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Defining of Wood Colour

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Abstract

Defining of wood colour with spectral photometer has been used for some time and has become one of the most frequent methods in researching of macroscopic and aesthetical properties of wood. Measuring the colour of wood as a heterogeneous material of biological origin is difficult. The colour of wood is not uniform due to the alternating early wood/late wood colour. The aim of this study was to examine the relationship between the density of wood and early wood/ late wood colour. Sycamore maple species (*Acer pseudoplatanus* L.) was used in this study. It was established that colour parameters *L**, *a**, *b** of early wood zone were not statistically correlated to density. The same result was obtained for late wood of *Acer pseudoplatanus.*

Key words: wood colour, spectral photometer, colour variation, tangential section.

1 Introduction

When we talk about wood colour, it means the natural colour tone of dried wood (Ugrenović, 1950). In the textbooks, wood colour is usually defined descriptively so the description of certain types of wood provide general information, describing the colour of a yellowish, brown, red-brown, etc. (Horvat and Krpan, 1967). This may be in the nature of colour, a large variability in the colour of wood, but also in a difficult notion of technical-measuring values of the wood colour.

When the light affects the surface of the wood, part of the incident light directly reflects from the surface, and the other part enters the surface wood cells. The basic structure of wood (cellulose, lignin and hemicellulose) differently absorbs and reflects light, and pigments absorb certain wavelengths of light. Part of the light that is not absorbed into the cell walls disperses and rejects, and partially passes through the wood substance. Unabsorbed light is recognized as the wood colour, and by nature of wavelength changes we sense specific wood colour of some wood species.

The natural wood colour is specific for each species, and the total number of more than 30000 wood species is the largest source of variability of the wood colours. Growth conditions can also affect the colour variation within the same wood species; growth rate, soil nutrition and the brightness affects the wood colour.

Wood colour is also affected by the physical factors such as the angle of the light falling on the fibres and surface roughness (Nishino *et al.*, 2000). The incidence angle of light on some wood surface shows strong differences in the gloss in direction and perpendicular to the fibres, which affects the impression of colour.

Defining of wood colour with spectral photometer has been used for some time and it has become one of the most frequent used methods in researching of macroscopic and aesthetical properties of wood (Blanchard and Blanchet, 2011; Brischke *et al*., 2007; Chen, T. *et al.*, 2012; Chen, Y. *et al.*, 2012; Jung *et al.*, 2008; Miklečić *et al.*, 2011; Miklečić *et al.*, 2012; Nemeth *et al.*, 2013; Nishino *et al.*, 1998). Research in the area of early wood density and late wood density and their relationship with the colour has not been done. The aim of this research was to measure and calculate the movement of density and colour of wood in the radial direction. Sycamore maple (*Acer pseudoplatanus* L.) was selected for the investigation.

Attempt was made to contribute to research and better understanding of the changes in colour and differences in density of early and late wood, since maple wood is diffuse porous hardwood. Maple wood is interesting to explore, as a diffuse porous wood species has a uniform structure with slight differences within annual ring and poorly visible annual ring border. The density of wood as a physical property is specific for a certain wood species, but because of biological origin is also highly variable, both among the different species and within the same wood species. In the same way the wood colour varies from species to species. Some species have darker and some have lighter colour, but with measuring and specifying the components we can accurately quantify it.

2 Material and Methods

For investigation were used randomly selected samples from three different maple trees. All three trees came from the same forest unit, which means that they had equal conditions for growth. Bark to bark cores, 70 cm in height were sawn from the trees. After the cores had dried to a water content of about 12%, from the highest part of the core, which was in the area of the chest height (1.3 m), samples of 20 mm × 20 mm × 25 mm were made (Figure 1). The samples were sawn in the radial direction from heart to bark and labelled with markers that indicate from which tree they were sawn, to which side of the world they belong to and the ordinal number from the heart to bark.

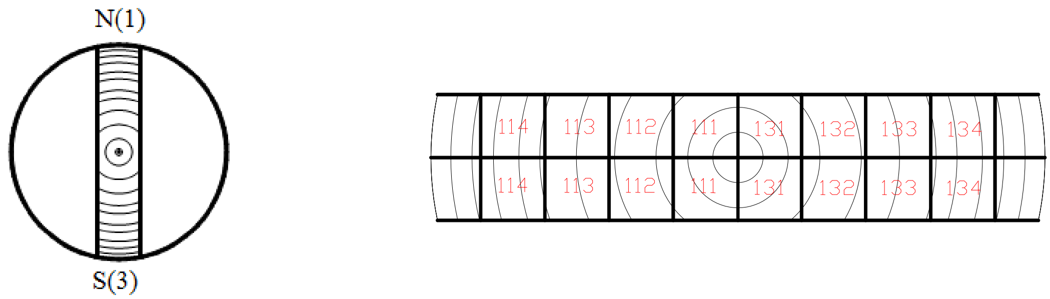

Figure 1 *Bark to bark core (North – South) and samples of 20 mm × 20 mm × 25 mm from core.*

After making of test samples, those with the widest annual rings were selected. From these samples one annual ring was cut with chisel, meaning wood chips were cut from annual ring from the early wood and late wood zone. Total of 30 wood chips from early wood and 30 wood chips from late wood was made.

To be able to perform spectral photometer colour measurement, after cutting specimens of early and late wood, each sample was sanded with sandpaper granulation 180. Each sample was marked with a number that indicates the number of tree, the side of the world where annual ring was, as well as the number of sample from which it was cut.

Colour measurement was performed with spectral photometer Microflash 100d produced by Datacolor (d/8º measuring geometry, 10º standard observer, D65 standard illuminate).

Due to the 9 mm aperture at the measurement point, it was not possible to measure the colour of early and late wood in radial and cross-sectional area. Aperture of instrument crossed not only the line between early and late wood, but the border between the annual rings as well. For this reason, the measurement was performed on tangential sections and the results are only measuring from the tangential sections.

Measurement was performed for each sample of early and late wood simultaneously. Measuring gave the results of colour values using the CIE $L^*a^*b^*$ colour system, where L^* describes the lightness, and a^* and b^* describe the chromatic coordinates on the green-red and blue-yellow axes. C^* describes colour saturation and h_{ab} describes the colour tone.

Density was measured in addition to colour measuring from each sample of early and late wood. Due to the size and irregularities of samples (wood chips), volume was determined in mercury.

3 Results and Discussion

Table 1 Statistical data for early and late wood

Early wood							Late wood					
h_{ab}	C^*	b^*	a^*	L^*	□□*w*□		□□ *w*□	L^*	a^*	b^*	C^*	h_{ab}
					g/cm^3		g/cm^3					
30	30	30	30	30	30	COUNT	30	30	30	30	30	30

70,37	14,97	14,42	3,46	69,26	0,417	MIN	0,441	75,33	3,87	14,76	15,31	72,20
73,20	17,77[A]	16,98[A]	5,17[A]	75,66[A]	0,591[A]	AVER	0,641[A]	78,81[A]	4,69[A]	16,17[A]	16,84[A]	73,87
77,37	22,20	21,11	6,96	82,60	0,690	MAX	0,860	82,58	5,58	18,06	18,89	76,41
1,62	1,79	1,62	0,91	3,28	0,071	STDEV	0,112	1,68	0,51	0,97	1,04	1,11
11,96	4,33	17,66	9,55	10,10	2,22	CV	17,51	2,13	10,92	5,97	6,18	1,50

Key: ρw - density at the time of measurement, L - colour lightness, a* - chromatic coordinate (red - green), b* - chromatic coordinate (blue - yellow), C* - chromatic saturation,* h_{ab} *- chromatic coordinate, COUNT - number of samples, MIN - minimum value, AVER - mean value, MAX - maximum value, STDEV - standard deviation, CV – coefficient of variation*
[A] *Average values identified with the letters A are statistically different at α = 95%, t-test was used.*

Statistical data shows that the mean density of the early and late wood zone varies. Although the maple wood is diffuse porous hardwood species and it is difficult to determine the boundary between the zones of early and late wood, measurement demonstrated that the early wood zone has a lower density than the late wood zone (Table 1) as expected; and the colour composition of early wood and late wood are different. Unexpected is that early wood colour has lower value of *L** (lightness) compared to late wood, meaning the early wood zone is slightly darker than the late wood zone.

The average value of the chromatic coordinates *a** in early wood zone is slightly higher than the average value of *a** in the late wood. The same case is with the average value of chromatic coordinate *b**. In the early wood zone, average color saturation *C** is slightly higher than in the late wood zone, and the color tone h_{ab} is very similar in the early and late wood zone. All measured values between early and late wood are statistically different (tested with t-test).

Table 2 Pearson's correlation coefficients for the relationship between wood colour parameters and density of early and late wood of *Acer pseudoplatanus.*

	*L**	*a**	*b**	*C**	*H**
Density of early wood	-0,18 P=0,354	0,13 P=0,505	0,04 P=0,833	0,05 P=0,788	-0,20 P=0,288
Density of late wood	-0,24 P=0,207	0,34 P=0,066	0,29 P=0,123	0,30 P=0,105	-0,28 P=0,136

Correlations are sigfnificant at P<0,05

No significant correlation coefficients were found between the density of the early wood zone and colour coordinates *L**, *a** and *b** at 95% confidence level (Table 2).

Figures 1, 2 and 3 show the relationship between density of early wood zone and colour parameters *L**, *a** and *b** of sycamore maple wood. The coefficient of correlation between colour parameters and wood density are detailed in Table 2 for early wood and for late wood of *Acer pseudoplatanus.*

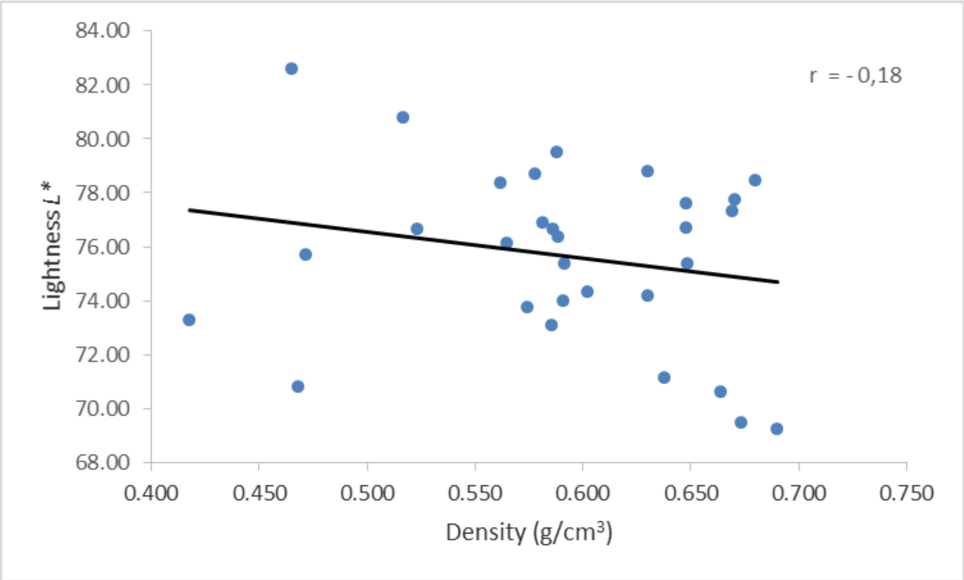

Figure 2 *Relationship between density of early wood zone and colour parameter L* of sycamore maple wood*

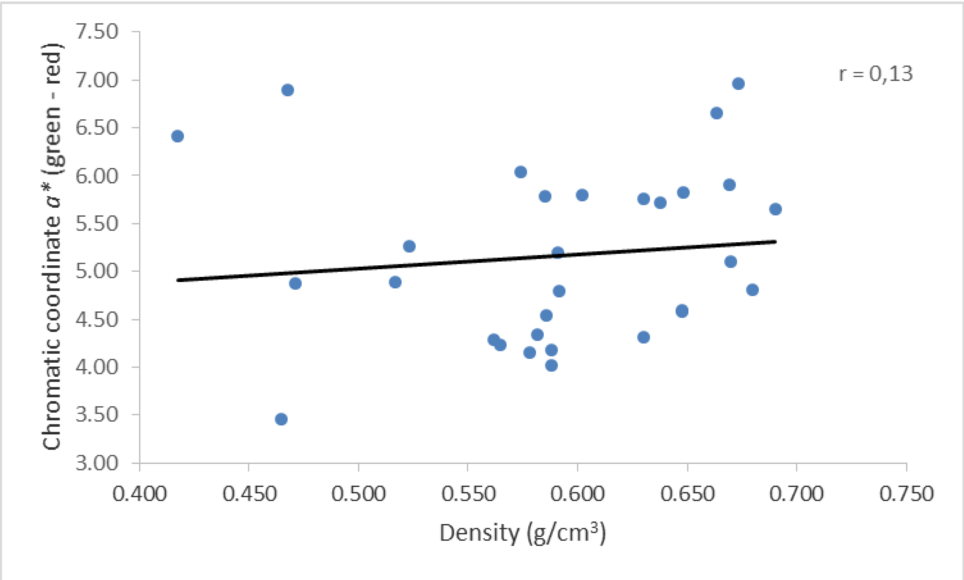

Figure 3 *Relationship between density of early wood zone and colour parameter a* of sycamore maple wood*

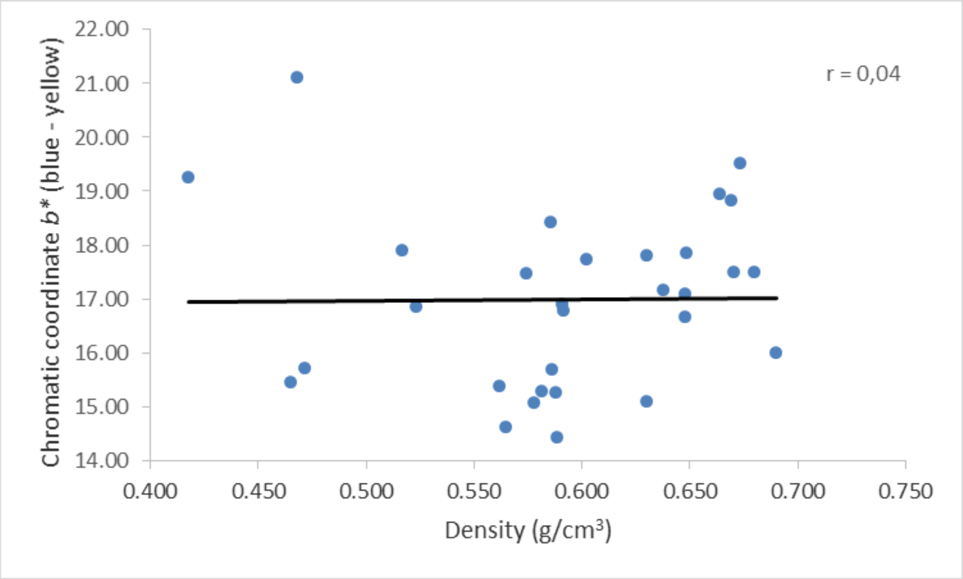

Figure 4 *Relationship between density of early wood zone and colour parameter b* of sycamore maple wood*

Figures 4, 5 and 6 show the relationship between density of late wood zone and colour parameters *L**, *a** and *b** of sycamore maple wood.

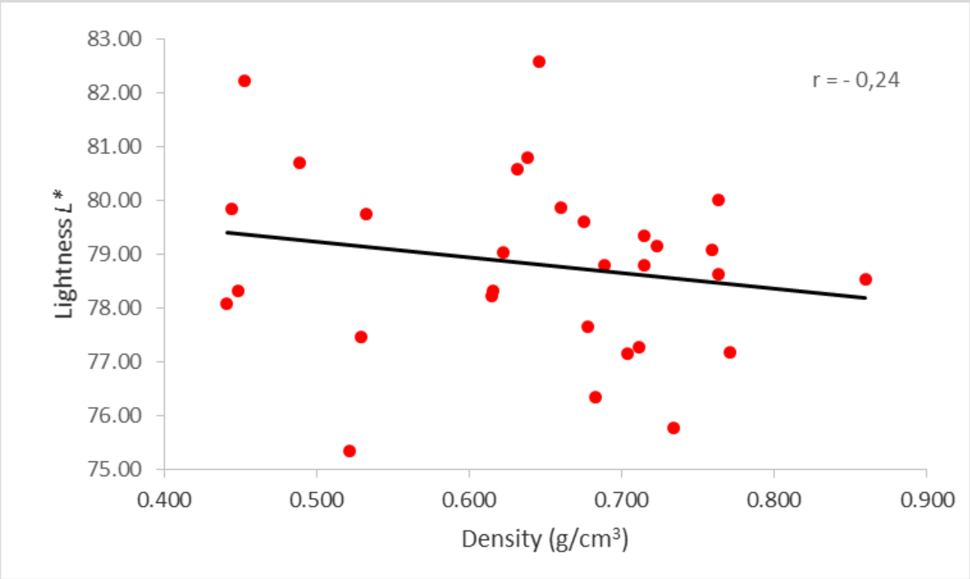

Figure 5 *Relationship between density of late wood zone and colour parameter L* of sycamore maple wood*

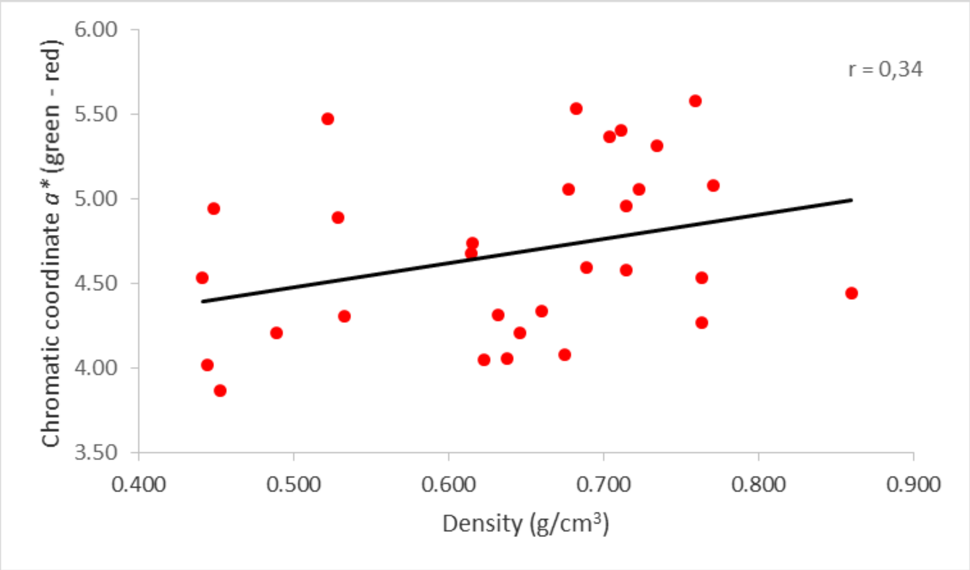

Figure 6 *Relationship between density of late wood zone and colour parameter a* of sycamore maple wood*

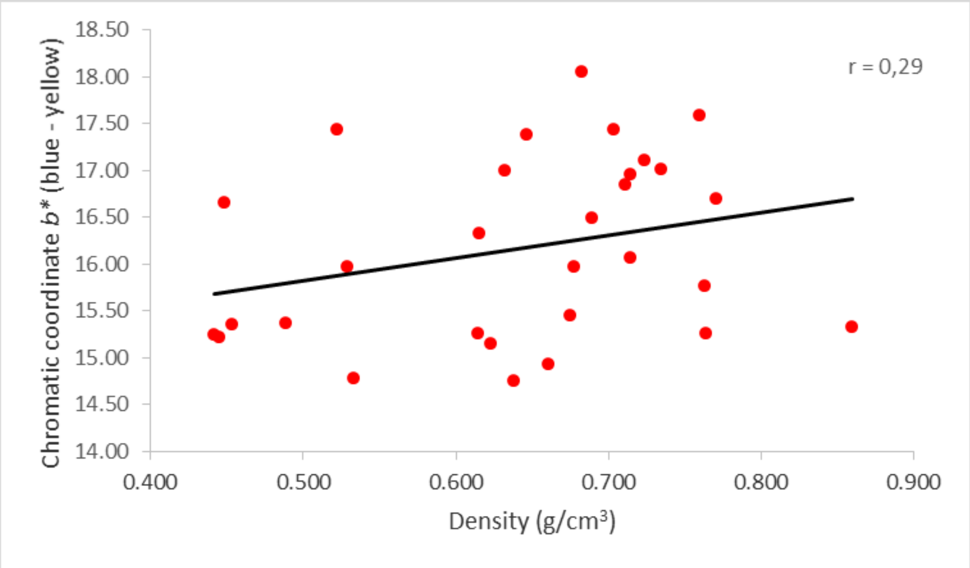

Figure 7 *Relationship between density of late wood zone and colour parameter b* of sycamore maple wood*

4 Conclusions

From the analysis of the data obtained in this investigation, the conclusion was that the increase in density of the early wood zone of sycamore maple (*Acer pseudoplatanus* L.)

reduces the colour coordinates L^*, meaning that the wood gets darker tone. The same result was obtained in the early wood and the late wood zone.
With increasing of density in the early and late wood zone, the values of colour coordinates a^* and b^* are growing. Increase in density also leads to an increase in colour saturation in the early and the late wood zone. Slight differences were measured in the average colour saturation C^* and colour tone h_{ab} between early and late wood zones. These results are not statically significant.

Statistically, the mean values of early wood density (0.591 g/ cm^3) and the mean density of the late wood (0.641 g/cm^3) are significantly different.

With this measuring method, on these samples it was not possible to find significant correlation between density of wood and colour of wood.

The unexpected result was obtained by comparing the mean values of the colour coordinates L^* (the lightness of the early and late wood). The average lightness of late wood zone is greater than the average lightness of the early wood zone, meaning that the early wood zone is darker than the late wood zone.

Lack of significant correlation between density and wood colour opens new questions in wood colour measurement. Repeating this measuring method on larger number of specimens, and different wood species could be a good topic for future research.

5 Literature

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