Thermally Modified Douglas-fir Color Preferences of Home Show Attendees

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Although thermal modification is primarily used to improve wood durability, it also has a tendency to darken lighter colored hardwoods to make them more valuable. This process might also be useful for darkening softwoods, but it will be important to develop colors that customers prefer. One potential species for this application is Douglas-fir (*Pseudotsuga menziesii*). Consumer preferences for differing degrees of thermal modification (*i.e*. darkening) were assessed using a convenience sampling survey at a Home Show in Eugene, Oregon. Respondents provided demographic information then ranked five thermally modified samples with widely differing degrees of darkening based on their most to least preferred colors. The lightest colored sample was most preferred; however, the darkest sample was the second most preferred. There were no preference differences for samples in between the extremes, suggesting that there is some latitude with regard to color that could be used to differentiate modified Douglas-fir from other products.

Keywords: Thermal modification; Color preference; Douglas-fir

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INTRODUCTION

Thermal modification was originally developed to alter the hygroscopic properties of wood, but it also has applications for altering wood color to make certain species more marketable (Brischke *et al*. 2007; Esteves and Pereira 2009). Over time, the focus of thermal modification changed from purely aesthetics to improving wood durability and moisture behavior (Esteves and Pereira 2009). However, it is important to consider the value of this process for enhancing timber appearance.

Thermal modification might be useful for altering timber color and enhancing its value for interior applications. Douglas-fir (*Pseudotsuga menziesii*) is a widely used structural timber, but it also has some applications in interior paneling. The heartwood of this species has a rich orange to pink color, but the patterns can vary quite widely with the timber source. Thermal modification has the potential for creating a wider range of colors that might increase the potential interior applications for this material. An important component of that development process is determining consumer preferences for the colors.

There is little research concerning how consumers perceive the range of colors that result from thermal modification. However, there are several studies on wood color that focus on wood used in decks and interior applications. Thermally modified wood is primarily used in these non-structural applications in which physical strength is less critical (Esteves and Pereira 2009).

Consumers appear to prefer wood with even coloring and have negative reactions to preservative-treated wood (Nyrud *et al.* 2008). A study of wooden furniture found that color and grain were key attributes consumers used to form preferences for wood samples (Bigsby *et al.* 2005). Many other studies also found color to be a major factor in wood choice among consumers (Bumgardner and Bowe 2002; Nicholls and Roos 2006; Esteves and Pereira 2009; Nicholls and Barber 2010). Most architects preferred matching the wood species and color of building elements and finishes in a project (Gaston 2014). Wood color is clearly important to the end consumer and should be of importance to lumber suppliers seeking to differentiate their products. The use of thermal modification to change color could create wider options for softwoods in architectural applications (Li *et al.* 2018). Bumgardner and Bowe (2002) suggested that darker colored hardwoods were generally perceived by consumers as more expensive, formal, and stately when compared to lighter colored hardwoods, which were perceived as casual and inexpensive. A study on flooring preferences in Canada showed that consumers preferred the medium and medium-light colors when presented with an array of five flooring samples with colors ranging from dark to light (Spetic *et al.* 2007). However, there does not appear to be sufficient research to determine a clear wood color preference among consumers.

As such, the objective of this study was to survey consumers concerning their preferences for colors of thermally modified Douglas-fir timbers.

EXPERIMENTAL

Methods

The samples used for this survey were taken from a larger study evaluating the effects of thermal modification on flexural properties and the decay resistance of Douglas-fir. Small samples (20 by 50 by 125 mm long) were subjected to a range of thermal modification processes (for details, see Yan and Morrell, 2014, 2015, 2019). While these experiments showed that the processes had no significant negative effect on properties nor did they increase or improve durability, they did produce a wide range of color changes.

Data were collected using a quantitative survey that consisted of two demographic questions about age and gender (questions can be seen below in Fig. 1), followed by respondents being asked to rank the appearances of five samples from their most preferred to least preferred (Fig. 2). The five samples were selected to provide a range of colors ranging from non-thermally modified native wood to more heavily modified wood that was very dark in color. The sample size was limited to 5 specimens because using too many samples would make it more difficult for respondents to delineate between samples, as well as, could potentially reduce the willingness of consumers to participate.

Data were collected using an in-person convenience intercept survey at the Home and Garden Show in Eugene, Oregon in the Fall of 2016. Attendees at this show tended to own a house and had an interest in home building, maintenance, and/or renovation. These are all potential markets for thermally modified wood, making this a reasonable location to distribute the questionnaire. A total of 248 attendees responded to the survey, yielding 230 usable responses. The 18 unusable surveys were excluded due to incomplete or illogical responses. The usable data collected provided respondent age, gender, and ranked the consumer's color preferences of the Douglas-fir samples, where 1 was most preferred and 5 was least preferred.

Q1. On the table in front of you are 5 pieces of thermally modified Douglas-fir wood that have different colors. Please rank the blocks based on their appearance.

	Most preferred	More preferred	Neutral	Less Preferred	Least Preferred
Block ID					

Q2. Please Indicate your age

18-44 45-65+ Prefer not to answer

Q3. Please indicate your gender

Male Female Prefer not to answer

Fig. 1. Survey questionnaire used to assess wood color preferences

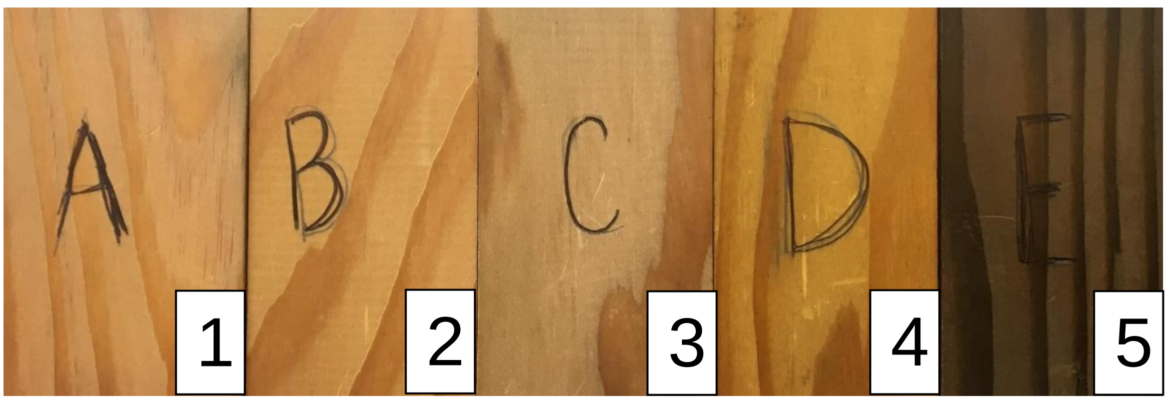

Fig. 2. Five samples of Douglas-fir heartwood that were ranked on appearance by respondents

The analysis included descriptive statistics compiled with Microsoft Excel (Microsoft, 2013, Belleview, WA, USA) for demographic analysis and a Kruskal-Wallis analysis preformed using R Studio (R Studio, *version* 0.99.903, Boston, MA, USA) for the color preference question. The Kruskal-Wallis test was chosen because the data did not meet the normality assumption of a one-way analysis of variance (ANOVA).

The color differences in the samples were quantified by scanning them at 3200 dpi on an Epson Perfection V370 Photo Scanner (Nagano, Japan). Color determination was measured on the entire surface of two wide faces of each of the sample blocks (measured area = 30 mm^2). A Konica Minolta CR-5 chroma meter spectrophotometer (Tokyo, Japan) was used, and color parameters were determined using the CIELab system. This system estimates wood color using the three spatial coordinates of L^*, a^*, and b^*, where L^* represents lightness ($\underline{L}$ = 0 for black and L = 100 for white), a^* represents the chroma value and defines the position on the red-green axis (+100 values for red shades, −100 values for green shades), and b^* represents the chroma value and defines the position on the yellow–blue axis (+100 values for yellow shades, −100 values for blue shades). The analyses of sample color were performed using an ANOVA with posthoc analysis using Tukey's HSD (p = 0.05).

RESULTS AND DISCUSSION

In the study, 40% of respondents were male and 55% were female, with 5% preferring not to answer. The majority of the respondents were 45+ years old (74 %), while only 22% were between 18 and 44 years old (4% did not answer). We had arbitrarily set age groups in the belief that older respondents might have more disposal income and broader life experiences with regard to timber. There were no statistically significant differences in the results between age and/or gender groups.

A descriptive analysis of the appearance ranking results showed that Sample 1 was the most preferred choice, capturing 40% of the "most preferred" responses. Sample 5 captured the second highest number of "most preferred" responses at 28%. However, Sample 5 was also the least preferred choice, and received 34% of the "least preferred" responses (Fig. 3). Sample 5 was the darkest sample, which suggests that consumers had very strong opinions about this material; either preferring it strongly or not at all.

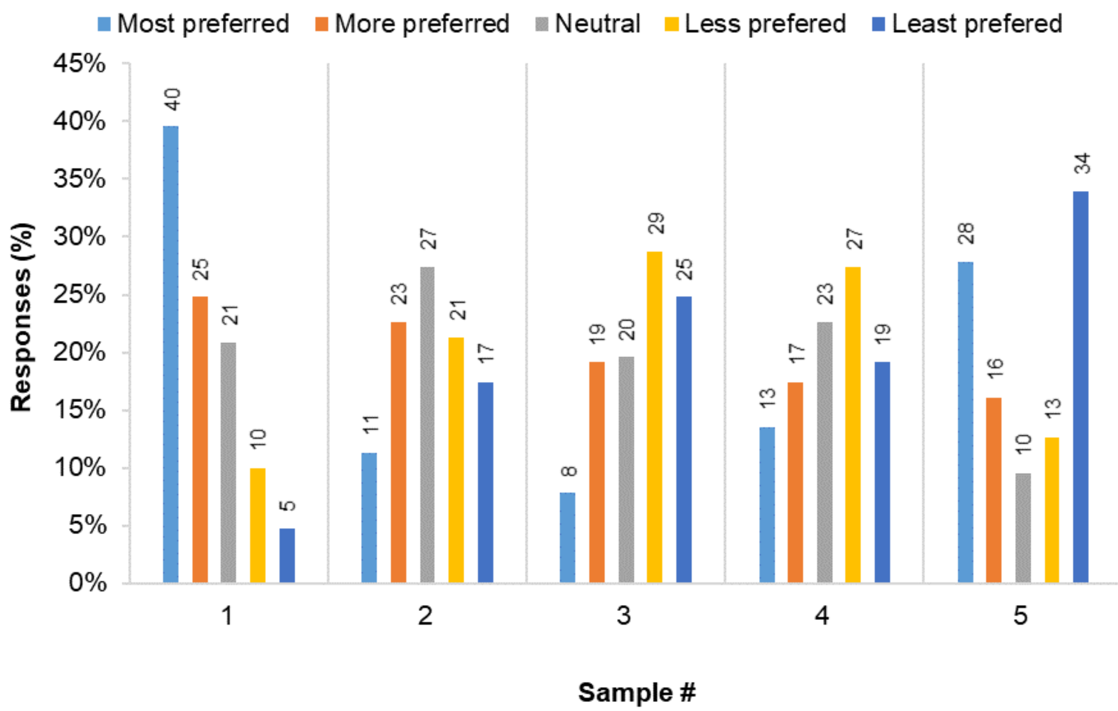

Fig. 3. Graphical display of the percentage of responses received by each sample

Modes represent the rank given to a sample that was selected most often by respondents. Based on the modes, sample 3 was the least preferred overall (Fig. 4). Sample 1 had the highest mode, and samples 2, 4, and 5 had similar modes, meaning that respondents did not preferentially select any of these more often than other samples. Respondents tended to react differently to sample 5 than to any of the other samples, and it had the widest range of preferences (Fig. 5). The Kruskal-Wallis test showed that there were significant differences between at least one set of groups. There were no significant differences between samples 1, 2, and 3, or 1, 2, and 4, but there were significant differences between samples 3 and 4. Sample 5 differed significantly from all the other samples supporting the premise that potential consumers had strong opinions on this sample.

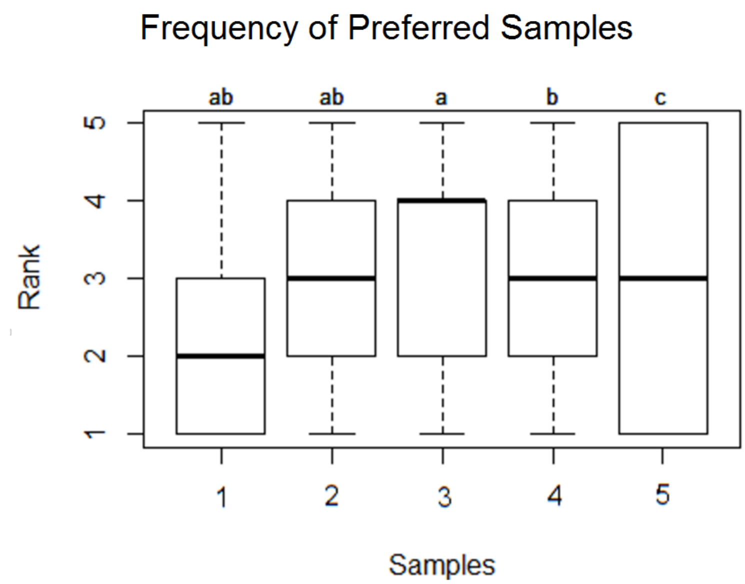

Fig. 4. Box and whisker plot for the frequency of rank (preference) for thermally modified Douglas-fir samples, where a rank of 1 was the most preferred and 5 was the least preferred; samples with the same letters did not differ significantly by a difference of means

Color analyses showed that the *L**, *a**, and *b** values for sample 5 were significantly lower than the other samples ($p < 0.05$), which could explain the differences in rank of the responses for this sample (Table 1).

Table 1. Color Measurements *L**, *a**, and *b** for Thermally Modified Douglas-fir Samples

Sample	L*		a*		b*	
	Mean	SE	Mean	SE	Mean	SE
1	70.43 a	2.84	9.76 a	0.45	17.46 a	0.93
2	70.34 a	0.40	8.55 ab	0.39	19.43 a	0.69
3	68.32 a	2.61	7.91 b	0.70	15.29 a	1.91
4	65.07 a	0.15	8.08 ab	0.03	18.51 a	0.34
5	57.31 b	0.3	3.29 c	0.13	8.13 b	0.28

*Means based on an average of n = 2 (one reading from each tangential face with Ø = 30 mm); means with different letters differed significantly by Tukey's HSD ($p < 0.05$); SE= standard error.

The *L** values for samples 1 to 4 were within roughly five points of each other (70.43, 70.34, 68.32, and 65.07, respectively), while those for sample 5 were almost 10 points lower in lightness (57.31). Additionally, significant differences in chroma values with sample 5 were observed for *a** and *b** values (Fig. 5). These results suggest that there were few perceptible differences between the lighter four samples; however, the photographs clearly show a trend towards darkening, culminating in the much darker sample 5. Though values of all samples were lower in the red-yellow quadrant of the plot, samples 1 to 4 had significantly different *a** *b** values than those of sample 5 (Fig. 5).

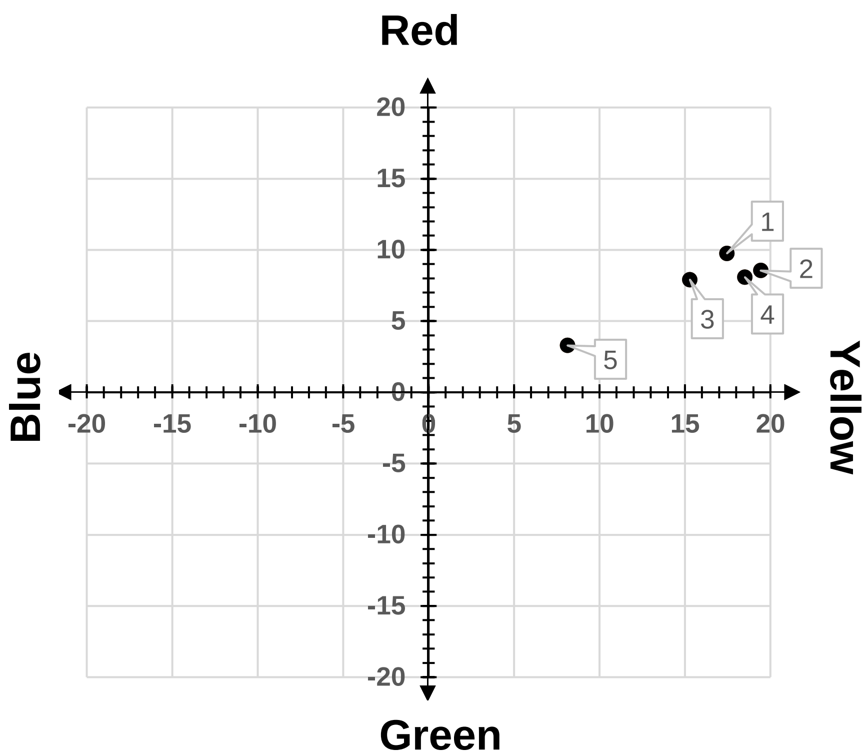

Fig. 5. The *a** and *b** chroma values for five thermally modified Douglas-fir samples, where the *y*-axis represents the *a** values, with positive numbers being redder and negative numbers being greener, and the *x*-axis represents the *b** values, with positive numbers being yellower and negative numbers being bluer

All colors were acceptable to potential users, but preferences varied more as the colors became more distinct. These findings support previous studies in wood color, showing that color was important, but that there was no universal color preference (Bumgardner and Bowe 2002; Nicholls and Roos 2006; Esteves and Pereira 2009; Nicholls and Barber 2010). One shortcoming of the survey was that respondents could not equally rank any of the specimens. Additionally, specimens were not cut from the same section of the board, leaving them with varying earlywood/latewood patterns that impacted the specimen appearance and could have affected respondent preferences. Despite these limitations, the results suggested that thermal modification could be used for developing a range of colors to meet the range in consumer preferences.

Anecdotally, some respondents claimed they could detect “the thermally modified sample” or which sample was Douglas-fir, but in fact all samples were Douglas-fir and all but one sample were thermally modified. This suggested that some respondents were unable to accurately identify wood treatments and/or species. Though this information could be used to develop markets targeting particular customer segments, it also suggests that the reputation of a species or treatment may be more important than the treatment itself.

The results indicated that thermal modification may represent a simple method for altering Douglas-fir to differentiate the materials in the market.

CONCLUSIONS

1. The lightest and darkest woods were more preferred by respondents, but the darker samples also had the most dislikes.
2. There were no differences in preferences for samples in between the extremes, suggesting some latitude when developing processes for modifying the colors.
3. Consumers lack strong preferences for lighter color woods but have distinct preferences for darker woods.

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