INTO THE WOODS OF NEW YORK- AN INDUSTRY SENSORY PANEL

A Project Paper

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ABSTRACT

Oak aging can play an integral role in creating well-balanced, cohesive wines. The chemical and biochemical reactions that occur during oak barrel aging transforms a wine into a unique representation of its terroir and wine making procedures. Aromas like vanilla, coconut, and smoke are extracted during barrel aging, as are desired mouthfeel characteristics that add texture and depth. In this study, multiple species of wood local to the Finger Lakes AVA were used for wine aging to analyze perceived mouthfeel differences in wine samples. Regional industry members were asked to rank aged wines for common mouthfeel attributes to initiate an exploration of New York white oak, acacia, black cherry, and sugar maple as adjuncts for wine aging.

BIOGRAPHICAL SKETCH

Megan Rae Seeley is a student studying at Cornell University thrilled to complete her Master of Professional Studies degree in the field of Food Science in May 2023.

Megan studied at Jamestown Community College and SUNY Fredonia where she earned her Associates in Math and Science degree and Bachelor of Science degree in biology with a minor in chemistry, respectively.

During harvest season of 2021, Megan interned with *Delicato Family Wines* in Manteca, California where she fell in love with the art and science of winemaking and grape growing. Following her move back to New York, she interned with *Advanced Manufacturing Technologies* in Jamestown, New York in 2022 where she learned about food processing and contract manufacturer duties.

Her past and present work/education background has allowed her to gain direct and theoretical experience to be ready to integrate herself back into industry after the completion of her schooling.

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Introduction/Literature Review

The first recorded use of barrels for beverage storage was when the Gauls used wooden barrels bound with metal hoops to transport beer. As the Roman empire expanded, these barrel technologies were adopted, and were widespread by 300 AD. Before the barrel there were many vessels used for beverage fermentation and storage including animal skins, qvevri, amphorae, and haustrums, which were open wooden buckets with handles (Twede, 2005). The popularity of oak barrels increased over time due to their convenience, reusability, flexibility, and resilience. *Quercus petraea* and *Quercus robur* were abundant oak species present in Europe when barrels were first developed and the two dominant species that were used for barrel construction (Chatonnet, 1998). Their woods were both light and inexpensive making them a prime candidate for production. Ship-building technology is thought to be the inspiration behind barrel-making because of the materials and methods in which they were built. Both creations, ships, and barrels, were made by taking thin pieces of wood, bending them into curves and binding them together (Twede, 2005). The use of oak species for shipbuilding reinforced the knowledge that oak would be liquid-tight and suitable for beverage storage. It was only later that connoisseurs would discover that liquid-tightness and resilient structure would not be the only factors which made barrels desirable vessels for wine.

It can be said that picking oak for the construction of wine barrels was a strike of luck. Over time the Romans recognized that wine was more palatable after aging in transit than it had been at the beginning of the journey (Estreicher, 2013). The porous structure of the wood allows for natural micro-oxidation of the wine and transfer of the gaseous molecular oxygen to its dissolved state (Schmidtke, 2011). Oak barrels have been found to have significant effects on both wine aroma and flavor, as well as chemesthesis properties (Chira, 2015). Barrel aging also is thought to help with color stability and clarification due to the sedimentation of solids and copigmentation of anthocyanins with extracted phenolics in the wood like vanillic acid and gallic acid (Carpena, 2020). The extraction of sensory compounds from the wood produces desired tertiary odorants in wine (Granja-Soares, 2020), and some primary odorants present in grapes and secondary odorants that arise during yeast metabolism can be transformed further during oak aging (Abreu, 2021).

In modern times, alternative vessels like glass bottles have been used for storage and shipping, but barrel aging continues to be a common winemaking technique to age and enhance certain characteristics in a variety of wine styles. Depending on the winemaker, the wine type, and style desired, average barrel aging can last up to 30 months, which presents a bottleneck in the wine production process before bottling and shipping. However, the current and future availability of oak is being questioned, resulting in increased demand. Oak forests in the United States are dominated by mature trees which are being threatened by invasive species, disease, drought, and overzealous markets (National Park Service, 2020). Shortages in both oak and labor have led to wineries seeking alternatives to produce barrel quality wine without the expense and space of barrel aging (Oberholster, 2015). Research and development within the wine industry has allowed the discovery that forced micro-oxygenation and wood adjunct products can contribute similar characteristics (Caldeira, 2021).

Wood adjuncts are pieces of processed wood available in various shapes which have proven to be an efficient and economical alternative to produce wines with wood notes that are comparable to wines aged in barrels for about three months (Ortega-Heras, 2010). They come in many different forms, primarily powder, chips, cubes, and shavings. More recently, spiral staves have been advertised as most efficient due to the optimized surface area for wood-wine contact, as the greater surface area of spiral staves are alleged to induce more rapid aging than barrels and other staves (Jeffery, 2012). Whether the wood is used during fermentation or aging, for small or large batches, wood adjuncts may make it easier to customize to specific wine needs. The wood can be seasoned, toasted, and dried in several different configurations allowing for even more ways to manipulate wine flavor profile. Barrels for wine aging are usually toasted prior to use, so this treatment is also common with wood adjuncts. During this step, many wood components undergo thermodegradation to form other volatile compounds. Some examples of this mechanism are the degradation of carbohydrates to furanic acid and the production of oak lactones from the dehydration of acids. Toasting the wood before use can produce a stronger sensory effect, especially through smell (Koussissi, 2009). Toasting levels have a significant impact on the concentrations of volatile phenols as well as phenolic aldehydes and ketones due to the degradation of lignin, lipids, and other biopolymers present in the wood (De Simon, 2010). Sensorially, using wood that has been toasted helps increase aromatic compounds and decrease overall astringency (Martinez-Gil, 2020). Toasted wood products come in an array of different toasting degrees ranging from light to heavy, with medium and medium-plus toasting levels also available.

As stated earlier, scientific investigation of the use of wood adjuncts and micro-oxygenation to make an alternative for barrel aging is underway, but little literature is available to compare the mouthfeel sensations or chemesthesis effects of various hardwoods on wine, especially within the New York region.

Methods

Wood Procurement and Toasting

Multiple wood samples from four New York tree species, white oak (*Quercus alba*), acacia (*Robinia pseudoacacia*), black cherry (*Prunus serotina*), and sugar maple (*Acer saccharum*) were obtained from various small lot forestry cooperages, mills, and the Finger Lakes region Craigslist. Each sample was cut into 2"x4"x1" pieces and toasted at 200°C for 30 minutes in a convection oven (Rational, Model SCCWE201G) in the Cornell Food Venture Center Pilot Plant (Cornell AgriTech, Geneva, NY). Once toasted, pieces were allowed to cool to ambient temperature and then cut into ½ inch cubes using a Wen 10-inch bandsaw (Model BA3962). Any damaged or chipped cubes were discarded so the surface area was consistent among cubes.

Wine

A commercially available Pinot grigio (*Domaine Bousquet Natural Origins*, Italy, 14.5%, 3L bag-in-box) was purchased locally. This wine is a light bodied, dry wine that was selected for its neutral sensory profile. Three-gallon glass carboys were sparged with compressed nitrogen for about 1.5 minutes before filling the carboys with 7.7 liters of wine, followed by 70 cubes of a single wood species. Vessels were closed with a bubbler airlock then transported to a 16°C room with no light exposure for 8 weeks. For the control treatment, two boxes of the Pinot Grigio were put aside and saved in the same storage room.

Bottling Sample

After 8 weeks of wood soaking, the wine was decanted into identical, 750mL glass bottles and sealed with metal screw caps. Before filling, bottles were sparged with nitrogen gas, labeled with 3-digit codes (Table 1), and stored at 16°C until needed for sensory evaluation.

Table 1: Three-digit code and wood treatment pairings.

Code	Wood Type Treatment
197	Sugar Maple
645	NY Oak
735	Cherry
904	Acacia

Sensory Evaluation

Sensory evaluation was performed by 35 attendees at the B.E.V. NY Conference in Syracuse on March 28th, 2023. Panelists were members of the New York grape and wine industry over the age of 21 who participated voluntarily. Aged wine samples were labeled with 3-digit random numbers, and 30 mL of each wine sample was served at room temperature, in standard ISO wine glasses, in one of two service orders: {Control,645,904,735,197} or {Control,197,735,904,645}. Panelists were provided with a sensory attribute key (Table 2) and a tasting sheet (Figure 1) with lists of sensory attributes and were asked to rate each of them on a scale of 0-9, where 0 was not present, 1 was 'low' and 9 was 'high.'

Table 2: Sensory attribute key provided to panelists for sensory evaluation of wood-aged wine samples.

Attribute Key			
Bitter	Harsh or tannic mouthfeel	***Prickle***	Any tingling or stinging effect in the mouth
Sweet	Presence of residual sugar (Not fruitiness)	***Thin***	Any wateriness or low viscosity mouthfeel
Sour	Having a sharp or acidic 'biting' taste	***Creamy***	Smooth mouthfeel. Any buttery of fatty presence.
Grippy	Any strong adhesiveness to the mouth	***Abrasive***	Any coarseness felt from consuming
Green	Any sharp unripe tannin	***Mouthcoat***	Any layering left in the mouth after consuming

Control		**645**		**904**		**735**		**197**	
Attribute	Rating [0-9]	Attribute	Rating [0-9]	Attribute	Rating [0-9]	Attribute	Rating [0-9]	Attribute	Rating [0-9]
Bitter		*Bitter*		*Bitter*		*Bitter*		*Bitter*	
Sweet		*Sweet*		*Sweet*		*Sweet*		*Sweet*	
Sour		*Sour*		*Sour*		*Sour*		*Sour*	
Grippy		*Grippy*		*Grippy*		*Grippy*		*Grippy*	
Green		*Green*		*Green*		*Green*		*Green*	
Prickle		*Prickle*		*Prickle*		*Prickle*		*Prickle*	
Thin		*Thin*		*Thin*		*Thin*		*Thin*	
Creamy		*Creamy*		*Creamy*		*Creamy*		*Creamy*	
Abrasive		*Abrasive*		*Abrasive*		*Abrasive*		*Abrasive*	
Mouthcoat		*Mouthcoat*		*Mouthcoat*		*Mouthcoat*		*Mouthcoat*	
Additional Comments		Additional Comments		Additional Comments		Additional Comments		Additional Comments	

Figure 1: Panelist tasting sheet for sensory evaluation of one control wine and four wines aged in different wood species.

Statistics

A linear mixed model was run on *JMP Software* to detect and identify differences in wines for each attribute individually. A *Tukey HSD* test ($p < .05$) was run to control the possibility of any Type I (false positive) errors. Model assumptions were checked before the data presented was accepted and documented.

Results & Discussion

Of the ten mouthfeel attributes, four (abrasive, bitter, grippy, and mouth coat) were perceived differently among wine samples (Figure 2). Oak, cherry, and acacia all had higher abrasive ratings than control wine samples that contained no wood. Acacia and oak both had higher bitterness and grippy ratings than the control. Further, oak resulted in a higher mouth coat rating compared to the significantly lower mouth coat rating that sugar maple received (Table 3). Oak was ranked higher in all four attributes while acacia was significantly higher than the control for three attributes (abrasive, bitter, grippy).

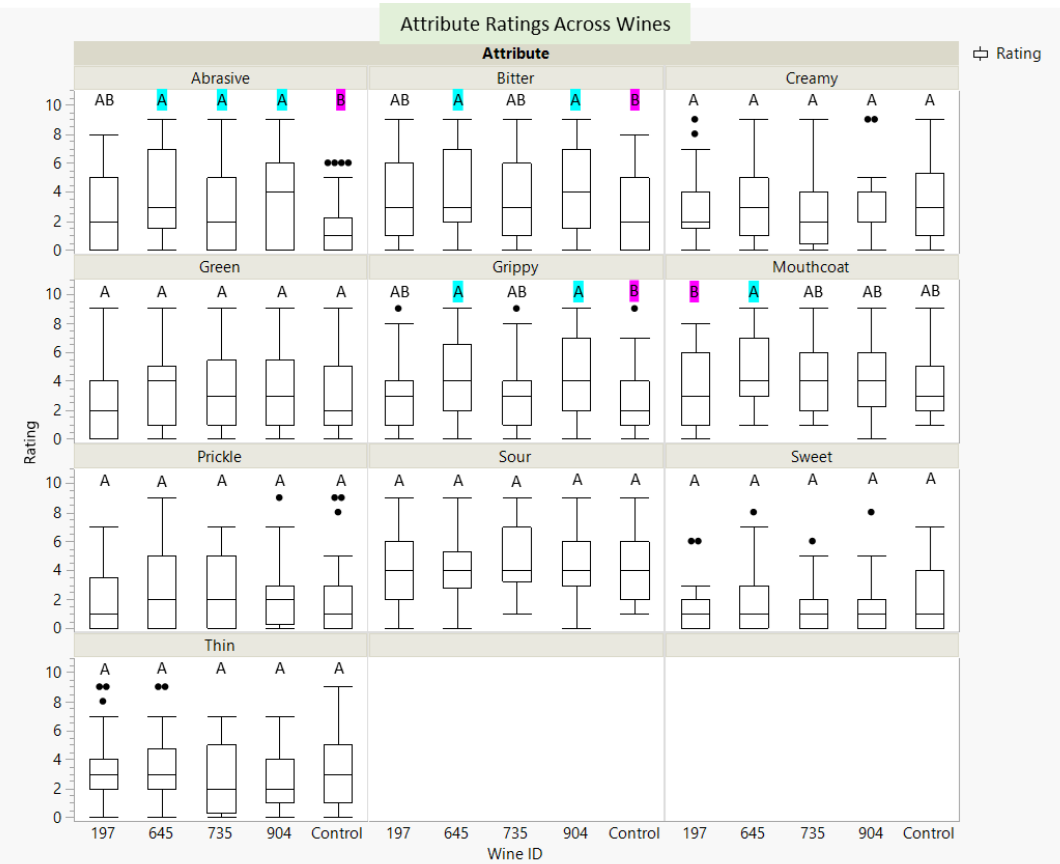

Figure 2: Box plots represent data from the Tukey HSD test ($p<.05$) configured by *JMP Software*. Means with different letters within an attribute box are significantly different.

Table 3: Results from box plot translated into wood treatment with what differences were identified [↑ meaning significantly higher than ↓ (significantly lower) data].

Attribute	Differences	
	↑	↓
Abrasive	NY Oak, Cherry, Acacia	Control
Bitter	NY Oak, Acacia	Control
Grippy	NY Oak, Acacia	Control
Mouthcoat	NY Oak	Sugar Maple

In this study, the oak treatment produced a wine with higher mouth coat, abrasive, bitter, and grippy ratings than the control. The composition of white oak is around 45-50% cellulose, 22-25% hemicellulose, 23-32% lignin, and 3-10% acids, phenolic compounds, and carbohydrates (Glasbania, 2006). Among these components, hydrolysable tannins (ellagitannins) are responsible for 10% of the dry weight of the wood (Chira, 2015). Sensory experiments in the past have proven the positive correlation (R=.93) between perceived astringent and bitter sensations and the amount of ellagitannins present (Chira, 2013). A study done to isolate and evaluate sensory impact of wine due to ellagitannins in *Quercus alba* reported that astringency was detected and identified at low concentrations (.2-6.3 µmol/L) and bitterness was detected at higher concentrations (410-1650 µmol/L) (Glabasnia, 2006). Depending on their concentration, ellagitannins can directly interact with the salivary proteins of the wine drinker or combine with condensed tannins to interact with salivary proteins (Watrelot, 2018). These hydrolysable tannins may be responsible for the higher ratings of abrasive, grippy, and bitter attributes in this study's sensory panel. Also, in this study it was concluded that the oak resulted in a higher rating of "mouth coat" than sugar maple. One major difference between oak and sugar maple wood is their porosity. The oak chosen is a "ring-porous hardwood" and the sugar maple is a "diffuse-porous hardwood" (Frihart, 2008). Diffuse-porous hardwoods have small vessels that are distributed evenly throughout a growth ring and ring-porous hardwoods have a range of vessel sizes throughout (Hafner, 2023). The main idea of using wood to age wine is to help with the exchange of compounds from wood to wine. If the vessels that are responsible for this exchange are too small, the wine will not be able to pick up as much as it could if the vessels/pores were bigger. Either sugar maple requires more time or more surface area, or the use of sugar maple is not ideal for wine penetration and aging. It is likely that the inability of sugar maple to allow tannin/protein interactions resulted in no perceived changes in mouth coating compared to the control. However, as oak allows enough exchange through its adequately sized pores, there is a perceived increase of mouth coating and other mouthfeel characteristics.

The acacia treated wine samples were rated higher in abrasiveness, bitterness, and gripyness compared to the control, significantly changing one less mouthfeel attribute that oak did. A study utilizing acacia (*Robinia pseudoacacia*) and oak (*Quercus petraea*) barrels was done to compare sensory notes and chemical compositions of wines aged in them. After three and six months of aging in acacia barrels, simple volatile phenols were found while wines aged in oak barrels had zero presence of o-Cresol and p-Cresol (Kozlovic, 2010). There is research that connects the addition of volatile compounds with an increase of astringency perception (Ferrer-Gallego, 2014). If this was done by the acacia wood adjuncts, the increase in ratings of the abrasive and grippy attribute correlates. In the sensory study done by Kozlovic, the oak flavor duration was higher in oak barrel aged wines than in acacia barreled wines. Connecting to the chemical analysis of the same study, oak barrel wines contained more abundant oak lactones while acacia contained very little of these, explaining why acacia did not have any mouth coating effects like the oak did in the present study. Kozlovic stated that "The acacia barrels are less 'aggressive' than oak and add less wood character to wines" which the panelists seemed to enjoy based on the hedonic liking of the acacia wines that was much higher.

The cherry wood treated wines only rated higher than the control in the abrasive attribute. In a study comparing two Greek red wines treated with different woods, polyphenol concentrations were measured and compared. When chestnut and cherry wood chips were used, overall polyphenol levels and catechin concentrations were significantly higher (Gortzi, 2013). Polyphenols themselves have astringent tastes and bring roughness to the mouth, but these effects can be reduced by other components. In a study attempting to explore the relationships between polyphenols and proline rich components, a casein micelle model was made. A harsh astringency was observed when there was no milk present but when there was, the polyphenols were removed into the casein micelles, ultimately reducing astringency (Luck, 1994). Polyphenol complexation occurs when polyphenols bind to proteins or other components like anthocyanins or polysaccharides, forming complexes with them. A chemical comparison between cherry and chestnut revealed that cherry wood extract has low amounts of condensed phenolics and extremely high amounts of polysaccharides containing 118.6% more than chestnut extract (Cesprini, 2022). The high concentration of polysaccharides in cherry wood could be acting the same as the casein micelles in the micelle model study, binding and removing the lone polyphenol and reducing astringency so there is no perceivable difference compared to the control.

In this study, oak has produced more changes in mouthfeel attributes during aging than any of the other treatments. This is why oak has been the industry standard for wine aging and making barrels for so long and why there is some hesitation to use other woods for this purpose. However, these results are promising towards other New York wood options, showing that alternative woods can also change the mouth feel of wines. There is no question that more investigation is needed to explore the vast diversity of woods in New York, but it all starts with the willingness of researchers and winemakers to push the limits of tradition and try to utilize local wood sources along with local fruit to create cohesive wines.

Conclusions

In this study it was observed that regionally sourced oak and other hardwoods can change the character of wine mouthfeel. Although oak was most notable, this work suggests potential for other wood types, like cherry and acacia, to modify wine sensory profiles.

Sensory evaluations are crucial to address consumer perception of a product, however it would be of great use to analyze differences in chemical and physical compositions to compare with sensory changes. If various woods could be “mapped” with information like this (sensory vs composition of wood), it would eventually be possible to connect wood type to expected aged wine characteristics. Data to support this would be beneficial to winemakers who are looking to expand their wine aging to something other than oak barrels and oak adjuncts. Purchasing and using local woods benefits the local economy, strengthens relationships between winemakers and community, and allows for production of unique, terroir expressive wines.

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