IDENTIFICATION OF THE COLOR FALSE HEARDWOOD OF *FAGUS SYLVATICA* L. IN THE COLOR SPACE CIE L*A*B*

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ABSTRACT

The paper presents the differences in the color of native beech wood between the false heardwood and sapwood in the color space CIE L*a*b*. The visual evaluation of the differences in the color of beech wood between the false heardwood and sapwood clearly shows that the color of the false heardwood of beech wood has a reddish-brown color with values on the coordinates L* = 67.5, a* = 12.7, b* = 20.3 compared to sappwood, the color of which is a light white-gray color with a yellowish tinge with values on the coordinates L* = 77.1, a* = 9.5, b* = 18.4. The degree of color difference at the individual coordinates of the CIE L*a*b* beech wood color space between the false heardwood and sapwood indicates the fact that while the brightness of the false heardwood relative to the sapwood is ΔL* = -9.6 smaller, the red values Δa* = +3.2 and yellow Δb* = +1.9 in color are higher in the false heardwood in penetration with sapwood beech wood. A comparison of the values of the standard uncertainty of the measurement of the color of the false headrwood with the values of the relative standard uncertainty of the sapwood shows that the variability of the color shades of the brown-red color of the false heardwood is greater than the variability of the sapwood beech wood.

Key words: beech wood, false heardwood, color wood, color space CIE *L*a*b**.

INTRODUCTION

Beech wood belongs to the scattered-porous woody species of coreless wood with the possibility of forming a false heardwood. Beech wood of sapwood is medium-heavy, flexible, easy to split. It has good mechanical properties, plasticizes very well, bends and is machined. Thanks to its high permeability, it impregnates well, stains and paints. Beech wood is used for the production of furniture, floors, sports equipment, toys and small household items. Beech sapwood dried by low-temperature drying modes has a light white-gray color with a touch of yellow. In the color space CIE *L*a*b**, the sapwood beech color is by the authors: *Babiak et al. (2004)* identified by values on the coordinates *L** = 75.96; *a** = 6.62; *b** = 17.63. Similar values for the color of sapwood are also given by the authors: *Tolvaj et al. (2009), Dzurenda (2014), Meints et al. (2017), Dzurenda – Dudiak (2021).*

The false heardwood of beech is a growth error caused by the reaction of air with wood in the zone of sapwood. The primary cause of a false heardwood is an injury to the trunk or branches of the tree, which allows air to enter the trunk of the tree. Oxygen contained in the air causes oxidation of soluble carbohydrates and starch (contained in living or partially dead parenchymal cells), resulting in brown colored polyphenolic compounds that penetrate and stain neighboring tissues *Bauch – Koch (2001), Račko – Čunderlík (2010).* According to the occurrence of the false heardwood in the trunk of the tree and its shape on the cross section of the trunk, the false heardwood is divided into: Round, Mosaic Star, Flame (eccentric, cen-

tric) *Mahler – Höwecke (1991).* False heardwood has a lower moisture content in a growing tree compared to white and green wood and, according to *Babiak et al. (1990),* a lower fluid permeability. The color difference between false heardwood and sapwood is the reason for the elimination of sawmill blanks for the production of bentwood furniture, sports equipment, as well as construction and carpentry products.

The reason for the different color of beech wood are the chromophores, i.e. functional groups of the type: > C = O, -CH = CH-CH = CH-, -CH = CH-, kernels found in chemical components of wood (lignin dyes, tannins, resins and other extractive substances found in sappwood and false heardwood) which absorb electromagnetic radiation in the UV-VIS area of daylight radiation. The reflected electromagnetic radiation entering the human eye creates in the human mind a psychophysiological sensation manifested in the vision of the color of the object observed by the human eye. *Wilson – Keil (1999), Kubovský – Urgela (2004).*

The aim of this work is to identify the color of false heardwood in the color space CIE *L*a*b** and to quantify the degree of total color difference Δ*E** between the color of beech wood of false heardwood and sapwood.

MATERIALS AND METHODS

Beech wood in the form of blanks with a false heardwood measuring 27 × 75 × 320 mm was dried to moisture content w_p = 10.0 ± 0.5 %.

The wood color of beech blanks in the color space CIE *L*a*b** was measured with a Color reader CR-10 colorimeter (Konica Minolta, Japan). A D65 light source was used and the diameter of the optical scanning aperture was 8 mm.

The measurement of the brightness values *L** a of the basic chromatic coordinates red *a** and yellow *b** of the color space CIE *L*a*b** of white and false heardwood was performed on a set of n = 58 blanks. The measured values are given in the form of a record $x = \bar{x} \pm u_C$ i.e., average measured value and combined standard measurement uncertainty.

The calculation of the average values $\bar{x}_L, \bar{x}_a, \bar{x}_b$ from the measured values L_i, a_i, b_i on the coordinates of the color space CIE *L*a*b** is given by the equations:

$$\bar{x}_L = \frac{\sum L_i}{n}; \quad \bar{x}_a = \frac{\sum a_i}{n}; \quad \bar{x}_b = \frac{\sum b_i}{n}; \tag{1}$$

Where: L_i, a_i, b_i – measured values on coordinates color space CIE *L*a*b**, n - number of measurements.

The combined standard uncertainty takes into account type A and type B uncertainties.

$$u_C = \sqrt{u_A^2 + u_B^2} \tag{2}$$

Where: u_A - standard uncertainty type A, u_B – standard uncertainty type B.

The calculation of the combined standard uncertainty for the values at the individual coordinates of the color space CIE *L*a*b** is given by the equations:

$$u_{C_L} = \sqrt{\frac{\sum(L_i - \bar{x}_L)}{n \cdot (n-1)}} + u_{B_L}^2, \quad u_{C_{La}} = \sqrt{\frac{\sum(a_i - \bar{x}_a)}{n \cdot (n-1)}} + u_{B_a}^2, \qquad u_{C_b} = \sqrt{\frac{\sum(L_i - \bar{x}_b)}{n \cdot (n-1)}} + u_{B_b}^2, \tag{3}$$

Where: L_i, a_i, b_i – measured values on coordinates color space CIE *L*a*b**,

$\bar{x}_L$, $\bar{x}_a, \bar{x}_b$ – average values of sets of measured values on color space coordinates,

n – number of measurements,

u_{BL}, u_{Ba}, u_{Bb} = 0.1 standard deviations of the Color reader CR-10 from the nominal value.

The degree of scatter of the determined values in the color space CIE *L*a*b** of the false heardwood and sapwood beech is evaluated by means of the relative standard uncertainty $_{rel}u_C$. The relative standard uncertainty values for each color coordinate describe the equations:

$$_{rel}u_{C_L} = \frac{u_{C_L}}{\bar{x}_L}.100\ [\%], \qquad _{rel}u_{C_{a^*}} = \frac{u_{C_{a^*}}}{\bar{x}_{a^*}}.100\ [\%], \qquad _{rel}u_{C_{b^*}} = \frac{u_{C_{b^*}}}{\bar{x}_{b^*}}.100\ [\%] \tag{4}$$

Where: u_{Ci} – the combined standard uncertainty of the value at the appropriate coordinate color space,

$\bar{x}_i$ – average value.

The calculation of the total color difference ΔE^* of the difference between the color of sapwood and false heardwood beech is described by the following equation:

$$\Delta E^* = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2} \tag{5}$$

Where: L^*_1, a^*_1, b^*_1 average values on the coordinates of the color space of sapwood,

L^*_2, a^*_2, b^*_2 average values on the coordinates of the color space of the false heardwood.

RESULTS AND DISCUSSION

The visual difference in the colors of the wood of the false heardwood beech from the sapwood beech is shown in Fig. 1.

Figure 1: Examples of beech wood color with false heardwood formation

The values of brightness *L**, red color *a** and yellow color *b** on the coordinates of the color space CIE *L*a*b** color of the sapwood wood and false heardwood on the planed surface of the loading surfaces of beech blanks with moisture content w = 10.0 ± 0.5 % are given in the Table 1. and sapwood Table 2.

Table 1: Values on coordinates color space CIE *L*a*b describing the false heardwood of beech**

False heardwood of beech blanks	Coordinates of color space CIE *L*a*b**		
	*L**	*a**	*b**
number of measurements [-]	58	58	58
coordinate value [-]	67.5 ± 4.2	12.7 ± 2.3	20.3 ± 1.9
relative standard uncertainty [%]	6.2	18.1	9.3

Table 2: Values on coordinates color space CIE *L*a*b describing the sapwood of beech**

Sapwood of beech blanks	Coordinates of color space CIE *L*a*b**		
	*L**	*a**	*b**
number of measurements [-]	58	58	58
coordinate value [-]	77.1 ± 2.9	9.5 ± 1.3	18.4 ± 1.1
relative standard uncertainty [%]	3.7	13.6	5.9

The degree of color difference at the individual coordinates of the color space CIE *L*a*b** between the false heardwood beech and the sapwood beech is shown in Fig. 2.

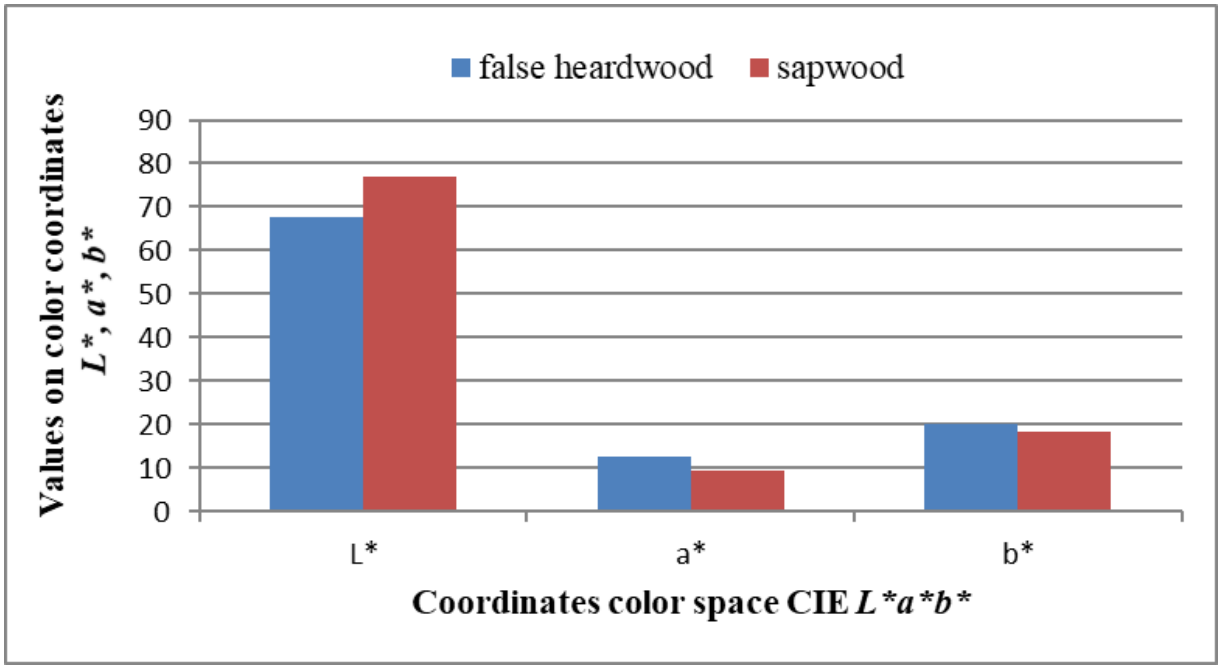

Figure 2: Graphic evaluation of colors on individual coordinates of the color space between the false heardwood and sapwood beech.

In Fig. 2 shows the degree of color difference on the individual coordinates of the color space CIE *L*a*b** beech wood between the false heardwood and the sapwood. They point to the fact that while the brightness of the false heardwood compared to the brightness of sapwood is ΔL^* = -9.6 smaller (the wood is darker), the value of the red

color a^* of the false heardwood is $\Delta a^* + 3.2$ higher than the value red color a* of sapwood and the value of yellow color b^* in the false heardwood is higher by $\Delta b^* = + 1.9$ higher compared to sapwood. This is due to the increased number of chromophores in polyphenolic compounds formed by the oxidation of air-oxygen-soluble carbohydrates and starch contained in living or partially dead parenchymal cells, as reported by *Bauch – Koch (2001), Račko – Čunderlík (2010).*

Higher values of relative standard uncertainties of the false heardwood brightness of the $_{rel}u_{CL}$ = 6.2 % of the red color of $_{rel}u_{Ca}$ = 18.1 % and of the yellow color of $_{rel}u_{Cb}$ = 9.3% of the wood given in Table 1 in comparison with similar values of sapwood beech wood given in Table 2 show a greater variability in the color shades of the brown-red color of the false heardwood compared to the homogeneous color of the sapwood.

CONCLUSION

The paper presents the coordinates of the color of the false heardwood of beech in the color space CIE $L^*a^*b^*$. The red-brown color of the false heardwood beech, based on the statistical processing of the measured values, has a brightness $L^* = 67.5 \pm 6.8$ and values on chromatic coordinates: red color $a^* = 12.7 \pm 2.3$ and yellow color $b^* = 20.3 \pm 1.3$.

Higher values of relative standard uncertainty of $_{rel}u_{CL}$ = 6.2 %, red color of $_{rel}u_{Ca}$ = 18.1 % and yellow color of $_{rel}u_{Cb}$ = 9.3% of false heardwood compared to values of relative standard uncertainty of sapwood beech $_{rel}u_{CL}$ = 3.7 %, $_{rel}u_{Ca}$ = 13.6% and $_{rel}u_{Cb}$ = 5.9% indicate a greater variability of color shades of brown-red color of the false heardwood.

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