

ASPECTS OF SUBFOSSIL OAK FINISHING WITH TWO NATURAL COATING MATERIALS

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Abstract:

Subfossil oak is a special and valuable material, whose distinctive appearance and altered chemical structure may influence its finishing behavior and color stability. This study evaluated finishing of subfossil oak in comparison with recent oak, using two traditional natural coating materials: siccative linseed oil and beeswax. Specimens were finished using three variants: two layers of linseed oil, two layers of beeswax, or successive layers of linseed and beeswax. The application rates, changes in the CIELab color parameters as result of the finishing process, and color stability during an accelerated light exposure test were assessed. Subfossil oak generally needed a lower coating application rate for surface saturation than recent oak, with statistically significant differences particularly for beeswax. SEM–EDX observations identified iron- and calcium-containing deposits and a partially compressed anatomical structure in the subfossil oak, which may account for its reduced coating uptake. All finishes enhanced color saturation and luster, thereby accentuating the wood texture and underscoring its visual characteristics. Color changes following finishing were higher in recent oak than subfossil oak, while linseed oil produced stronger color saturation than beeswax in both substrates. After 144h UV light exposure, uncoated subfossil oak exhibited a lower total color difference than recent oak (ΔE values of 7.76 and 9.66, respectively). Coated subfossil oak showed only barely visible to small color changes ($\Delta E = 0.88$ – 2.05), whereas coated recent oak showed medium changes ($\Delta E = 4.02$ – 6.07). All coatings improved the color stability towards simulated indoors light exposure, with linseed oil showing the greatest protective effect for subfossil oak under the tested conditions. The results support the use of natural finishes for enhancing and protecting subfossil oak surfaces, although further studies involving more material sources, replicates, and coating systems are required.

Key words: artificial ageing test; beeswax; linseed oil; light induced color changes; subfossil oak.

INTRODUCTION

Subfossil oak (SO), or *black oak*, may be defined as non-petrified oak wood that has been buried and preserved in anaerobic wet environments for a long period of time, ranging from centuries to millennia (adapted from Kolar *et al.* 2014, Beldean and Timar 2021). SO has similar macroscopic and microscopic structure as recent oak, it is still an organic material, though it contains more minerals, but it clearly differentiates from recent oak by its specific color, varying from golden-brown to dark-grey up to black, especially in the outer layer of the trunk (Veizović *et al.* 2018, Veizović *et al.* 2018b, Lachowicz *et al.* 2024). The sub-fossilization process is initiated by the perishing, falling or cutting down of living trees, which consequently become waterlogged or buried in wet sediments or bogs.

The environments in which subfossil oaks have been identified are diverse, including peat bogs (bog oaks), floodplain alluvia and gravel deposits associated with river channels, as well as lowland marsh or wetland soils, where tree stumps remain buried *in situ* (Leuschner *et al.* 2002; Kern and Popa 2016; Sass *et al.* 2005).

In the respective conditions various minerals are penetrating into the wood structure, and chemical reactions occur between some wood components, especially tannins, and those minerals. Color changes into dark grey to black, with various shades of brown, rendering to subfossil oak a particular aesthetical aspect, are a consequence of this process. In particular, the reaction of iron ions with tannins in oak is important in explaining the color of subfossil oak by formation of non-water soluble ferric tannate complexes (Baar *et al.* 2020). Iron is taken up from the bog water, or the moist environment in which wood was buried, as Fe^{2+} and oxidizes only when the wood emerges from the water and comes into contact with air, so that Fe^{3+} is mostly found in the air conditioned SO (Burck *et al.* 2012). More recent research has demonstrated a direct negative

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correlation between the CIELab color parameters of subfossil oak and the iron content determined by XRF (X-rays fluorescence). Lower color parameters, meaning darkening and decrease of chromaticity, respectively turning to grey up to black, were correlated with higher iron content (Nedelcu *et al.* 2024).

Subfossil oak, often discovered by chance in various locations, represents an unconventional resource for a rare, special and valuable material, which is of interest for the production of high-quality furniture and decorative items, mainly due to its exquisite aesthetic qualities. The finishing process is of paramount importance for both new and subfossil wood, as it enhances the appearance and beauty of wood surfaces by color saturation and highlighting of the anatomic structural features, while also contributing to their resistance to the usual physical, chemical and environmental factors in everyday use. This process might be considered as of particular significance for subfossil oak, which has undergone significant chemical changes over time, affecting its natural durability (Baar *et al.* 2020) and some of its physical and mechanical properties (Kolar *et al.* 2014, Nedelcu *et al.* 2024). For instance, the lower durability to fungal attack and higher dimensional instability and hygroscopicity of subfossil oak compared to recent oak should be considered in choosing adequate finishing technologies or specialized treatment to ensure its longevity and aesthetic appeal.

At the same time, the distinctive composition of subfossil oak, resulting from extended exposure to water and sediments, renders it more sensitive to abrasive wear by sanding with different grit sizes (P80, P120, P240, P360, P800) compared to recent oak. This result highlights the necessity to determine the parameters of the surface roughness of the machined SO wood surfaces, as well as the need of contributions to a broader picture in the research of the subfossil oak in comparison to contemporary oak (Essert *et al.* 2023).

With this respect, it has to be said that finishing of subfossil oak wood and/ or to the effect of light on the color stability of the uncoated and coated subfossil oak surfaces are subjects which have not been yet in the focus of research on subfossil oak wood, though their practical importance in the valorization of this valuable material in furniture and interior design seems obvious.

OBJECTIVES

The objectives of this study were threefold: firstly, to conduct a practical evaluation of the behavior of subfossil oak in comparison to recent oak when subjected to finishing technologies employing two natural coating materials; secondly, to evaluate the color changes that occur as a consequence of the coating process; and thirdly to assess the color stability of both coated and uncoated surfaces when exposed to light in an accelerated test simulating indoors ageing by natural light filtered by window glass.

MATERIALS AND METHODS

Materials

Wood material and test samples

Subfossil oak (*Quercus* spp.) wood material (SO) was sourced from a trunk discovered in Romania, in Timiș County, Tapia village, on the right riverbank of Timiș river, this source of SO being coded S1. The trunk was excavated from 7m depth, 4m below groundwater level and was further processed into lumber pieces, which were air-dried to 12% moisture content (MC). For comparison, new (recent) oak timber (*Quercus robur*), at similar MC, was employed. New oak (NO) and subfossil oak (SO) test samples of 120x80x5 mm, with longitudinal radial faces, were processed from the heartwood zone.

Coating materials and finishing variants

Two types of natural traditional coating materials were employed: siccative linseed oil (LO) and beeswax (BW). A commercial LO product (trade name Ekonomic produced by Fabryo, Romania) and block pure beeswax (from Fenghua Trading Co. China) were used within the experiments. The test samples were finished in three variants: F1- consisting of two successive layers of linseed oil (2xLO); F2 - consisting of two successive layers of beeswax (2xBW); and F3 - consisting in a first layer of linseed oil and a second one of beeswax (LO+BW).

The solid wax was scraped and then dissolved into white spirit (WS) (from Moustash Romania) at 18% weight concentration, on a warm water bath. The siccative linseed oil was employed diluted (volumetric ratio LO:WS = 3:1) as first layer and undiluted as second layer.

The coating materials were applied manually onto the wood samples employing a cotton cloth. The manual traditional technique envisaged a uniform coverage of the surface until substrate saturation. The actual application rates in g/m² were calculated based on the weight of the samples before and after application, for each finishing layer and test sample.

Methods

Color measurements

Color measurements in the CIELab system were carried out in order to assess the chromatic changes as result of finishing, as well as to evaluate the color stability of both coated and uncoated specimens when subjected to light-induced accelerated ageing.

The three measured parameters were: L^* - the lightness, varying from 0 for black to 100 for white; a^* - the chromatic parameter on red (+) to green (-) axis and b^* - the chromatic parameter on the yellow (+) to blue (-) axis, of the CIELab spheric space. Measurements were carried out under the D65 day light illuminant and at 10-degree observer angle (according to EN ISO/CIE 11664-6:2022 standard), employing a AvaSpec-USB2 spectrometer equipped with an integrating AVA sphere. The measuring aperture of the sphere was 8 mm in diameter. Data was registered with the color application of AVASOFT - version 7 and were further processed in excel.

The CIELab parameters were measured on fifteen fix points on each specimen, so that to ensure repeatability of measurements on each test sample. The measuring points were situated along three measurement lines, with five points, spaced 2 cm apart, on each line. A special device was employed for this purpose (Fig.1).



Fig. 1.

Special device employed for repeatably measuring the CIELab color parameters in the same points, situated along three measurement lines, with five points, spaced 2 cm apart, on each line:
a – measurements on line "A"; b – measurement on line "C".

To evaluate color change by finishing, color measurements were done before and after coating on five specimens for each finish (F1-F3). To evaluate the color stability of the coated and uncoated surfaces when exposed to light in an accelerated test, three specimens were used for each type of finish and for the control. Measurements were recorded prior and after light exposure.

The color changes due to the finishing in the three variants, respectively the light induced color changes after various exposure times were expressed by the color difference ΔE , calculated as follows:

$$\Delta E = [(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2]^{1/2} \quad (1)$$

where: L_1^* , a_1^* , b_1^* are the CIELab color parameters prior finishing or light exposure

L_2^* , a_2^* , b_2^* represent the same parameters after finishing, respectively light exposure.

Light exposure

The specimens were exposed to light in an accelerated test to simulate indoors light-induced aging by natural light filtered by window glass. An environmental climatic chamber (FEUTRON FKS 400), equipped with a UVA-SPOT 400/T light source of 400 kW, with a cut off filter H2 allowed exposure to UVA–UVB–VIS radiation in the range 295–600 nm. It is rational to say that the UV radiation might have contributed the most to the color and chemical changes occurring as result exposure due to its higher energy (Machova *et al.* 2019, Tomak *et al.* 2024). Accordingly, the term UV exposure / UV ageing was currently employed for the experimental light exposure achieved in this research and coding of samples. However, the contribution of short waves visible light (400-600 nm) in the violet - blue region of visible spectrum, which were found active in light induced color changes of wood surfaces (Živković *et al.* 2014, Liu *et al.* 2022) should be acknowledged.

The UV irradiation procedure was conducted based on a programmed complex cyclic protocol, adapted from Method B of EN ISO 16474-3 for simulating the effects of daylight transmitted through window glass. A complex cycle included 4 sub-cycles of UV irradiation at 40°C alternating with dark periods (6h UV/ 30 min dark), as well as initial (0.5h) and final (24h) conditioning periods at 20°C, 55% relative humidity, as detailed in previous publications (Timar and Beldean 2022). A total number of 6 complex cycles, each of them including

24h UV exposure, were achieved. The results presented in this paper refer to the final aspect of the samples, after 144h UV (light exposure).

RESULTS AND DISCUSSION

Finishing of the test samples

The average values of the achieved application rates (g/m^2) for each coating layer and total are summarized in Table 1. These values were calculated for each finish type (F1, F2, F3) and for each type of wood substrate: subfossil oak (S1) and new oak (NO), with the view of determining any relevant differences or short-comes in finishing subfossil oak surfaces, in comparison with new oak.

Table 1

Average values and standard deviations of experimental application rates for the three finishing variants, depending on the wood substrate

Finishing technology		Specific consumption. g/m^2					
		Subfossil oak S1			New oak NO		
		Layer 1	Layer 2	Total	Layer 1	Layer 2	Total
Finish F1 (2×LO)	Average	26.52	13.69	40.21	26.82	17.27	44.09
	St dev	6.86	3.58		3.37	2.59	
Finish F2 (2×BW)	Average	10.70	12.41	23.10	16.82	17.73	34.55
	St dev	2.62	2.34		2.59	4.37	
Finish F3 (LO+BW)	Average	24.60	12.83	37.43	29.09	22.73	51.82
	St dev	2.83	3.70		7.08	1.61	

The experimental data show that the mean values of application rates for subfossil oak (S1) were generally slightly lower than those for new oak in all cases, regardless of the type of coating material (LO, BW) in both the first and second layer. For the F1 (2×LO) finish, the total specific consumption for subfossil oak S1 was 40.21 g/m^2 , compared to 44.09 g/m^2 for new oak, but the differences were not statistically significant for neither of the two successive layers of LO, according to a t-test for two sample assuming unequal variances. For the finish F2 (2×BW), the average total specific consumption value for subfossil oak was 23.10 g/m^2 , while for new oak it was 34.55 g/m^2 . Statistical analysis of data by a similar test showed that the application rates on the new oak wood substrate were significantly different and higher than those achieved for the subfossil oak for both the two successive layers of BW applied. For the finish 3 (LO+BW) there was registered the highest difference in total specific consumption between subfossil oak (37.42 g/m^2) and new oak (51.82 g/m^2). However, statistic processing of data showed that there were no statistic significant differences for the application rate of linseed oil as first layer, but there were significant differences for the application rates of beeswax as second coat, namely a higher application rate was again obtained when applying BW on NO, compared to SO (S1).

As the application was done manually until an apparent substrate saturation, a degree of subjectivity has to be considered. However, a correlation to possible differences in the absorption capacity of the two types of substrates due to a partial filling of the pores with various minerals during the sub-fossilization process could be considered as a possible cause of the registered differences. The fact that consistently no significant differences were found in the case of the very fluid oil, but were observed for the more viscous wax solution is in accordance with the previous hypothesis.

Indeed, the pictures in Fig. 2 show comparatively some anatomical structural features alongside elemental chemical composition in some relevant points of the transversal section of subfossil oak S1 and new oak NO, obtained by employing a SEM-EDS electron microscope Phenom XL, at magnification of 700-1000x. The images mainly show large earlywood vessels filled with tyloses and some vasicentric axial parenchyma, easier to observe within the less affected structure of NO (Fig.1b). Some white dots are clearly visible on the tyloses of subfossil oak S1. Punctiform energy dispersive X ray analysis (EDX) in such area (marked as blue cross in circle) identified iron ($\text{Fe} = 1.7\%$) and calcium ($\text{Ca} = 1.8\%$) denoting the existence of mineral deposits accumulated during long-time sub-fossilization process. In contrast, no such deposits were identified in the case of NO substrate. Moreover, a partially crushed structure, with compressed and deformed cell is visible in the case of subfossil oak S1 compared to NO, which may indicate a reduced porosity and permeability compared to NO, explaining the previously presented results. More investigations are needed related to this aspect.

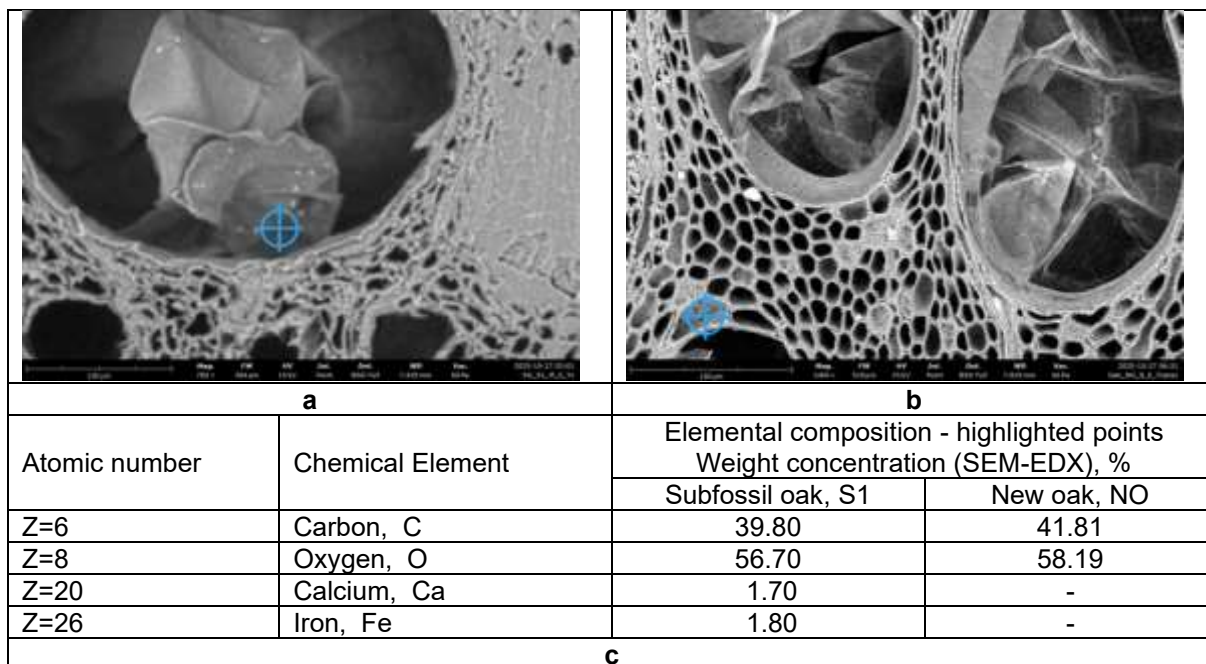


Fig. 2.

Comparative SEM microscopic aspect of a cross-section in the two types of wood material:
a- subfossil oak S1; b- new oak; c- results of chemical elemental analysis by SEM-EDX in the points
marked by a blue cross in a circle.

However, some relativeness of data due to the manual application and possible subjectivity in appreciating the stage of substrate saturation should not be neglected either.

Visual aspects and color changes due to finishing

The pictures in Fig. 3 present comparatively the general aspect of the subfossil oak (S1) and new oak test specimens before finishing (Fig.3a) and after finishing (Fig.3b) in the three variants F1 (2×LO), F2 (2×BW) and F3 (LO+BW).

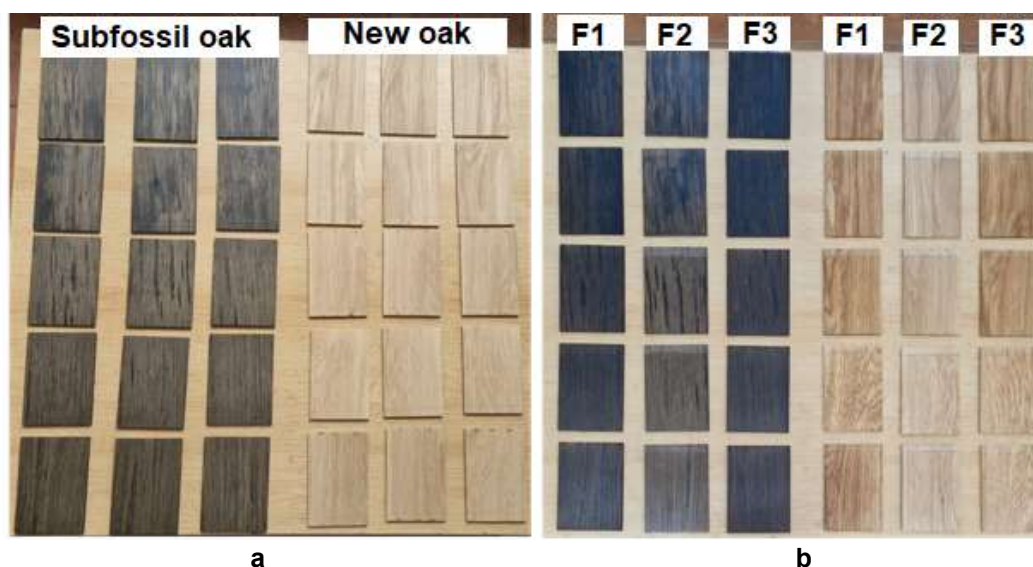


Fig. 3.

Test specimens of the two types of substrates (SO-S1 and NO):
a - before finishing; b- after finishing.

It is clearly visible that coating of both types of oak wood substrates with the two natural traditional coating materials, namely siccative linseed oil (LO) and beeswax (BW), resulted in the intensification and saturation of their original color, thereby yielding more vibrant and lustrous hues. This effect was accompanied

by a clearer highlighting of the wood substrate's texture, contributing to an enhanced aesthetic appearance, an outcome specific to finishing technologies.

These changes in appearance were further emphasized by color measurements conducted within the CIELab system. Table 2 provides a summary of the mean values and standard deviations of the color parameters (L^* , a^* , b^*) measured prior (Control M) and after the coating of the test specimens for each type of oak substrate (S1, NO) and finishing variant (F1-F3). The table also includes the calculated values of the changes of the individual color parameters changes (ΔL^* , Δa^* , Δb^*) and the global color difference ΔE , as result of finishing, alongside elements of visual perception of these changes.

Table 2

Initial CIELab color parameters (average values and standard deviations in brackets) and color changes ΔL^* , Δa^* , Δb^* and ΔE as result of finishing of the two types of oak wood substrates (SO-S1, NO) in the three variants F1 - F3

Wood material	Code of sample	Initial color (uncoated surfaces)			Color difference as result of finishing				Visual perception of color changes
		L^*	a^*	b^*	ΔL^*	Δa^*	Δb^*	ΔE	
Subfossil oak S1	S1_M	49,45 (± 1.15)	2,47 (± 0.83)	4,63 (± 2.10)					
	S1_F1	44,34 (± 0.58)	3,01 (± 0.76)	0,18 (± 2.05)	-5,11	0,54	-4,46	6,80	Darkening, some reddish shade
	S1_F2	47,13 (± 0.68)	3,67 (± 0.73)	7,04 (± 1.77)	-2,33	1,20	2,41	3,56	Slight darkening, clear yellow shift
	S1_F3	43,96 (± 0.94)	3,00 (± 1.07)	1,40 (± 2.10)	-5,50	0,53	-3,23	6,40	Darkening, red and yellow chromatic shift
New Oak NO	NO_M	69,93 (± 1.34)	7,46 (± 0.57)	15,72 (± 1.05)					
	NO_F1	57,14 (± 2.35)	11,21 (± 0.74)	16,11 (± 2.13)	-12,79	3,75	0,39	13,33	Darkening, red and yellow chromatic shift
	NO_F2	66,91 (± 1.50)	8,92 (± 0.62)	18,25 (± 1.48)	-3,02	1,46	2,53	4,20	Slighter darkening, clear shade of yellow
	NO_F3	60,30 (± 1.68)	10,87 (± 0.70)	17,77 (± 2.13)	-9,63	3,41	2,05	10,42	Darkening, red and yellow chromatic shift

The CIELab color space is considered as linear with visual perception, meaning that lower calculated color differences ΔE should correspond to lower differences of visual perception. According to literature data, different ranges of ΔE values were associated to: smallest / barely visible difference by human eye ($0.2 < \Delta E < 2.0$), small color difference ($2.0 < \Delta E < 3.0$), medium color difference ($3.0 < \Delta E < 6.0$), high color differences ($6.0 < \Delta E < 12.0$), while ΔE values above 12 units account for visual perception as different colors (Allegretti et al 2009, Timar and Beldean 2022).

According to this info and the data in Table 2, it can be stated that finishing of the subfossil oak and new oak substrates with LO and BW, with the two natural, traditional coating materials, resulted in medium to high color differences, with a positive aesthetic effect. The total color differences were influenced by both the type of coating material and the wood substrate. Higher color differences were registered for new oak compared to subfossil oak, while linseed oil produced a higher color saturation than beeswax, for both substrates. This is a valuable characteristic of siccative oils, especially linseed oil (Cirule et al 2024, Mondal 2025, Vidholdová et al 2021). However, a short-come of the finishing technologies applied in this research is the fact that the pores, namely the visible vessels in earlywood are not filled or colored, appearing white, especially in the case of subfossil oak (see pictures in Fig. 3), which contains high amounts of calcium (Nedelcu et al 2024). Usually, finishing technologies, which employ special-colored materials, able to fill in and highlight the pores areas, are preferred for oak and other ring porous species, in order to better highlight their specific and appealing texture. This aspect should be considered in future work.

Light induced color changes

Exposure of the coated samples to UV-VIS light in the accelerated artificial test simulating the effect of natural solar light in indoors conditions resulted in barely visible to small color changes, as can be observed from the pictures in Fig. 4. After 144h light exposure the color changes for both subfossil oak and new oak

were smaller than those visible for the uncoated substrates (coded M in Fig. 4), demonstrating a protective effect of the applied coatings. However, the influence of the substrate was also visible, the color changes of the coated subfossil oak samples being lower, actually barely visible, in comparison with those observed for the new oak coated samples. The color changes for coated subfossil oak SO-S1 were more shade shifts than distinct changes of lightness. These chromatic shifts and the global color difference directly perceived by eye depend on the type of finish. For the subfossil oak substrate, a minimum color change with a yellow shift was observed for the beeswax finish (F2), while for the finishes including linseed oil as first layer, a very slight darkening with different color shifts were perceived: towards red for F1 and towards red and yellow (orange) for F3. In the case of new oak, a first impression of darkening seems more evident, especially for the wax finish (F2), while a color shift to red is the first impression when observing the surfaces finished in variants F1 and F3, which have in common the first layer of linseed oil.

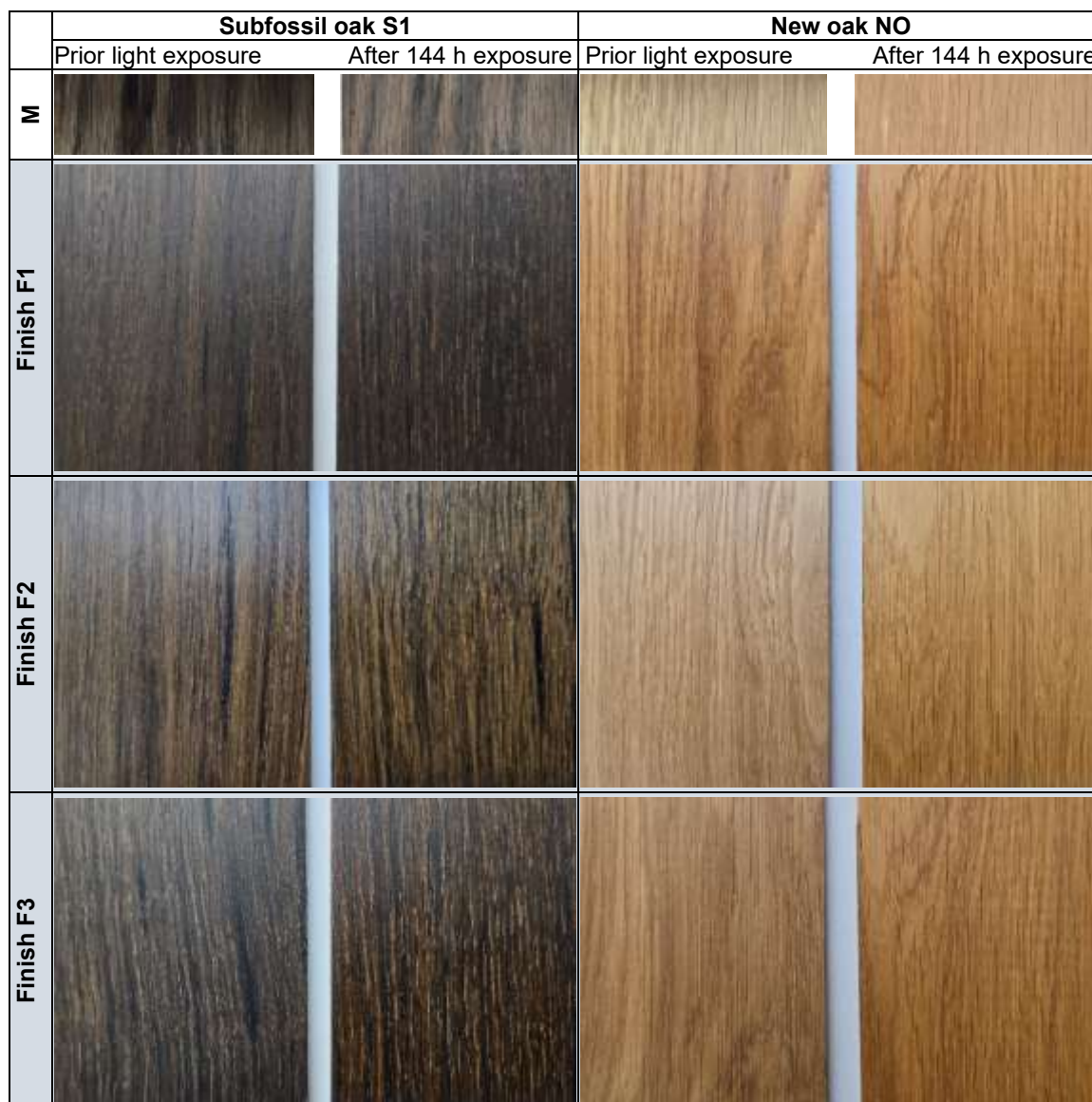


Fig. 4.

Comparative aspect of the coated samples prior and after 144h light exposure, for subfossil oak S1 and new oak NO, finished in three variants: F1-linseed oil, F2-beeswax and F3- linseed oil and beeswax.

Table 3 shows comparatively the measured changes of the color parameters (ΔL^* , Δa^* , Δb^*) and the total color difference (ΔE) determined for the surfaces of uncoated (M) and coated subfossil oak (S1) and new oak (NO), as a function of the type of finish (F1. F2. F3), following 144 h light exposure, in the conditions of the presented research. The main aspects of a comparative visual observation of the subfossil and new oak surfaces before and after 144 h light exposure are also included in Table 3.

Table 3

Changes in the color parameters (ΔL^* , Δa^* , Δb^*) and the total color difference ΔE as result of light exposure for 144h of the surfaces of the subfossil oak SO-S1 and new oak NO, uncoated and coated in the three variants F1 -F3

Wood material	Code of samples	Color differences after 144h UV exposure				Visual perception
		ΔL^*	Δa^*	Δb^*	ΔE	
Subfossil oak SO-S1	S1_M	0,06	-1,06	7,68	7,76	Chromaticity changes, distinct shade of yellow
	S1_F1	-0,88	0,06	-0,03	0,88	Barely noticeable change, slightly darker and reddish
	S1_F2	0,30	-0,06	-2,03	2,05	Barely noticeable change, yellow changes
	S1_F3	0,54	0,15	1,81	1,89	Slightly lighter, yellow-red hue
New Oak NO	NO_M	-4,78	0,37	8,38	9,66	Darkening and yellow-red color change
	NO_F1	3,05	1,22	5,11	6,07	Slight darkening, increased chromaticity, yellow-red areas depending on texture
	NO_F2	-1,18	2,52	4,69	5,45	Slight darkening, color shift towards yellow and red
	NO_F3	0,59	2,01	3,43	4,02	Slight lightening and a shift in color towards yellow and red

First of all, the numeric data in Table 3 highlight some significant differences in the lightfastness of the two types of uncoated oak substrates: subfossil oak S1 is more resistant than new oak, the total color change, ΔE , after 144h being 7.76 units, by 19,7% lower than for NO (9.66 units). Moreover, the contribution of the color parameters in the global color change is totally different: color changes of S1 resides mainly in yellowing ($\Delta b^* = 7.68$) and some decrease of redness, whilst in the case of NO there is a clear darkening ($\Delta L^* = -4.78$) alongside important yellowing ($\Delta b^* = 8.38$). This is in accordance with literature data (Machova *et al.* 2019, Tomak *et al.* 2024).

Secondly, it is obvious that the color of the coated subfossil oak surfaces, in all the three finishing variants F1-F3, is more light-resistant than that of the new oak surfaces with similar coatings. Indeed, the color changes, ΔE , after 144h light exposure were in the range 0.88-2.05, accounting for the smallest, barely visible difference by human eye ($0.2 < \Delta E < 2.0$). The color changes ΔE after 144h light exposure for the coated NO surfaces were in the range 4.02-6.07, accounting for medium color differences ($3.0 < \Delta E < 6.0$) for visual perception.

Thirdly, coating of both subfossil oak (S1) and recent oak (NO) substrates resulted in an increased color stability against light exposure, for all the three types of finishes. However, the decrease of the total color changes after 144h light exposure was higher for S1 compared to NO and influenced differently by the three types of finishes. For instance, finishing in variant F1 (linseed oil) reduced ΔE by 88% for S1 and only 37% for NO. Finishing in variant F2 (beeswax) reduced ΔE by 73% for S1 and 69% for NO, while in the case of finishing variant F3 (LO+BW) the percentage reductions of ΔE were 75% for S1 compared to 58% for NO.

It is interesting to observe that, based on the above presented data, coating with linseed oil (F1) appears to be the best option for color light stability of the subfossil oak surfaces, whilst this type of finish seems to be the least efficient in providing light fastness to the new oak surfaces. However, definite conclusions should not be drawn without further confirmation, considering the variability of the wood material. Moreover, there seem to be some differences between a comparative evaluation of the protective effect of the three finishes by direct visual perception of the color changes and the numeric results from color measurements and calculations. More research is needed with this respect.

CONCLUSIONS

The present work focused on the finishing of subfossil oak (SO) in comparison with and recent oak (NO), looking at technological practical aspects, the color of the coated surfaces and their resistance to light exposure in indoor conditions, simulated by an accelerated aging test. The results-based conclusions are resumed as follows.

- Three variants of finishes based on two types of natural coating materials, namely linseed oil and beeswax, were successfully applied on subfossil oak and new oak surfaces by manual traditional techniques.
- The total application rates for an apparent similar substrate saturation were generally lower for subfossil oak compared to new oak, with statistic significant differences for the application of beeswax.

- SEM-EDX investigation revealed mineral deposits with content of iron and calcium in the vessels of subfossil oak, alongside a partially crushed structure, with compressed and deformed cell compared to NO, which may indicate a reduced porosity and permeability compared to NO, which may explain the different application rates.
- Finishing in the three variants was visually perceived as an intensification and saturation of the initial color of both types of substrates, yielding more vibrant and lustrous hues, accompanied by a clearer highlighting of substrates' texture and an overall enhanced aesthetic appearance.
- The measured color differences as result of finishing were influenced by both the type of coating material and the wood substrate. Higher color differences were registered for new oak compared to subfossil oak, while linseed oil produced a higher color saturation than beeswax, for both substrates.
- Uncoated subfossil oak surfaces proved to be better light resistant than new oak, the total color change, ΔE , after 144h exposure being by 19,7% lower than for NO.
- Coating of both subfossil oak and recent oak substrates resulted in an increased color stability against light exposure, influenced by both the type of finish and substrate. The color of the coated subfossil oak surfaces was more light-resistant than that of the new oak surfaces with similar coating.
- Coating with linseed oil appears to be the best option for color light stability of the subfossil oak surfaces, whilst this type of finish seems to be the least efficient in providing light fastness to the new oak surfaces. Further research is needed to clarify this aspect.

Also, more research, with an increased number of replicates, subfossil oak from different sources and an extended assortment of coating materials is needed in the future in order to identify the most adequate finishes for this exquisite material.

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