color heterogeneity. About 30 000 commercial wood species is the greatest source of natural variability of wood color, with a pronounced influence of wood anatomy (Phelps and McGinnes 1983), growth conditions and genetics (Rink and Phelps 1989). On the macroscopic level, the influence of anatomy on wood color is often explained with differences of early- and latewood and closely linked with geometry, thickness and orientation wood cells. In these cases, a significant correlation of anatomy with density and wood color is used in some densitometric methods.

Black locust heartwood has by nature yellowish to greenish brown color caused by a number of chemical substance such as robinetin deposited in cell lumina and cell walls. Marketing of products made of black locust in its natural color has met serious problems because its color is not acceptable for most consumers and in some cases extremely inhomogeneous (Molnár and Tolvaj 2004).

Cherry wood is a decorative, high quality wood species, often used for extra performance wooden products. The solid wood of cherry is easily cut, peeled, bended and sawed. Bonding as well as surface treatment of cherry wood is very good. Drying the timber is not difficult, however warping and coloring of wood is very common in practice (Straže and Gorišek 2003).

The steaming of wood is a common procedure in wood industry for the sterilization, softening of wood in veneer production, for the improvement of dimensional stability of wood as well as for intensifying the wood color (Brauner et al. 1964, Kubinsky and Ifju 1973). In most wood species darker hues of wood color are achieved after the steaming procedure, which is a result of hydrolysis of accessory compounds and arised condensed polyphenolic products (Chen and Workman 1980, Straže 2004). The significant influence of temperature, pressure, and duration of maintained conditions during steaming as well as their interaction were confirmed in many other studies (Kollman et al. 1951, Schmidt 1982). Some authors stress the strong impact of some inherent wood properties, especially wood moisture content, on the direction and intensity of the coloring process (Brauner and Conway 1964, Schmidt 1986, Straže et al. 2001, 2003, Tolvaj 2000). The cited studies confirmed good possibilities of hydrothermal treatment to stabilize and equalize the wood color, where further treatments as well as the proper end-use of products insignificantly change this wood property.

The aim of this thesis is investigation of coloring of cherry wood and black locust during steaming, using steaming temperature of 95° and 110°C. For determining the color change, the CIE L*a*b* system was used which is successful for following the color changes of wood (Tolvaj and Faix 1995, Mitsui et al. 2001).

MATERIAL A METHODS

For laboratory steaming cherry wood and black locust were used. Samples were without any wood defects. Wood species were divided into two groups (according to the temperature of steaming). Small samples were taken from each sample. Natural color of wood was determined using these small samples. Average moisture content of cherry wood was 30% and of black locust was 39%. These samples were not conditioned.

Relative humidity in the steaming chamber was 100%. Samples were inserted into the boxes in the drying chambers. Temperature in the first chamber was 95°C. This chamber was filled by one group of cherry samples and one group of black locust samples. Cherry samples were removed after 1, 2, 4, 7 and 10 days, and samples of black locust were removed after 1, 2, 4, 6 and 8 days.

Two second sets of samples were inserted into the pressure pot because of much steam and high pressure, which raised up during steaming under high temperature. In this case we used temperature of 110°C. Samples of cherry wood and black locust were removed after 1, 2, 4, 7, and 10 days.

Color measurements were done by colorimeter MINOLTA 2002.

The reflection spectrum was measured in the region of 400 – 700nm. From these data, the values of L*, a*, b* color co – ordinates were calculated. The D65 light source was used. Twenty randomly color measurements were done on the surface of each black locust sample. On the surface of cherry samples, 50 randomly color measurements were performed. The results were used for further analyses.

RESULTS AND DISCUSION

The aim of this work was reduced color differences of wood. Color heterogeneity can be observed and measured not only between two or more samples but within one wood specimen. Color homogenization of wood can be achieved using steaming. Analyses of colorimetric results showed the influence of steaming on color changes of wood. Applying higher temperature the homogenization effect was faster and the created dark surface became more uniform.

Cherry

The color of cherry wood often described as yellow to golden brown frequently varies in lightness, especially in the transition from sapwood to heartwood. The sapwood possesses a lighter color, with yellow to white-yellow hue. The lightness is quite high and average value is 75,49, tone between red and green color is a*=7,52 and tone between yellow and blue color is b*=21,7.

Tab. 1: Means, variances and variation coefficients of basic color parameters (L, a*, b*) of cherry wood before and after steaming*

	Lightness (L*)		Green-red axis (a*)		Blue-yellow axis (b*)	
	Mean	Var. coeff.	Mean	Var. coeff.	Mean	Var. coeff.
non-steamed	75,49	3,69	7,52	13,41	21,7	7,46
steamed (95°C)	66,42	2,18	10,96	10,38	20,16	4,54
steamed (110°C)	52,7	2,84	11,53	5,05	17,68	4,78

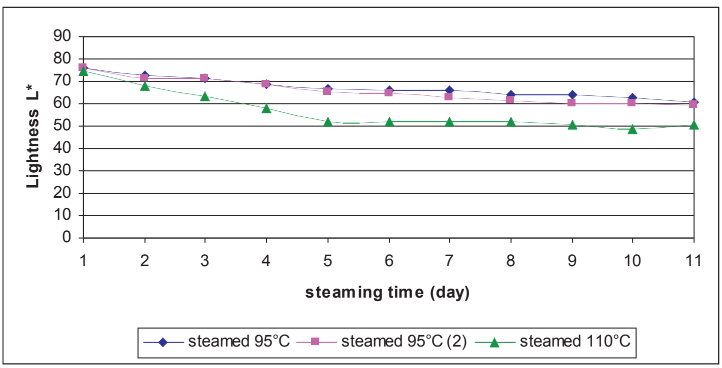

Fig. 1: Lightness changes of cherry wood during steaming

Fig. 1 shows changes of lightness during steaming using two kinds of temperature. Lightness values are stabilized after the fifth day regardless of temperature of steaming. Color of wood steamed under the temperature of 110°C was darker. This difference was about 14 units. In the Fig. 2 we can see the increase of red hue during steaming. This increase was more rapid at the beginning and the values became stabilized after the seventh day. Wood steamed at higher temperature had less red hue at the end of process. Yellow hue wasn't changed a lot.

Lower values were detected during the whole steaming process at the temperature of 110°C. This difference was from 2 to 5 units (Fig. 3).

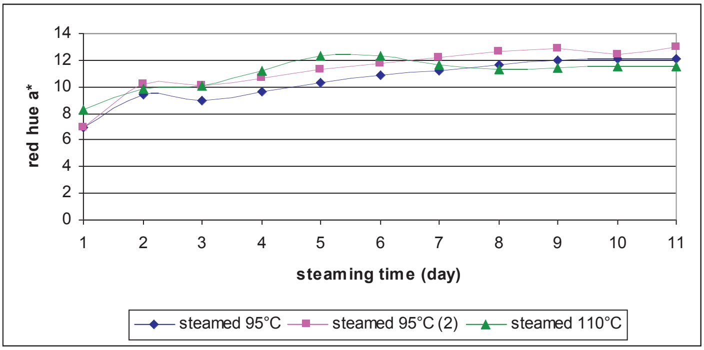

Fig. 2: The change of red hue of cherry wood during steaming

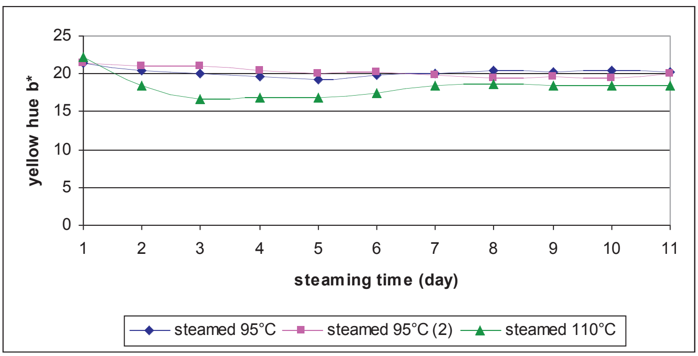

Fig. 3: The change of yellow hue of cherry wood during steaming

Color change occurred during steaming under the temperature 95°C was continuous and the color of wood was quite heterogeneous (Fig. 4). Homogeneity was achieved after the seventh or tenth day of steaming. Wood became more red and brow (a* = 10,96). Values of yellow hue b* didn't change in comparison to original value (b* = 20,16).

During steaming at 110°C, color changes were faster and we can see higher homogeneity (Fig. 5) than in the first case. Lightness had lower values than during steaming at lower temperature (L* = 52,7), red hue was approximately the same (a* = 11,53) and there was more brown hue. It was result of decrease of yellow hue (b* = 17,68).

Decrease of hue *h* and of lightness *L** was linear (Fig. 6). More expressive changes were occurred during steaming under temperature 110°C. Values of hue *h* were lower about 5 units comparing to steaming under lower temperature.

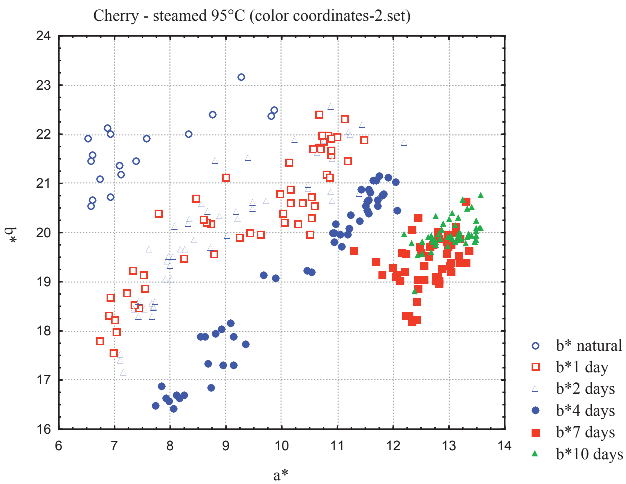

Fig. 4: Color change of cherry wood as a function of steaming temperature (95°C) and time, compared with non-steaming sample (upper left)

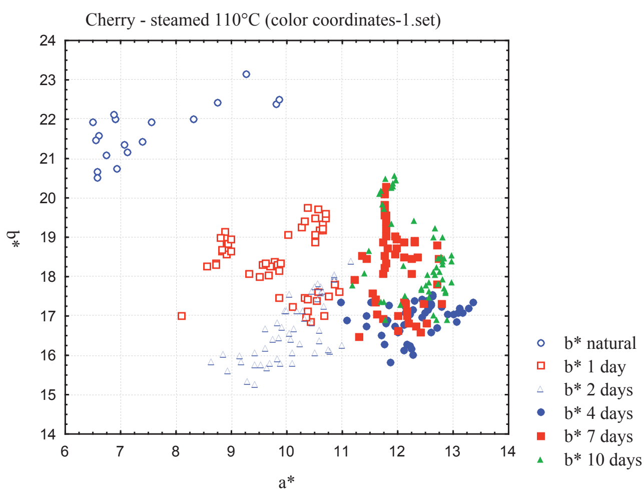

Fig. 5: Color change of cherry wood as a function of steaming temperature (110°C) and time, compared with non-steaming sample (upper left)

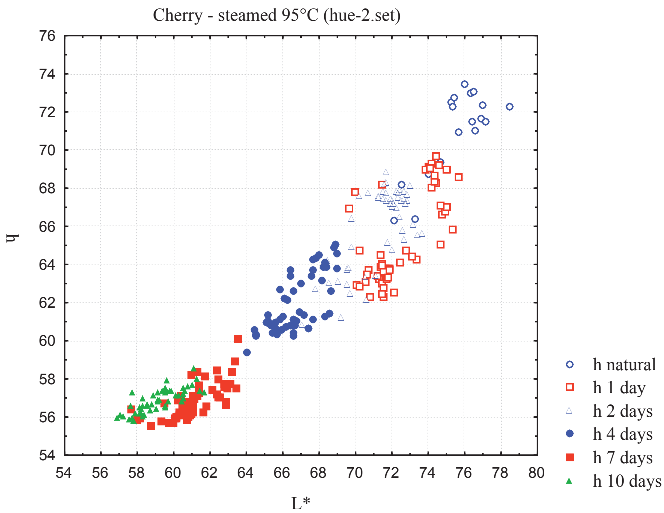

Fig. 6: Lightness (L) and hue (h) of cherry wood before and after steaming (95°C)*

Chromacity values were more heterogeneous during steaming at the temperature of 95°C (Fig. 8). The values were approximately the same after seventh day of steaming. These values were more homogeneous at higher temperature of steaming (Fig. 9). Lightness of samples decreased with rising time of steaming.

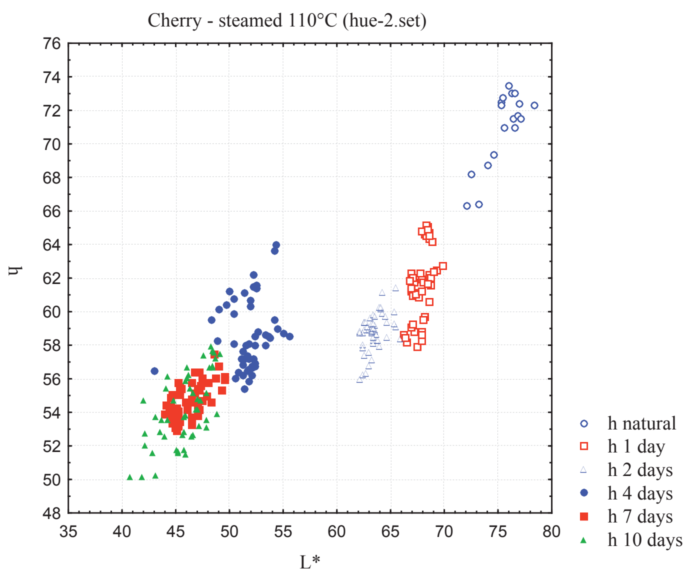

Fig. 7: Lightness (L) and hue (h) of cherry wood before and after steaming (110°C)*

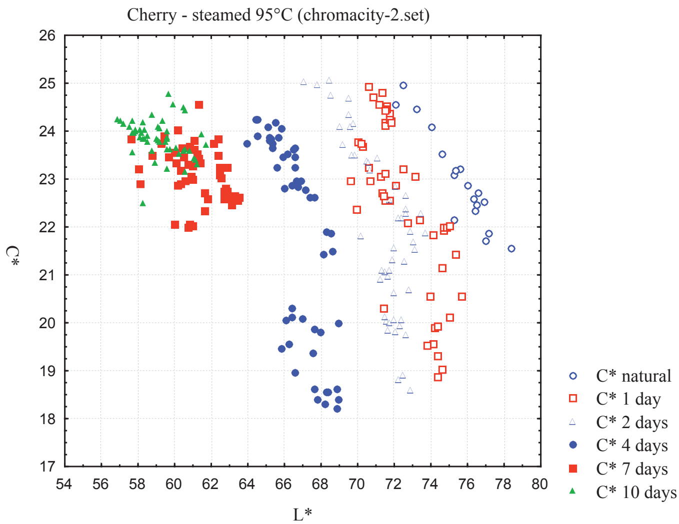

Fig. 8: Lightness (L) and chromacity (C*) of cherry wood before and after steaming (95°C)*

Steamed cherry wood is darker with more red and brown hues and visually undistinguishable in comparison to steamed sapwood and heartwood. The desired equal color of steamed cherry wood was achieved on many elements or in their separate regions, whereas a great part of specimens exhibited high heterogeneity. Locations of higher lightness and lower chromaticity of wood color were frequent and hues varied from yellow to red-brown. Boundaries between differently altered tissues after steaming were visible on many elements similar to the observations made by Straže and Gorišek (2003).

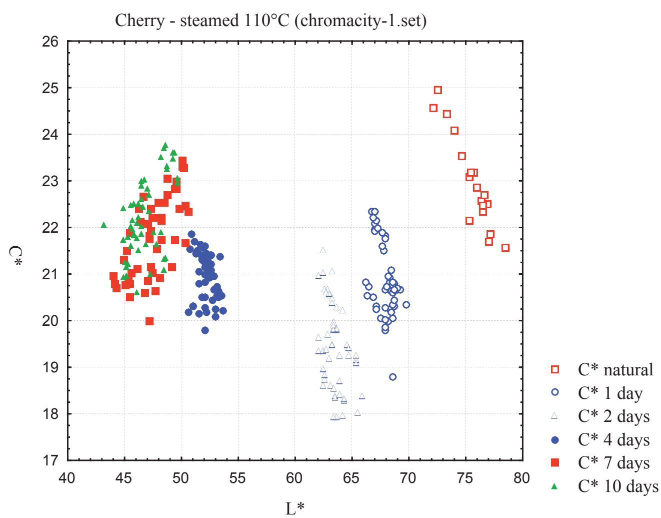

Fig. 9: Lightness (L) and chromacity (C*) of cherry wood before and after steaming (110°C)*

Black locust

Natural color of black locust is yellow-brown to golden with green hue and with change of the lightness, regarding early and late wood. Average value of black locust lightness is 72,01 and color co-ordinate a*=2,16 and b*=30,86.

Tab. 2: Means, variances and variation coefficients of basic color parameters (L, a*, b*) of black locust before and after steaming*

	Lightness (L*)		Green-red axis (a*)		Blue-yellow axis (b*)	
	Mean	Var. coeff.	Mean	Var. coeff.	Mean	Var. coeff.
non-steamed	72,01	2,08	2,16	31,21	30,86	4,7
Steamed(95°C)	54,15	2,25	8,35	4,58	23,48	5,57
Steamed(110°C)	43,85	3,04	8,43	5,55	15,51	7,36

Black locus lightness decreased during steaming. Greater decrease of values occurred again during steaming at the temperature of 110°C. The difference was about 10 units. Progress was constant after the ninth day (Fig. 10). Red hue was changed expressively in the first days of hydrothermal treatment. During first three days changes were expressive and increase was linear. The values became stabilized after the seventh day. Values of red hue increased from the beginning of the steaming at 110°C and than they decreased a little. Changes become stabilized after sixth day (Fig. 11). Decrease of yellow hue was very variable during steaming at 95°C. Using higher temperature, decrease of this co-ordinate was similar, expressive in the first days and stable after the eighth day of steaming (Fig. 12). It can be result of faster color homogenization during steaming at higher temperature.

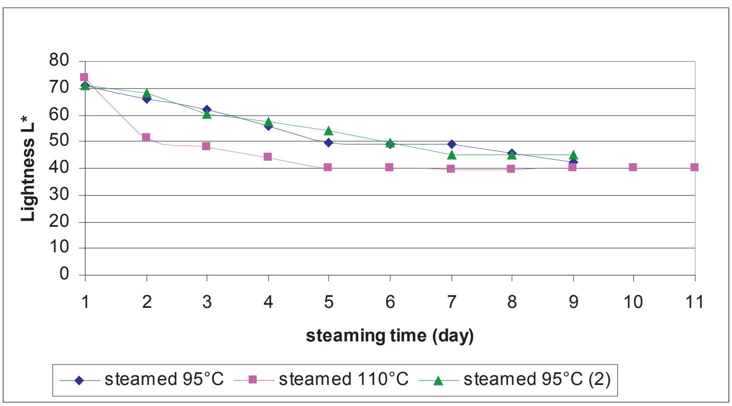

Fig. 10: The change of lightness of black locust during steaming

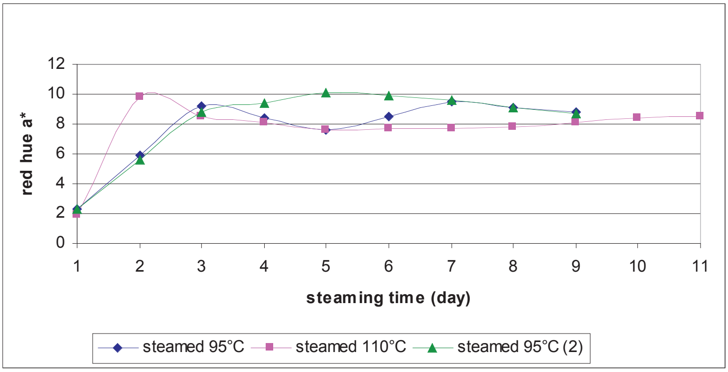

Fig. 11: The change of red hue of black locust during steaming

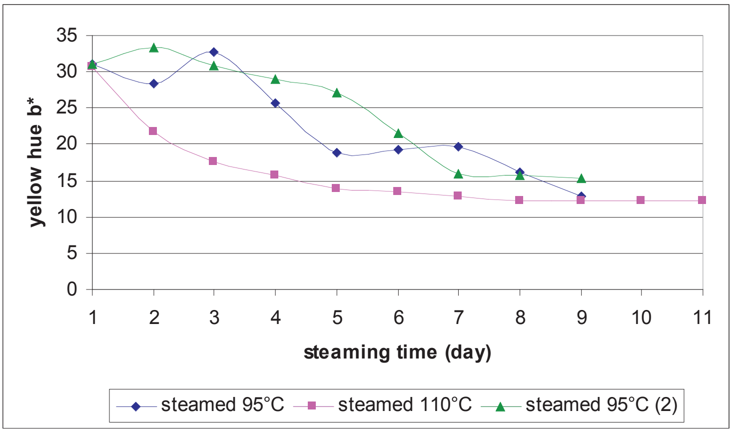

Fig. 12: The change of yellow hue of black locust during steaming

Wood has dark brown color with yellow and red hue after steaming. It is darker because of decrease of lightness. Average value of lightness was L*=54,15. Value of red hue a* increased (a*=8,35), yellow hue b* decreased (b*=23,48). So wood has less yellow, but browner color. We can see this result with naked eye.

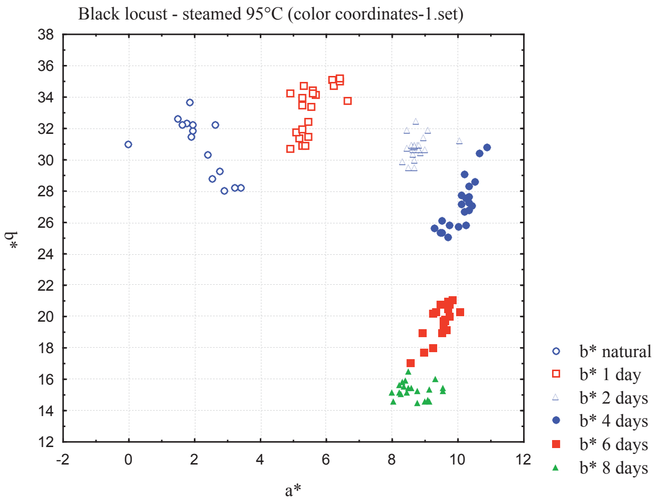

Fig. 13: Color change of black locust as a function of steaming temperature (95°C) and time, compared with non-steamed sample (upper left)

Color changes were faster during steaming using higher temperature. After the first day of steaming using the temperature of 110°C, black locust achieved changes similar to steaming at 95°C after the sixth day. During next nine days wood became darker but values of red hue a* didn't change a lot. Values of yellow hue b* decreased to tenth day.

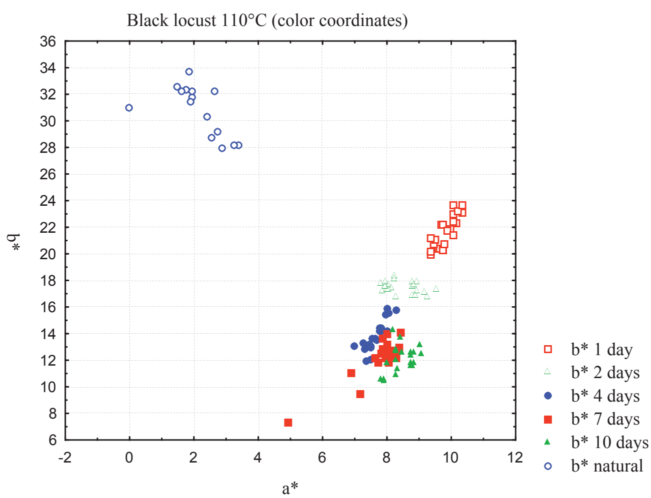

Fig. 14: Color change of black locust as a function of steaming temperature (110°C) and time, compared with non-steamed sample (upper left)

Lightness of samples steamed under higher temperature was lower (L*=43,85), value of red hue a* was approximately the same (8,42) and value of yellow hue b* was 15,51. The result was that the wood steamed at higher temperature (110°C) was darker than wood steamed at lower temperature (95°C). According Molnar and Tolvaj (2004), applying higher temperatures the homogenization effect was faster and the created dark surface became more and more uniform.

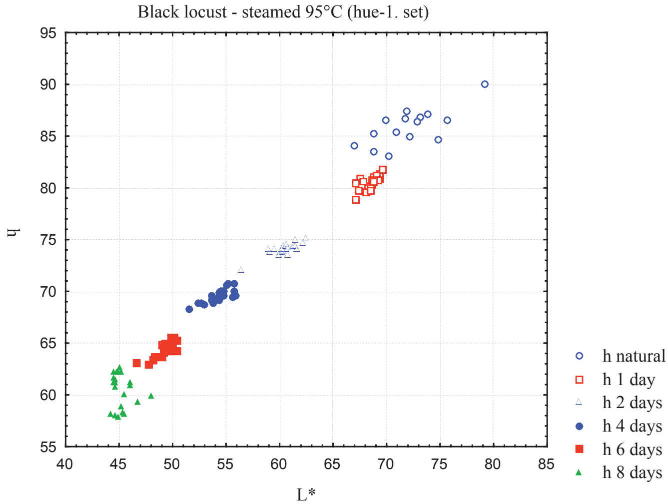

Fig. 15: Lightness (L) and hue (h) of black locust before and after steaming (95°C)*

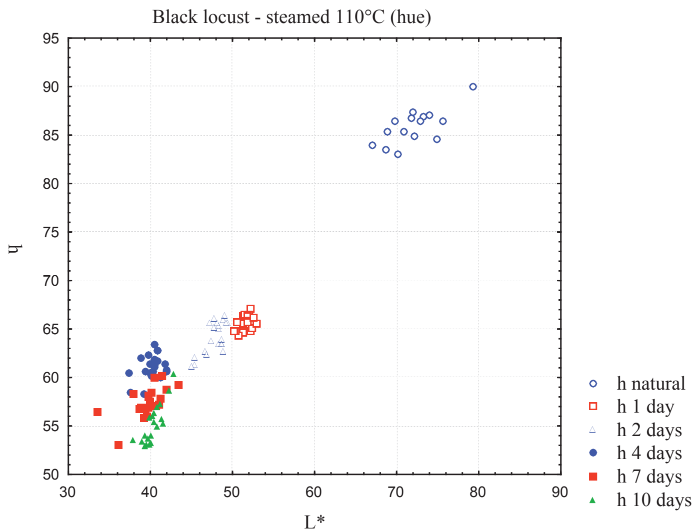

Fig. 16: Lightness (L) and hue (h) of black locust before and after steaming (110°C)*

From the Fig. 15 and 16 is evident, that the decrease of change of hue *h* and lightness *L** was linear. Values of these parameters decreased faster and change was expressive during steaming under temperature 110°. Values were the same after first day than values achieved by steaming under temperature 95°C after six days.

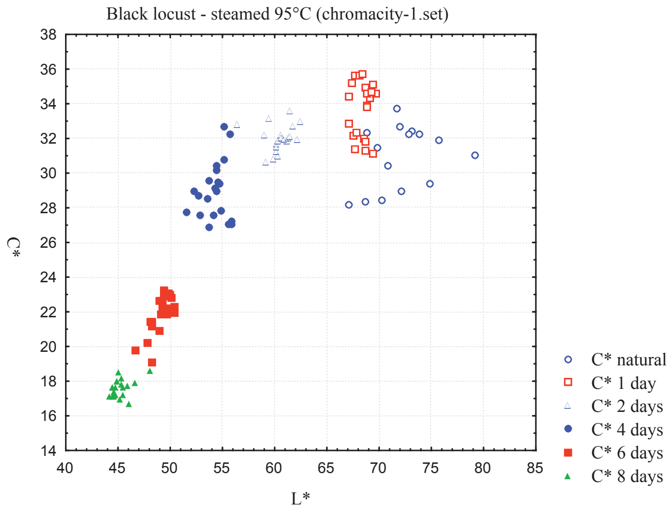

Fig. 17: Lightness (L) and chromacity (C*) of black locust before and after steaming (95°C)*

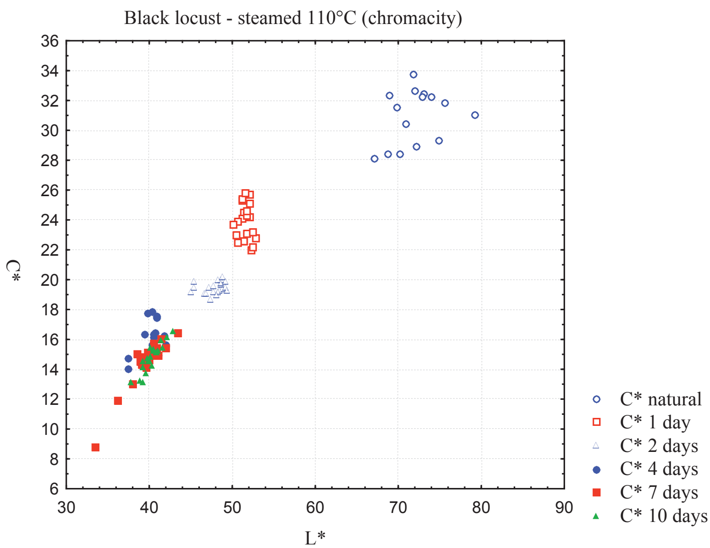

Fig. 18: Lightness (L) and chromacity (C*) of black locust before and after steaming (110°C)*

In the Fig. 17 and 18 we can see that during steaming did not decrease only lightness of black locus but chromacity, too. Progress of these values was linear.

CONCLUSION

The results have a practical value, when applying color measurement for hydrothermal procedures. It is known that wood changes its color during steaming. We can achieve small color changes but total homogenization of wood products, too. This homogenization can be faster when higher temperature of steaming is used. Less time for homogenization is needed when we use higher temperature. We can achieve darker hue of wood using these conditions.

These results can be used in practice, for example when costumer requires certain wood color. Knowledge of color measurements and color co-ordinates of certain wood can be used to evaluation of wood quality and grading of wood products according to the color.

REFERENCES

1. Brauner, A., Conway, E.M., 1964: Steaming walnut for color. Forest Products Journal 14, 11, Pp. 525 – 527
2. Chen, P., Workman, E.C., 1980: Effect of steaming on some physical and chemical properties of black walnut heartwood. Wood and Fiber 11, 4, Pp. 218 – 227
3. Kollmann, F., et al., 1951: Verfärbungen des Vollholzes und der Furnier bei der künstlichen Holztrocknung. Holz als Roh- und Werkstoff, 9, Pp. 385 – 391
4. Kubinsky, E., Ifju, G., 1973: Influence of steaming on the properties of red oak. Part I. Structural and chemical changes. Wood Science 6, 1, Pp. 87 – 94
5. Mitsui, K., et al., 2001: Changes in the Properties of Light-Irradiated Wood with Heat Treatment. I. Effect of Treatment Condition on the Change in Color, Holzforschung, 55, Pp. 601 – 605.
6. Molnár, S., Tolvaj, L., 2004: Color homogenisation of diferent wood species by steaming. Interaction of Wood with Various Forms of Energy, Pp. 119 - 122
7. Phelps, J. E., McGinnes, E.A. Jr., 1983: Growth-quality evaluation of black walnut wood. Part III. An anatomical study of color characteristics of black walnut veneer. Wood and Fiber Science, 15, 3, Pp. 212 – 218
8. Rink, G., Phelps, J.E., 1989: Variation in heartwood and sapwood properties among 10-year old black walnut trees. Wood and Fiber Scienca, 21, 2, Pp. 177 – 182
9. Schmidt, K., 1982: Auswirkungen verschiedener Parameter beim Dämpfen von Rotbuchenholz. Teil 1. Holzforschung und Holzverwertung, 34, 3, Pp. 47 – 51
10. Schmidt, K., 1986: Untersuchungen über die Ursachen der Verfärbungen von Eichenholz bei der technischen Trocknung. Holzforschung und Holzverwertung, 38, 2, Pp. 25 – 36
11. Straže, A., Gorišek, Ž., 2001: Influence of drying parameters on discoloration in ash-wood (*Fraxinus excelsior* L.). Proceeding of the Fifth International Conference on the Development of Wood Science, Wood Technology and Forestry, ICWSF 2001, Ljubljana, Slovenia, Pp. 273 – 280
12. Straže, A., Gorišek, Ž., 2003: The color of steamed cherrywood (*Prunus avium* L.) and its variability. Wood in Construction Industry – Durability and Quality of wooden construction products, Pp. 41 – 48

13. Tolvaj, L., et al., 2000: Color modification of black locust by steaming, Drevársky výskum, 45, 2, Pp. 25 – 32
14. Tolvaj, L., Faix, O., 1995: Artificial Ageing of Wood Monitored by DRIFT Spectroscopy and CIE L*a*b* Color Measurements. I. Effect of UV light, Holzforschung, 49, Pp. 398 – 404

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