Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology № 92, 2015: 419-424
(Ann. WULS - SGGW, For. and Wood Technol. 92, 2015)

Changes of lightness (*ΔL**) of black walnut (*Juglans nigra* L.) under the influence of water and buffers of pH= 2 – 10

AGATA STACHOWIAK-WENCEK*, MAGDALENA ZBOROWSKA *, BOGUSŁAWA WALISZEWSKA *, WŁODZIMIERZ PRĄDZYŃSKI**, HELENA BIERNAT*

*Faculty of Wood Technology, Institute of Chemical Wood Technology, Poznań University of Lie Sciences
** Institute of Wood Technology, Poznań

Abstract: *Changes of lightness (ΔL*) of black walnut (Juglans nigra L.) under the influence of water and buffers of pH= 2 – 10.* The paper presents results of colorimetric analyses concerning changes in the parameter of lightness (ΔL*) in black walnut, caused by the effect of water and buffers: acid (pH in the range of 2 – 5), neutral (pH = 7) and alkaline (pH of 8 – 10). In order to more precisely characterise tested wood contents of its alkaline chemical constituents were determined, i.e. cellulose (43%), lignin (21.8%), pentosans (17.4%) and extractive substances (5.9%). It was found that the analysed wood under the influence of the above-mentioned factors became darker. The smallest changes in the parameter of lightness (ΔL*) were caused by water. Under the influence of 1h wood exposure its surface grew darker by 0.4 units, while after 24h treatment it was by 2.2 units. Changes in the parameter of lightness (ΔL*) caused by 1h exposure to buffers ranged from 0.5 to 4.2 units, whereas after 24 h they were greater, amounting to 2.4 up to 4.8 units. Among acid buffers the greatest effect on the degree of changes in lightness for wood of eastern black walnut were observed for buffer of pH = 5, while among alkaline buffer with pH = 8.

Keywords: lightness change (*ΔL**), black walnut , buffers

INTRODUCTION

Wood of exotic species is used increasingly often in various applications in our homes (Sudoł and Sulik, 2013). It is connected with its aesthetic value, i.e. an original and rich colour range, unusual grain as well as specific physico-chemical properties. Black walnut is one of the exotic wood species with a characteristic colour and interesting grain. It is a valuable wood species, with good workability and mechanical properties. It has been used for years in the furniture industry, as construction wood or even to produce musical instruments. It was also used by military contractors to manufacture stocks of firearms. This species is native to the United States, growing in the Mid-West and north east of that country in Kentucky, Indiana, South Dakota, Missouri, Kansas, Nebraska, Florida, Minnesota and Texas. It may also be found in south eastern Canada (Ontario). Black walnut is a fast-growing tree (annual increment of as much as 1.1 m), reaching a height of 25-30 m (Pióro 2009).

Wood colour, which is a key factor frequently determining the selection of wood product, changes under the influence of UV radiation. Discolouration of wood surface pertains equally to wood of exotic and Polish native species. Studies by Nowaczyk and Krzoska-Adamczak (2001) on natural veneers showed that walnut and birch veneers are most resistant to light. Beech and alder veneers were less resistant, while oak and cherry veneers were least resistant.

One of the parameters describing colour is lightness (L*). It indicates whether wood under the influence of UV radiation becomes lighter or darker. As it results from literature sources (Stachowiak-Wencek et al. 2013, Zborowska et al. 2015, Zborowska et al. (2014) and analyses of changes in parameters describing colour, i.e. lightness (*ΔL**) and chromatic

coordinates (*Δa*, Δb**), the parameter of lightness (*ΔL**) is frequently to the greatest extent responsible for the observed changes in sample colour (*ΔE**).

As a result of the large number of exotic wood species, a lack of international regulations concerning nomenclature as well as specific technical properties, determined e.g. by their growth under tropical climatic conditions exotic wood has not been sufficiently investigated (Sudoł and Sulik, 2013) and requires further studies, including research on changes in colour and factors causing these changes.

The aim of this study was to conduct a chemical characteristic of eastern black walnut wood and to determine changes in the parameter of lightness (L*) of this wood under the influence of the action of water and acid and alkaline buffers as well as a neutral buffer.

MATERIALS AND METHODS

Preparation of samples

The investigated material was exotic wood of eastern black walnut (*Juglans nigra* L.). Samples of 60 x 30 x 4 mm (±1 mm) (long. x tang. x red.) were prepared from the same boards. After cutting they were polished with sandpaper (400 P) prior to analyses. Then, they were divided into eight groups. The first group was the control sample. The next groups were dipped in H_2O and acid (pH = 2.0, 3.0, 4.0, 5.0), neutral (pH = 7.0) and alkaline (pH = 8.0, 9.0, 10.0) buffers, produced by Honeywell Burdick & Jackson. The tests were performed using three samples from each variant. Three circular measuring points were marked on each sample (diameter of 10 mm). The buffer treatment lasting for 1h and 24h was performed under laboratory conditions (23 °C, 45% RH). After dipping, the samples were dried at 40 °C for 24 h. The sample moisture content during the experiment was constant and amounted to 5.8%±0.1.

Chemical analysis of wood main components

Chemical analysis of pine included determination of extractive substances according to the T 204 cm-97 standard procedures (ethanol was used for extraction). For lignin quantification the T 222 cm-02 standard was used. Pentosans were determined according to the T 223 cm-01 standard procedure. Analysis of cellulose content was conducted according to Seifert (1956).

Colour measurements

All the colour measurements were taken from the surface of the samples before and after treatment in H_20 and buffers. The colour coordinates in the CIE *L*a*b** system were recorded with a Datacolour 600 dual-beam d/8° spectrophotometer, using the D_{65} standard illuminant. The wavelength range of the spectrophotometer ranged from 360 nm to 700 nm, reporting at 10 nm intervals. Reflectance of the instrument was 0.15 (max), 0.008 (avg.).The sensor head diameter was 10 nm. Colour coordinate *L** was measured on three samples per each variant. Calibration of the instrument was performed before testing using the white tile, green tile and black trap standards provided with the spectrophotometer. Three points of fixed locations were measured on each sample.

Data listed in this paper are averages of nine replicated measurements. The colour sphere is described as a tridimensional system of colour coordinates (axes *L**, *a** and *b**). Axis *a** depicts the share of green or red colour within the analysed colour; hues of green take on negative values and hues of red, positive values. Axis *b** depicts the share of blue or yellow colour within the analysed colour; hues of blue take on negative values and hues of yellow, positive values. Axis *L** describes colour brightness within the value range from 0 to 100. *L** = 100 means that a given colour is close to white, and *L** = 0 that a colour is close to black.

RESULTS

Chemical analyses of eastern black walnut wood included determinations of percentage contents of primary and secondary wood constituents. Results are given in Table 1.

Table 1. The contents of the main components of the black walnut wood

Constituent	Content [%]
Cellulose	43.0
Lignin	21.8
Pentosans	17.4
Extractives	5.9

The chemical composition of the tested black walnut wood (*Juglans nigra* L.) is typical of hardwoods. Studies by Wagenführ and Scheiber (1974) on wood of European walnut (*Juglans regia* L.) showed that the tested eastern black walnut wood was characterised by greater contents of cellulose (by 2.2%), pentosans (by 4.8%) and extractives (by 1.5) in comparison to wood of European walnut. In turn, lignin content in eastern black walnut wood was much lower (by 7.3%).

Figures 2 and 3 present changes in the parameter of lightness (*ΔL**) for the tested wood samples, caused by the action of water and buffers.

One-hour exposure of black walnut wood to acid buffers with pH ranging from 2 to 5 caused changes in the parameter of lightness (*ΔL**) ranging from 0.5 to 2.6 units. After 1h the smallest changes were recorded in the case of buffer with a strongly acid reaction (pH = 2), while they were the greatest for the buffer with a weak acid reaction (pH = 5). After 1h wood soaking in acid buffers it was stated that the degree of wood darkening increased with a decrease in solution acidity. This trend was not observed after 24h treatment. Po 24h the effect of the type of used buffer was markedly smaller. Results of the parameter (*ΔL**) varied slightly and amounted to 4.6 – 5.0 units. However, extending the duration of buffer action from 1 h to 24 h greatly intensified discolouration of surface in wood samples.

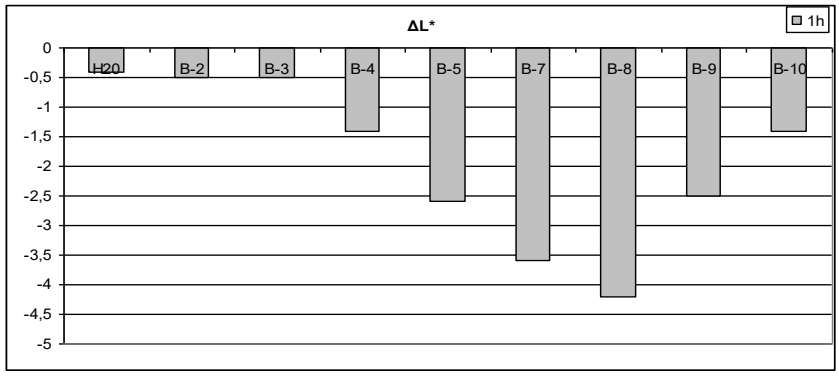

Fig. 1. Changes in the parameter of lightness (*ΔL**) in wood of black walnut after 1h soaking in water and acid, neutral and alkaline buffers

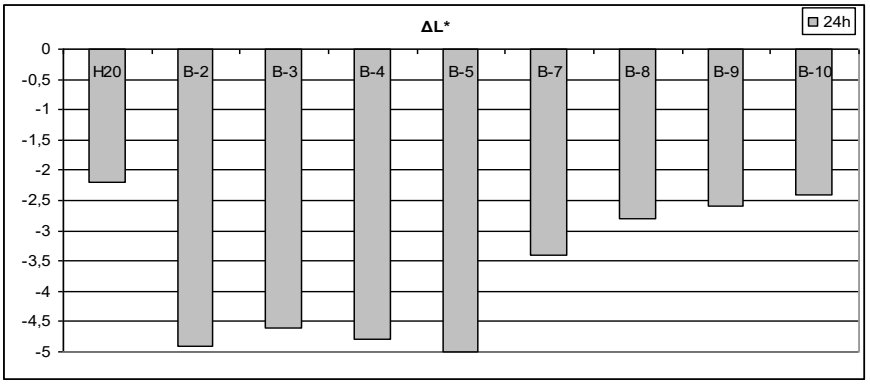

Fig. 2. Changes in the parameter of lightness (*ΔL**) in wood of black walnut after 24h soaking in water and acid, neutral and alkaline buffers

Soaking of wood in alkaline buffers for 1 h caused smaller changes in coordinate (ΔL^*) than it was for acid buffers. Wood of black walnut under the influence of 1h soaking in buffers with pH = 8 – 10 darkened within the range from 1.4 to 4.2 units. After 24h soaking the degree of darkening changed to 2.4 – 2.8 units. Both after 1h and 24h soaking the greatest changes were caused by buffer of pH = 8, while they were smallest for buffer of pH = 10, i.e. with an increase in the alkaline solution reaction wood darkening decreased.

The effect of buffer with a neutral reaction (pH = 7) on wood of black walnut was similar both after 1 h and 24 h, amounting to 3.4 and 3.6 units, respectively.

Studies on wood discolouration under the influence of acid and alkaline buffers were also presented in other literature reports (Stachowiak-Wencek et al. 2013, Zborowska et al. 2014, 2015). Zborowska et al. (2015) when testing pine wood exposed to buffers with pH = 4 and pH = 10 also observed the phenomenon of wood darkening. Pine wood after 24h treatment with acid buffer darkened (by approx. 0.5 units) to a lesser degree than under the influence of alkaline buffer (approx. 2.1 units). Similar results were recorded by Stachowiak-Wencek et al. (2013) for wenge wood. Soaking of wenge wood in acid buffer of pH = 4 did not cause its discolouration. In turn, under the influence of alkaline buffer of pH = 10 the value of the parameter of lightness increased by 6.24 units in relation to that determined for control samples. In turn, ipe wood after treatment with the acid buffer became lighter, while samples after treatment with the alkaline buffer were darker (Zborowska et al. 2014).

A study by Dziurzyński et al. (1995) on degradation of wood confirmed the phenomenon of wood sample darkening under the influence of wood hydrolysis with acid (H_2SO_4) and as a result of digestion with NaOH. This phenomenon is promoted by the reactions of lignin autocondensation occurring during the process of wood digestion as well as reactions of polymerisation and polycondensation of furfural with lignin and monosaccharides.

CONCLUDING REMARKS

1. It was found that wood of black walnut undergoes discolouration both under the influence of water and acid, neutral and alkaline buffers. Treatment with these chemical substances caused minor darkening of the wood surface.
2. Susceptibility of tested samples to discolouration was dependent not only on the type of used solution, but also the duration of wood exposure to its action. With an increase in the

time of treatment with water and buffers the observed changes in parameter (ΔL*) were greater, i.e. wood darkened to a greater extent.

3. After 24h sample soaking in solutions of buffers with pH = 2 – 10 greater changes of parameter (*ΔL**) were caused by buffers with acid reaction rather than those with alkaline reaction. The greatest changes in the parameter of lightness (*ΔL**) were recorded for samples exposed to buffer with pH = 5.
4. Among alkaline buffers the greatest changes leading to wood surface darkening were observed at treatment with solution with pH = 8. With an increase in solution alkalinity their on changes in (*ΔL**) decreased.

REFERENCES

1. DZIURZYŃSKI A., PRĄDZYŃSKI W., SURMIŃSKI J. (1995). Zmiany barwy drewna w procesie jego degradacji [Changes in wood colour during the process of its degradation]. Poznańskie Towarzystwo Przyjaciół Nauk, Prace komisyjne technologii wood, Poznań.
2. NOWACZYK M., KRZOSKA-ADAMCZAK Z. (2001). Pomiar zmiany barwy drewna pod wpływem światła [Measurement of changes in wood colour under the influence of light]. Roczniki Akademii Rolniczej w Poznaniu CCCXL 35: 79-85.
3. PIÓRO P. (2009). Orzech amerykański – czarny wojownik [Eastern black walnut – a black warrior]. Podłoga 6: 36-38.
4. STACHOWIAK-WENCEK A., ZBOROWSKA M., WALISZEWSKA B., PRĄDZYŃSKI W., NOWACZYK- ORGANISTA M. (2013). Colour changes in pine wood subjected to ageing tests in an UV chamber. Annals of Warsaw University of Life Sciences – SGGW. Forestry and Wood Technology 84: 300-304.
5. SUDOŁ E., SULIK P. (2013). Problematyka wykorzystania drewna egzotycznego w zewnętrznych przegrodach budowlanych [Problems with application of exotic wood in external contruction partitions]. Budownictwo i Architektura 12(3): 27-34.
6. WAGENFÜHR R., SCHEIBER CHR. (1974). Holzatlas. VEB Fachbuchverlag Leipzig.
7. ZBOROWSKA M., STACHOWIAK-WENCEK A., NOWACZYK-ORGANISTA M., WALISZEWSKA B., PRĄDZYŃSKI W. (2015). Analysis of photodegradation process of *Pinus sylvestris* L. wood after treatment with acid and alkali buffers and light irradiation. BioResources 10(2): 2057-2066.
8. ZBOROWSKA M., STACHOWIAK-WENCEK A., WALISZEWSKA B., PRĄDZYŃSKI (2014): Comparative studies of ipe (Tabebuia spp.) wood photodegradation caused by treatment with acid and alkaline buffers. Annals of Warsaw University of Life Sciences – SGGW. Forestry and Wood Technology 88: 287-291.

Streszczenie: *Zmiana parametru jasności (ΔL*) drewna orzecha amerykańskiego pod wpływem wody i buforów o pH 2 – 10.* W pracy przedstawiono wyniki badań kolorymetrycznych w zakresie zmian parametru jasności (*ΔL**) orzecha amerykańskiego, spowodowane działaniem wody oraz buforów: kwaśnych (pH w zakresie 2 – 5) obojętnego (pH = 7) i zasadowych (pH e zakresie 8 – 10). W celu bliższego scharakteryzowania badanego drewna oznaczono zawartość jego podstawowych składników chemicznych tj. celulozy (43%), ligniny (21,8%), pentozanów (17,4%) oraz substancji ekstrakcyjnych (5,9%). Stwierdzono, że badane drewno pod wpływem ww. czynników uległo ściemnieniu. Najmniejsze zmiany parametru jasności (*ΔL**) spowodowała woda. Pod wpływem 1h obróbki drewna wodą jego powierzchnia ściemniała o 0.4 jednostki a pod wpływem 24h obróbki o 2.2 jednostki. Zmiany parametru jasności (*ΔL**) spowodowane 1h działaniem buforów kształtowały się na poziomie od 0.5 do 4.2 jednostki a 24h były wyższe i wynosiły od 2.4 do 4.8 jednostki. Spośród buforów kwaśnych największy wpływ na stopień zmian jasności drewna orzecha amerykańskiego miał bufor o pH = 5 a spośród buforów zasadowych bufor o pH = 8.

Corresponding author:

Agata Stachowiak-Wencek
Institute of Chemical Wood Technology
Poznań University of Life Sciences
ul. Wojska Polskiego 38/42
60-637 Poznań
e-mail: agatas@up.poznan.pl
phone: +48 61 848 74 62