Colour Measurement for Determining the Steaming Properties of Wood

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Abstract**:** *The colour of some durable hardwoods does not meet the taste of most consumers and some others have inhomogeneous colour. Both problems can be solved by steaming. Black locust wood is highly sensitive to the steaming temperature. Its greenish yellow colour can be modified in a large scale. By steaming above 100°C, the colour of black locust can be modified to a very dark brown resembling that of some tropical timbers. In contrast, beech and turkey oak are much less sensitive to the steaming temperature. These timbers often have red heartwood. Side by side the white sapwood and the dark red or brown heartwood are nonattractive. This colour disharmony can be homogenised by steaming. The colour of white sapwood turns to warm light brown and the heartwood becomes also warm brown close to the colour of the steamed sapwood.*

Keywords: *color, pattern, harmony*

1 Introduction

The colour inhomogeneity of wood is one of the most beautiful colour harmony created by the nature. There are some species having white-greyish colour without visible texture, while some other have disturbingly inhomogeneous colour. Both disadvantages can be modified by steaming. In practice, steam treatment of wood for colour change was started as early as the second half of the last century. Mostly beech and black locust timbers were steamed. Beech is usually steamed to turn its white-grey initial colour into more attractive reddish. The great colour difference between white and red heartwood of beech can also be minimalised by steaming [1]. The systematic research to discover the specific effects of steaming parameters for individual wood species has been carried out only for 20 years. The steaming behaviour of black locust has the most detailed literature [2-3]. There are only a few publications regarding to the steaming properties of other species than beech and black locust [4-6].

The objective colour measurement in wood research was widely applied only in the recent past [7-11]. This objective colour measurement helped the researchers to find out the steaming behaviours of wood species.

2 Materials and Methods

For laboratory steaming black locust (Robinia pseudoacacia L.), beech (Fagus silvatica L.) and Turkey oak (Quercus cerris L.) samples were prepared with the size of 300x40x22mm (LxTxR) and only those were used for the tests, which were free from any defects. The treatment was carried out at atmospheric pressure (below 100°C) in a steam chest at 100% relative humidity. Above 100°C an autoclave was used. The total steaming time was 22 days. Here only the data of a 6 days long treatment are presented. Before colour measurements, the steamed wood specimens were subsequently conditioned for one month at room temperature (23C° and 50% rel. humidity). For the colour measurements a Konica-Minolta 2600d colorimeter was used. The L*, a*, b* colour co-ordinates were calculated based on the D_{65} illuminant and 10° standard observer with a test-window diameter of 6 mm.

3 Results

The reproduction of desired colour by steaming for beech is easy but the same for black locust is difficult. The reason was unknown up to introduction of the objective colour measurement. The lightness change of black locust samples is presented in Fig. 1. The lightness decreased continuously at any steaming temperature. This decrease was more pronounced with increasing temperature, demonstrating that the value of lightness change correlates exponentially to the steaming temperature. This lightness decrease was proportionally more effective in the first days and more or less levelling off around 10 to 4 day. The trend lines (belonging to different steaming temperatures) are fare from each other. That means the colour change of black locust is highly sensitive to the steaming temperature. This finding can be the reason why it is difficult to reproduce the same colour in a series of steaming. If the steaming temperature has not been kept constant the result will be an unwanted colour. Above 100°C the lightness trend lines are reaching the same lightness value. This means a decrease of ca. 50% of the original lightness of black locust. It represents that a wide range of colour can be created by altering the steaming temperature and time.

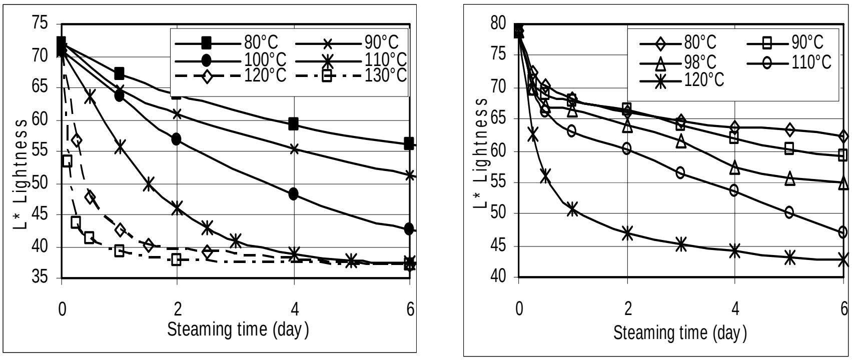

Fig. 1. Changes in lightness of steamed black locust (left) and beech (right) as a function of temperature and time.

The main colour co-ordinate, the lightness (L*) of beech samples changed in a different way comparing to the change of black locust (Fig. 1). Here the trend lines are almost in the same position below 100°C and within one day steaming time. It represents that steaming of beech is not sensitive to the steaming temperature if it is below 100°C. That is why the colour of beech wood can be reproduced easily even at an industrial scale.

The change of red colour component as a function of steaming time is presented in Fig. 2. The red colour of black locust represented by a^* co-ordinate increased rapidly at the beginning of steaming. This tendency was accelerated with rising temperature. Above 90°C the curves have a maximum value. (Probably at lower temperatures the curves also have maximum, but they are out at the examined steaming time range.) The place of maximum shifted towards shorter steaming time with rising temperature. This finding is important for industrial steaming, as this maximum can be an upper limit of the effective steaming time at the indicated temperature. During steaming new chemical components are created containing conjugated double band system. These structures are created during the degradation of the extractives being present in black locust wood. These newly created coloured molecules are extractable and the hot steam leaches them out resulting in a decrease of the red hue (a^* values). These leached components can be detected in the wastewater of the steaming process. The change of the red colour co-ordinate of beech was less temperature dependent compared to

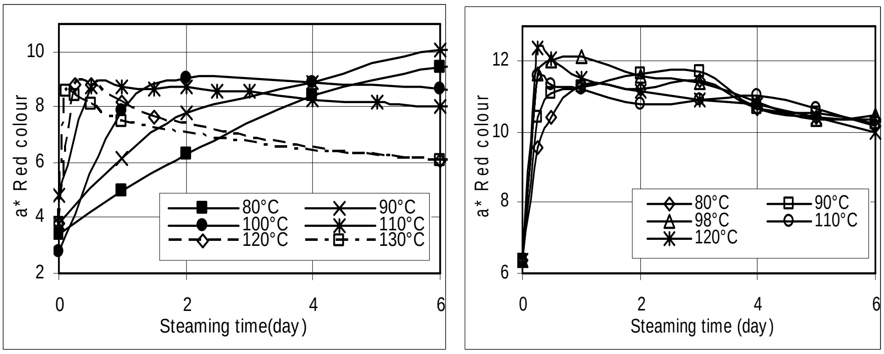

Fig. 2. Changes in redness of steamed black locust (left) and beech (right) as a function of temperature and time.

black locust (Fig. 2). The curves of red colour show a maximum too. The initial increase of the a* values before the maximum was extremely intensive, but the decrease thereinafter was moderate. These maxima shifted towards shorter steaming time with rising temperature.

Turkey oak has nice white but wide sapwood, and many trees have dark reddish-grey heartwood. The border between the dark and white portions is usually very sharp. This great colour difference can be diminished by steaming. The colour changes caused by steaming are presented in Fig. 3. Most of the colour change happened during the first 12 hours of steaming. There was no difference among the effects of various temperatures below 100°C. With increasing temperature the darkening of sapwood was greater during the first day of steaming. At 110°C the colour change was rapid in the first one days of steaming, and then the decrease became moderate parallel with the levels of the other temperatures. The treatment caused a little darkening of heartwood. This change was less intensive than the darkening of sapwood. The changes between sapwood and heartwood created a degree of colour homogenisation, thus giving the wood a more uniform appealing appearance. Much of the homogenisation happened during the first day of steaming. Before steaming the dark heartwood was almost twice as red as the sapwood. During steaming the trend changed. The red colour component of white sapwood increased more rapidly than the change of heartwood. The trend lines crossed each other a little before 12 hours of steaming at 110°C. At 80°C, this point was at 24 hours steaming time. The curves for colour change reach a maximum at one day of steaming for 110°C. At longer steaming times, the steam started leaching out the newly created chromophors, as it was also observed during steaming of black locust. More chromophors were removed from the heartwood than from the sapwood. The optimal colour homogenisation time (in viewpoint of red hue) was found at 12 hours for 110°C, and 24 hours for 80°C and for 95°C.

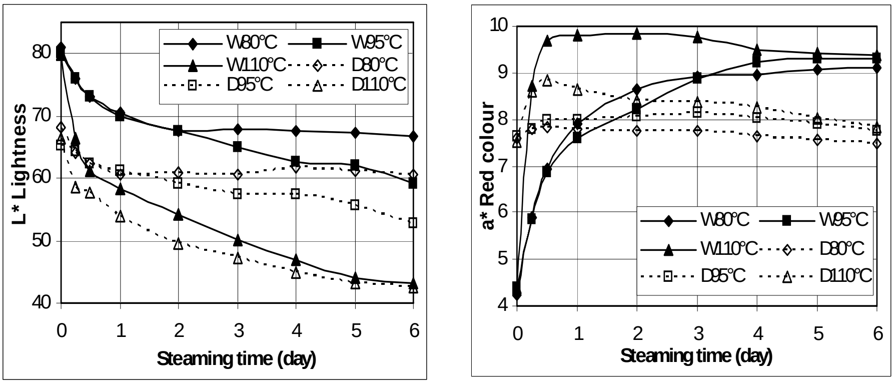

Fig. 3. Color change of white sapwood (W) and dark heartwood (D) of Turkey oak by steaming.

The created colour hues of both sapwood and heartwood were even redder than the hue of non-steamed heartwood. These newly created warm brown colours are visually more attractive than the original colour of heartwood. Based on the technical properties, steamed Turkey oak can be utilized for some indoor applications (e.g. parquet flooring, furniture components and front panels) after colour homogenisation.

Conclusions

The colour change of black locust is fast at the beginning of the steaming. This tendency decreases with time and goes to a constant level. By steaming at a temperature above 100°C, black locust colour can be modified to a very dark brown resembling that of some tropical timbers such as the African wengé (*Millettia laurentii*) or the Southamerican supupira (*Bowdichia spp.*) frequently used for solid wood and prefab flooring components. If a specific colour is desired, the proper process parameters controlling the steaming process have to be set accordingly and monitored closely.

All temperatures in the examined 80-120°C range are suitable to homogenise the colour of white and red heartwood of Turkey oak and beech. The colour change was similar below 100°C independently on the temperature. Most part of colour change has happened during the first 18 hours of steaming.

Based on the technical properties, Turkey oak can be utilized for some indoor applications (e.g. parquet flooring, furniture components and front panels) after colour homogenisation. The colour difference between sapwood and heartwood can be reduced effectively by steaming in the 80-110°C temperature range. The new appearance created is a visually more attractive brown colour than the natural colour of heartwood. Steaming above 100°C can be recommended if a special dark brown colour is needed.

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