Viticulture, enology and marketing for cold-hardy grapes

Northern Grapes News

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Interspecific Hybrid Red Wine Color

Claire Burtch and Anna Katharine Mansfield, Cornell University

Before consumers have an opportunity to smell or taste a wine, they begin to form first impressions and opinions through their sense of sight. Deep red wines are perceived as higher quality than wines with poor color, and knowing this, winemakers attempt to extract maximum color from grapes[1] while carefully maintaining aroma and flavor compounds.

Anthocyanins in grapes. Red wine color is incredibly complex. Any given wine is composed of hundreds of dynamic chemicals that are interacting and changing during the winemaking process. While evolution of color from purple-red to brick red in *Vitis vinifera* wines is familiar to both winemaking and scientific communities, the color of hybrid wines is less predictable, and often varies from the *V. vinifera* norm. So what is it that gives red wine its characteristic color, and what makes hybrid color wine so different from *V. vinifera*? The answer begins with the anthocyanins.

Anthocyanins are pigmented phenolic compounds located in the skins of all red grapes, and in the pulp of teinturier cultivars. Through crushing, maceration, and fermentation, these anthocyanins are extracted into the wine. The anthocyanin profile of a wine depends on the grape cultivar, growing conditions, and specific winemaking process. For example, thermovinification (heating the must between 50 and 60°C for 10 to 30 minutes before fermentation)[2] can increase color by increasing anthocyanin extraction, while SO2 additions to juice or wine will bleach color as SO2 interacts with anthocyanins.

Types of anthocyanins. In red *V. vinifera* grapes, there are five main anthocyanins: cyanidin-3-glucoside, delphinidin-3-glucoside, malvidin-3-glucoside, peonidin-3-glucoside, and petunidin-3-glucoside. These anthocyanins are all monoglucosides, so named because they have just one attached glucose unit. Each of these anthocyanins is slightly different in structure, and contributes a different color to wine, ranging from pink to red to purple. Hybrid wines that appear more blue or purple have higher concentrations of petunidin and delphinidin, the anthocyanins on the blue and purple end of the scale. *V. vinifera* wines have low concentrations of these anthocyanins, but in hybrids like Frontenac, they are often the dominant anthocyanins. Hybrid wines can also have extremely high total concentrations of anthocyanins compared to *V. vinifera*, so the observed color can be much darker and denser than in traditional red wines.

V. vinifera grapes are also different as they contain only monoglucosides, while non-vinifera and interspecific hybrids also have anthocyanins with two sugars, called diglucosides. Like the monoglucosides, different diglucoside anthocyanins contribute specific colors to wines. While diglucosides have similar colors to their monoglucoside counterparts, they are less ionized at wine pH, so the colors they contribute are less intense.[3]

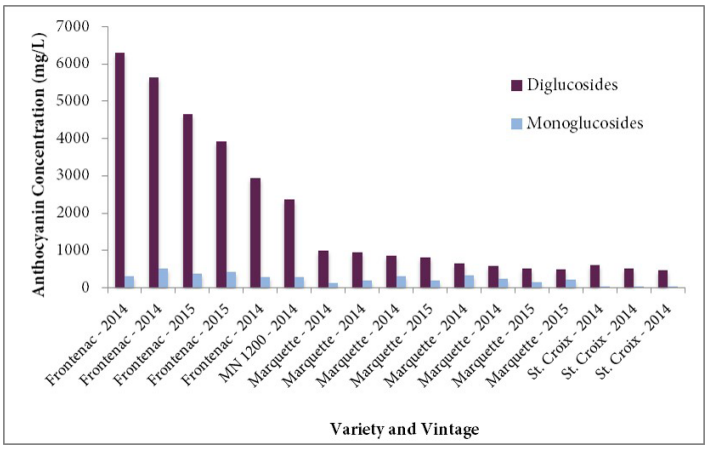
Samples of Merlot, left, and Frontenac, right, display the difference in color between red V. vinifera wines and red cold-hardy hybrid wines. The dominant anthocyanins in Frontenac are petunidian and delphinidin, which are more blue and purple than other anthocyanins.

photo: Matt Clark, University of Minnesota

In This Issue:

Anthocyanin content. Figure 1 shows the mono- and diglucoside anthocyanin concentrations in 17 samples of Frontenac, MN 1200, Marquette, and St. Croix. Samples were crushed and anthocyanins were extracted from the juice and analyzed using high performance liquid chromatography (HPLC). Diglucoside concentrations in all samples far exceed those of monoglucosides, which has great implications on anthocyanin color and reactivity.

Figure 1. Anthocyanin mono- and diglucoside concentrations in 17 hybrid grapes (Frontenac, MN1200, Marquette, and St. Croix) in 2014 and 2015.



Anthocyanin reactions. Upon release from the grape skins, anthocyanins react rapidly to form different and more stable pigments,[4] which have different colors than their original form, and are more resistant to changes in pH and to bleaching by SO2. Anthocyanins can react directly with other anthocyanins or flavanols like catechin and epicatechin to form red compounds. If this reaction is mediated by an aldehyde, the resulting compound is purple. The reaction of anthocyanins with tannins yields polymeric pigment, which tends to increase in concentration with wine age. Polymeric pigments have variable compositions because both tannin and anthocyanin composition is varied. Anthocyanins can also react with several small compounds like pyruvic acid, acetaldehyde, or acetone to form pyranoanthocyanins. Pyranoanthocyanins have an additional ring in their structure, which means these compounds cannot be bleached by bisulfites.

Each of these new, more stable pigments has a different color than the monomeric anthocyanin from which it is derived. In *V. vinifera* monoglucosides, these changes contribute to the evolution in wine color from purple-red to brick-red. In hybrid wines, however, the extra glucose on diglucosides inhibits the formation of pyranoanthocyanins and slows the formation of polymeric pigment. Polymeric pigment formation is also decreased in hybrids due to low concentrations of condensed tannin, a major component of stable color. *V. vinifera* wines can have more than a four-fold higher tannin concentration than hybrid wines.[5] Taken together, these factors mean that hybrid wine color is less stable over time, and wines that contain high concentrations of diglucosides will have less stable color as they age.

While it is fairly clear that hybrid wines will have lower concentrations of stable color, this doesn't have to be a negative characteristic. It simply means that hybrid wine color is different than *V. vinifera* color, and winemakers should not expect to see the typical *V. vinifera* transition from purple-red to brick-red. Instead, hybrid wines will have a unique color evolution that is likely to be driven by copigmentation rather than the formation of polymeric pigments, resulting in a blue or purple hue—and what consumer wouldn't want a wine that stays true blue with age?

Frozen hybrid grape samples are prepared for anthocyanin analysis in the laboratory.

photo: Claire Burtch, Cornell University

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NGP Team Profile: Amaya Atucha

Amaya is an Assistant Professor and Fruit Crop Extension Specialist in the department of Horticulture at the University of Wisconsin-Madison. Her research and extension program is focused on production practices to increase sustainability and fruit quality. She works closely with fruit growers across the state. As part of the Northern Grapes Project, she is conducting research on training systems and crop load management.

1. You grew up in Chile and studied agricultural engineering at Pontificia Universidad Catolica de Valparaiso, which focuses on horticulture. Given that you had no prior background in this area, why did you chose it as a major?
In high school I was really interested in biology and math, and agricultural engineering seemed like the perfect combination of both areas of study. I was also somehow influenced by my parents, who at the time had purchased a property in the countryside with the idea of establishing an avocado orchard. That was definitely a big incentive for me to choose that career path. Little did I know that I was going to end up in Wisconsin working with cold-hardy grapes and other temperate fruit crops!

2. After you finished your degree in Chile, you worked as an agricultural consultant and managed your family's avocado farm. How do you draw upon that experience in your current role?
The great advantage of having a broad background in fruit production is the ability to extrapolate and use previously-gained knowledge and experiences and adapt them to new fruit crop systems. For example, my undergraduate thesis focused on flower initiation and biennial bearing in avocados, and a lot of what I learned from that research I am now revisiting on some of my research projects related to flower induction and development on cranberries.

3. How did you find your way to Cornell University? Tell us a little about the research you did there for your PhD.
After graduating from college, I wanted to pursue a masters in citrus production in Spain, and contacted some of my former professors at the university to find information regarding graduate programs. One of my professors, a Cornell PhD, told me about the university and the excellent program they had in horticulture, and he really encouraged me to apply. I did, and was accepted in the graduate program in 2007 and starting working under the supervision of Dr. Ian Merwin, investigating the effects of groundcover management systems on orchard sustainability. I was very fortunate to be able to do part of my research work in Chile working on soil erosion, runoff and water quality in avocado orchards, in addition to my research project in apples in New York.

4. Given that you are the fruit specialist for all of Wisconsin, and have an appointment that includes extension, research, and teaching, your area of responsibility is quite broad. What is most challenging, and most rewarding, about this?
The most challenging part is definitely trying to find the balance between the teaching, research, and extension responsibilities; it can get pretty overwhelming during spring and fall when there is a heavy extension and teaching load. However, because I cover all the fruit crops in Wisconsin, I have the wonderful opportunity to work with a very diverse grower community, as well as the opportunity to learn about and do research on very different topics and cropping systems.

5. In your opinion, what is the most exciting research-based information that will come out of the *Northern Grapes Project*?
What is great and exciting about this project is how much information it does and will continue to provide to the cold climate viticulture industry. There is the viticulture, winemaking, and marketing component as well as the synergies among them; it is really amazing to have generated so much information in such a short period of time if you compare it to other wine grapes.

NGP Team Profile: Francis Ferrandino

Frank is an Agricultural Scientist in the Department of Plant Pathology and Ecology with the Connecticut Agricultural Experiment Station. He combines on-site weather measurement, inoculum quantification and epidemiological models to predict disease risk in support of the winegrape industry in Connecticut and greater New England. His contribution to the Northern Grapes Project is to examine the effects of training system, spacing, and pruning on the microclimate, disease susceptibility, productivity and fruit quality of northern winegrapes.

1. You have a PhD in Astrophysics. Tell us how you came to arrive at the Connecticut Agricultural Experiment Station.

My thesis was on turbulent dispersion reactions in red giant stars. That is when the things that are reacting with each other are mixed up by turbulence. Instead of having all your chemicals in a well-mixed flask, some are on the bottom and some are at the top and the reaction can only occur at the interface when and where they mix. In this case, the details of mixing are as important, or more important, as the nature of the reaction itself. In the early 1980's, the Connecticut Agricultural Experiment Station was concerned with the pollution in the Housatonic River caused by dumps of PCBs from upstream electrical transformer plants. I was hired to analyze the movement of PCB-laden sediment into Connecticut. Fish, which people caught and ate, began to exhibit dangerous levels of the cancer inducing contaminant. An objective risk-analysis to reduce contamination was obtained.

2. How did that research lead you to start working with plants?

The movement of nuclear isotopes in stars (my thesis), the entrainment of sediment from the bottom of a river (PCBs), and the aerial spread of wind–borne plant pathogens all obey the same physical laws. Epidemics are reactions. The two reactants are the inoculum (fungal spores, bacterium, or virus), and healthy plant material. The product is infected plant material, which produces more inoculum. This is a chain reaction! … akin to a forest fire, where burning plants produce sparks, which blow in the wind and ignite the surrounding foliage. Of course, the spread of this epidemic over time is crucially dependent on the nature of the wind in and above the canopy, which blows the spores around.

3. When and why did you start working with grapes, and how did you become involved with the N*orthern Grapes Project*?

For the past 30 years I have been studying the wind connection in spreading plant disease for many pathoystems: bean rust, septoria on tomato, apple scab, and powdery mildew on pumpkin, onion, tomato and, of course, grapes. Part of this study involves the use of in-situ weather stations to evaluate the risk of infection. In 2008, I co-wrote a grant with Dr. Richard Kyomoto to erect seven remote access weather stations in vineyards throughout southern New England (CT, MA, and RI). Products included weekly warnings to growers when disease risk was high for all pertinent winegrape pathogens. As part of this project, I planted small vineyards at three locations in CT. At these sites, disease resistance and productivity for cold-hardy hybrids and vinifera cultivars were compared. When Dr. William Nail left CAES in the spring of 2013, I took over management of his grower plots, which were part of the *Northern Grapes Project* and his NE-1020 plots, which included many cold hardy cultivars. At that time we had 2.7 A of vineyard, at four locations in CT, fielding 32 cultivars of winegrapes.

4. Tell us a little more about your research studying the turbulence in a grape canopy, and how the results of this work will help growers.

For field crops having a relatively homogenous canopy structure, the details of the wind field has been well studied. Trained trellised grapes, however, have a unique "elevated hedgerow" structure. The foliage along a row is limited to a height of between 1 and 2 meters and is trained using catch wires to extend less than half a meter perpendicular to the row. The nature of the turbulent wind in such a canopy is being measured in order to construct a detailed mathematical model for spore dispersal in vineyards. I have often been asked by growers whether or not spot application of fungicide in areas of the vineyard where disease levels are concentrated is efficacious. Another question is whether to spray an apparently "clean" field when an infected one is a few hundred meters away. The answer to these questions hinge on a thorough knowledge of the turbulent wind in vineyards.

5. In your opinion, what is the most exciting research-based information that will come out of the *Northern Grapes Project*?

In the past three winters, CT has had multiple sub-zero episodes in January before protective snow cover. This resulted in winter kill for more traditional vinifera and vinifera-labrusca hybrids. The most positive feedback that I have received from growers concerning the *Northern Grapes Project* is their excitement for using more cold-hardy cultivars, which were new to them, in expansion plantings.

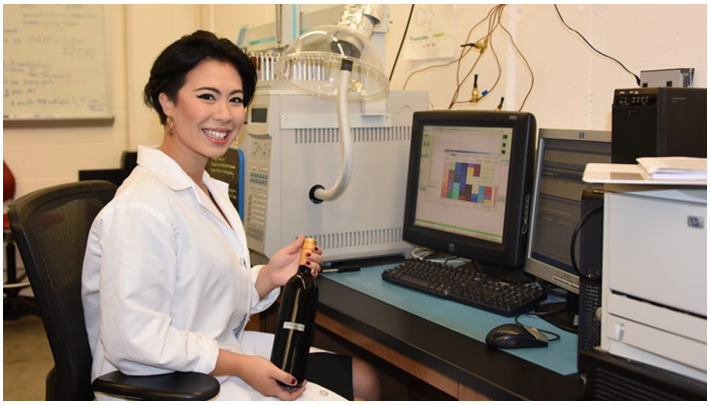
Simultaneous Chemical and Sensory Analysis of Frontenac and Marquette Wines

Somchai Rice, Iowa State University

Varietal specific 'signature' aromas, such as the green pepper aroma that methoxypyrazines give Cabernet Sauvignon and Cabernet Franc, are known and expected. Compounds responsible for these aromas can be attributed to a handful of chemicals. There are a variety of factors that can influence wine aroma including appellation, vintage, vineyard practices, and the skill of the winemaker. Understanding the volatile organic compounds (VOCs) that can contribute to the overall aroma profile of a wine is important in making high quality, aromatic wines, reflective of the region of origin.

The grape berry undergoes significant changes during ripening, including acid catabolism and accumulation of sugar, anthocyanins, flavor and aroma compounds. Sugars and acids are routinely measured to help determine optimal harvest time. Sugar content increases throughout berry ripening, and is understandably monitored as a function of maturity. In addition to sugar content, pH and titratable acidity of the grapes are monitored before harvest.

Flavor and aroma compounds, however, are complex, and not as easy to measure as brix, pH, and titratable acidity. There are many studies investigating compounds that contribute flavors and aromas to a wine. We are interested in identifying these compounds, and characterizing each compounds' perceived aromas, by using advanced analytical techniques such as multidimensional gas chromatography (MDGC) – mass spectrometry (MS) and simultaneous olfactometry (O). Our lab is able to link identification of the compound to human aroma perception.



Nanticha Lutt (2016 graduate of University of California at Berkeley and a 2015 George Washington Carver undergraduate summer intern at Iowa State University) using an automated SPME-MDGC-MS-O method to characterize aroma profile of Marquette and Frontenac wines.

photo: College of Agricultural and Life Science, Iowa State University

We evaluated wines made from Marquette and Frontenac grapes grown and harvested at both 22 and 24° brix at South Dakota State University in Brookings. Wines were made from each harvest time point using the same method, and the full aroma profile was characterized at Iowa State University. VOCs in the headspace of wine samples were analyzed using solid-phase microextraction (SPME) – MDGC – MS – O. SPME is a re-usable, solventless sampling device that extracts and pre-concentrates aroma compounds in the wine sample headspace. The MDGC allows for separation of the mix of volatiles and semi-volatiles into individual components (i.e., individual compounds responsible for primary, secondary and tertiary aromas). The advantage of MDGC over single column GC is that it enhances separation of compounds that cannot otherwise be teased apart, and MS then identifies and quantifies these separated compounds. The added bonus of our system is that the chemical identification (MS), occurs at the same time as olfactometry identification (i.e., a human panelist sitting at the sniff port).

Relative concentrations of these VOCs were calculated, as compared to an internal chemical standard. Next, odor activity values (OAV) of each compound detected in the headspace of the wine samples were calculated from published odor detection thresholds. OAV is defined as the ratio of the concentration of a compound to its odor detection threshold (ODT). Compounds of OAV > 1 were predicted to be the most odor impactful compounds contributing to the overall aroma profile of the Frontenac and Marquette wine samples. Aroma dilution analysis (ADA) of the wine samples was performed to isolate and confirm the most impactful aroma compounds present in the sample. Briefly, successive dilutions of the each wine samples in model wine were analyzed by headspace SPME-MDGC-MS-O until the odor response from each compound was no longer noted at the sniff port by the human panelist. The compounds detected in the most dilute wine samples were deemed the most odor impactful to the overall aroma profile of the wine.

We set out to determine if calculated OAVs could be used to estimate the aroma impact of compounds that are most prominent in the samples, as characterized by ADA. We hypothesized that the importance of an aroma compound to the overall total aroma of wine can be calculated by OAV, when using our SPME-MDGC-MS-O, without going through the entire process of ADA or training a person for olfactometry work. This would hold true if there are established ODTs already available for the compound(s) of interest.

Thirty-four compounds were identified across both varieties at both time points. Compounds with the highest relative concentration in headspace in each of the wines are listed in Table 1. The distributions of the compounds in Table 1 are shown graphically in in Fig. 1, listed by aroma descriptors. It is important to note that different compounds at the same concentration are perceived differently. Also, the same compound at different concentrations are perceived differently. The complexity of aroma acuity is further illustrated by 'fruity' aromas occurring over 15 times in Fig. 1, across thirty- four compounds of varying concentrations. It is clear that the link between human aroma perception of the chemical compounds and concentrations are complex and unpredictable.

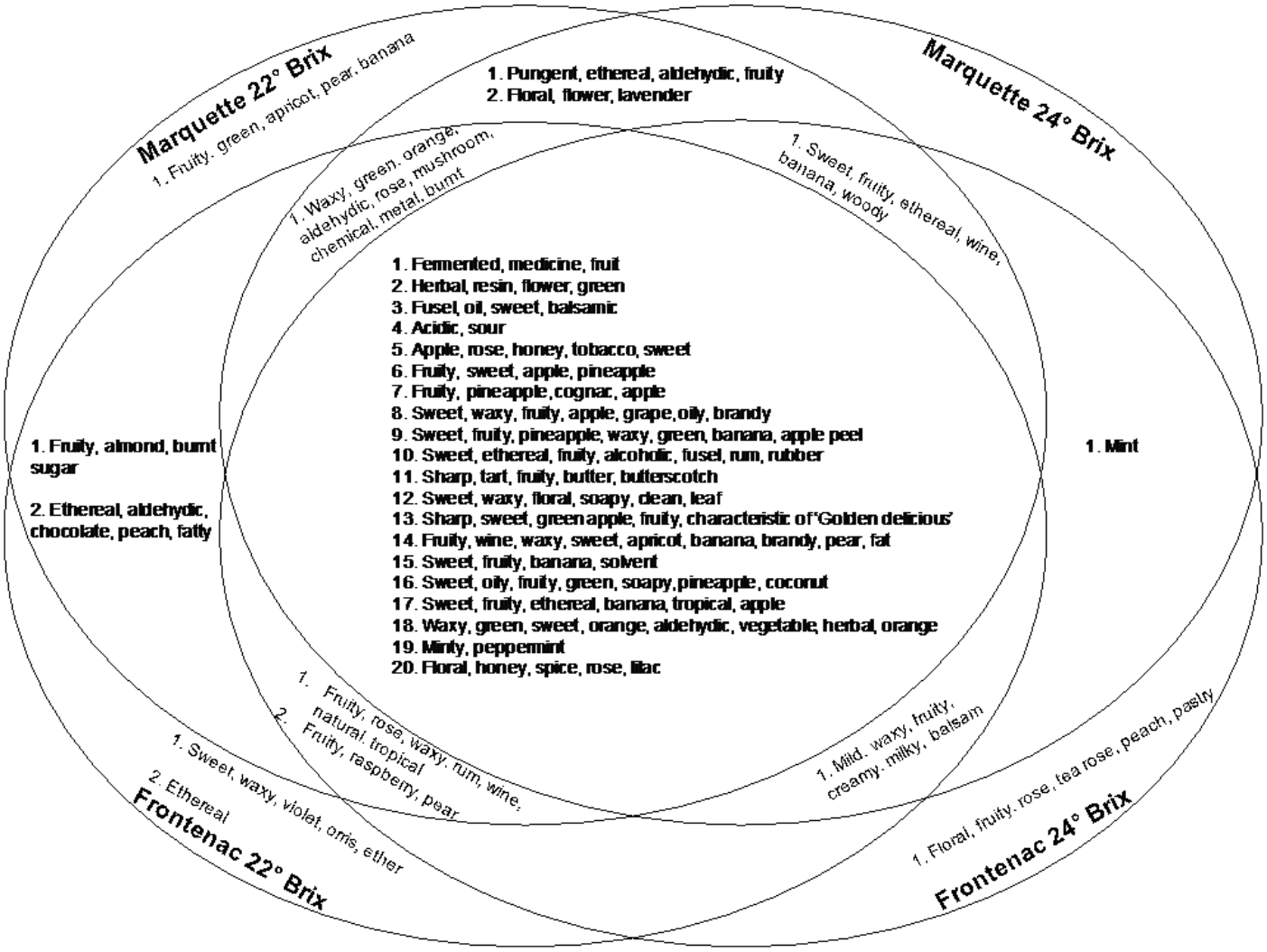
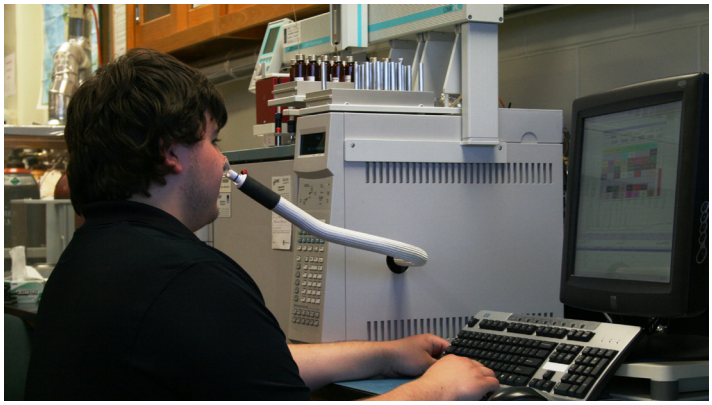


Figure 2. *A Venn diagram showing distribution of compounds found in wines, listed by aromas. For example, there are 20 compounds that were detected in all wine samples (center intersection), two compounds were detected in only Marquette wines (top, center intersection), etc.*



Jason Vallone (2013 graduate in Chemistry at Iowa State University) seated at the sniff port of an MDGC-MS-O to simultaneously identify and characterize volatiles from grape and wine samples.

photo: Tim Martinson, Cornell University

Table 1: Compounds with the highest concentrations in analyzed wine samples.

Marquette (22° Brix)	Marquette (24° Brix)	Frontenac (22° Brix)	Frontenac (24° Brix)
ethyl octanoate	1-pentanol	1-pentanol	1-pentanol
1-pentanol	ethyl octanoate	ethyl octanoate	ethyl octanoate
ethyl hexanoate	ethyl decanoate	ethyl decanoate	ethyl decanoate
ethyl decanoate	ethyl hexanoate	ethyl hexanoate	ethyl hexanoate
phenylethyl alcohol	phenylethyl alcohol	phenylethyl alcohol	ethyl lactate
ethyl lactate	ethyl lactate	ethyl laurate	isoamyl acetate
isoamyl acetate	isoamyl acetate	ethyl lactate	phenylethyl alcohol
ethyl butyrate	ethyl laurate	isoamyl acetate	ethyl laurate
1-hexanol	1-hexanol	acetic acid	ethyl butyrate
ethyl laurate	ethyl butyrate	ethyl butyrate	acetic acid
acetic acid	acetic acid	isoamyl octanoate	ethyl isobutyrate
isoamyl octanoate	isoamyl octanoate	1-hexanol	ethyl-2-methylbutanoate
ethyl isobutyrate	ethyl isobutyrate	ethyl isobutyrate	isoamyl octanoate
	2-pentanone	1-octanol	2-pentanone
		benzaldehyde	1-hexanol
		isovalaraldehyde	1-butanol
			beta-damascenone

Table 2: Key aroma compounds in wine samples, determined with aroma dilution analysis.

Marquette (22° Brix)	Marquette (24° Brix)	Frontenac (22° Brix)	Frontenac (24° Brix)
ethyl hexanoate (wine, apple, fruity)	ethyl decanoate (cheesy, body odor, sharp, sweaty)	ethyl hexanoate (licorice, black currant, strawberry)	ethyl octanoate (chocolate, molasses, dusty, mushroom)
ethyl isobutyrate (apple, fruity)	ethyl butyrate (chocolate, molasses, strawberry)	ethyl octanoate (chocolate, molasses)	ethyl decanoate (wine)
			1-pentanol (chocolate, cheesy, molasses)
			ethyl isobutyrate (strawberry, black currant, jam)

Next, to test our hypothesis, ADA was performed on the wine samples, using the same SPME-MDGC-MS-O method. Compounds identified as the most impactful (i.e., persisted in the most diluted wine samples, and detected by human panelist at the sniff port) are listed in Table 2.

In conclusion, compounds with calculated OAV > 1 were shown to be impactful to total aroma of the wine samples, confirmed by ADA and simultaneous chemical and sensory analysis. This indicates that OAV could be used to predict which compounds contribute to the overall aroma profile of wine without the use of olfactometry instrumentation. Instead, aroma impact can be calculated and estimated according to OAV, if the concentration of the compound can be measured. Further, statistical analysis indicated chemical concentrations of VOCs were most similar between both varieties at 22° brix. Wines made from both cultivars, and harvested at 24° brix were most variable. As sugar levels increased, Marquette wine aromas developed from 'wine, apple and fruity' to 'cheesy, chocolate, and strawberry', wheras in Frontenac, 'chocolate and molasses' aroma intensified, and 'jam' aroma developed, as sugar levels increased.

Tasting Room Visitor Surveys: Experience with and Enjoyment of Cold-Hardy Wines

Don Holecek, Dan McCole, and Jenni Lee

This article presents research findings with the aim of enhancing the ability of cold hardy grape wine producers to successfully market their wines. At the beginning of the *Northern Grapes Project*, there was evidence that most smaller wineries relied heavily on sales to visitors in their tasting rooms to sell their wines. As part of this project, we conducted a survey of wineries in Wisconsin to determine how dependent they are on direct sales to visitors to their tasting rooms. The wineries that participated in the survey reported selling on average of about 75% of their wine from their tasting rooms. Hence, to successfully market their wines, it is very important for wineries to understand their tasting room visitors, especially the smaller wineries which dominate the industry in states where cold hardy wine grapes are most commonly grown.

The 2012 Michigan "pilot" tasting room study. Because we are based in Michigan and had contacts with people associated with Michigan's wine industry, we chose to engage the Michigan wine industry in framing, then implementing, a pilot study of Michigan's tasting room visitors. While focusing this initial effort on Michigan wineries was logistically convenient, one drawback that became evident was that only a small percentage of wine grape plantings in Michigan are of the cold-hardy varieties. Yet, the pilot study was successful in achieving its main objectives including: 1) how to cost-effectively survey tasting room visitors, 2) how to recruit and retain winery research partners, and 3) to develop and test appropriate questionnaires.

The 2015 Wisconsin/Minnesota study. When it came to assessing subjects' brand awareness of cold-hardy grape wines, Michigan was not an ideal geographic venue, as noted above. Wisconsin and Minnesota, however, are very good venues because their wineries rely more on cold-hardy grapes to produce their wines than do Michigan wineries. The survey results indicated that Marquette, Frontenac, and La Crescent are the most widely-used varieties, but Edelweiss, St. Pepin, Brianna are also grown and used in winemaking.

We recruited 17 geographically well-distributed wineries in Wisconsin and five in Minnesota for the 2015 Wisconsin/Minnesota tasting room visitors study. We used the same questions as we did in the Michigan pilot study, and conducted the study in the late spring through fall, during the busiest time of year for these wineries. Over 2,000 tasting room visitors participated in the 2015 study, about 75% from Wisconsin and 25% from Minnesota.

Experience with Cold-Hardy Wines. The central interest in this study was to better understand consumer experience with cold-hardy grape wines including: 1) consumers' level of awareness of them 2) whether they've had the opportunity to taste any of them; and 3) how well they like them.

In both the Michigan study in 2012 and the studies in Wisconsin and Minnesota in 2015, tasting room visitors were asked to rank their familiarity with cold-hardy wines. As can be seen in Figure 1, very few respondents (14% in Michigan and 18% in Wisconsin and Minnesota) indicated that they were familiar with cold-hardy wines. This number initially struck us as low, especially in Wisconsin and Minnesota where there is a strong likelihood that the respondents were recruited at a winery that produced cold-hardy wines. Moreover, the Michigan tasting room visitors reported greater familiarity with the wines made from cold-hardy grapes than those in Wisconsin and Minnesota. This result too was initially surprising since, as explained above, cold-hardy wines are more common in Wisconsin and Minnesota than in Michigan.

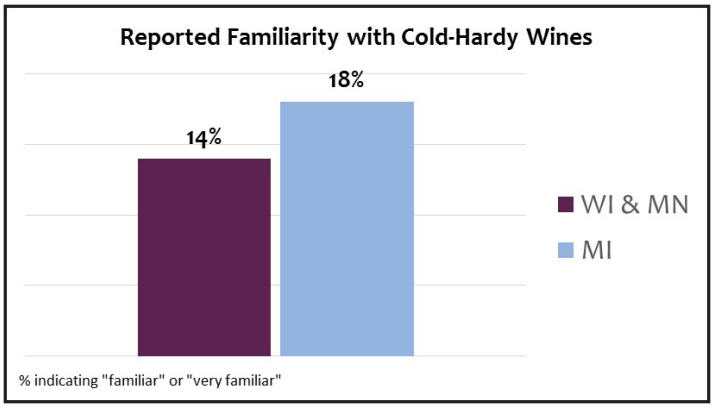


Figure 1. *Survey participants' familiarity with cold-hardy wines, both in the 2012 Michigan study, and the 2015 Wisconsin/Minnesota survey.*

It seems likely, however, that this finding is the result of respondents not understanding the meaning of "cold-hardy wines," which is a term used more frequently by the wine industry and researchers than by the general public. Because of this possible confusion, respondents were also asked to rate their familiarity with specific cold-hardy wine varietals. Figure 2 indicates respondents' familiarity with several cold-hardy grape varieties for Michigan tasting room visitors and Figure 3 shows results to the same question for tasting room

visitors in Wisconsin and Minnesota. The varieties Snowbird, Crystal Lago, and Alpino Rouge were bogus names created by the researchers to better understand the validity of respondents' answers.

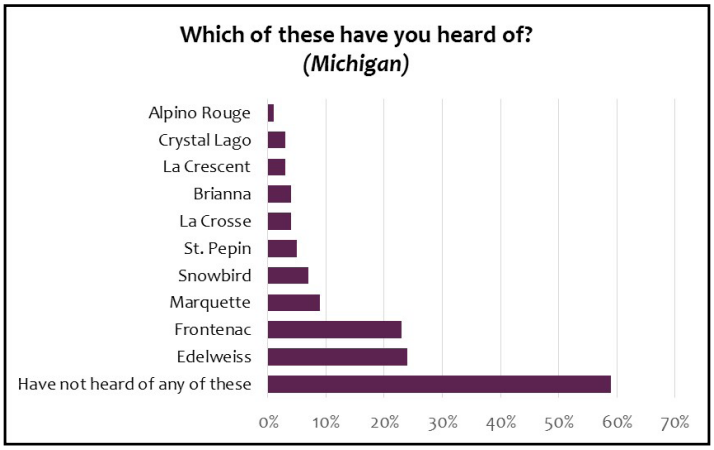


Figure 2. *Percent of survey participants who have heard of various cold-hardy grape cultivars, including the 'made-up' names Alpino Rouge, Crystal Lago, and Snowbird, in the 2012 Michigan survey.*

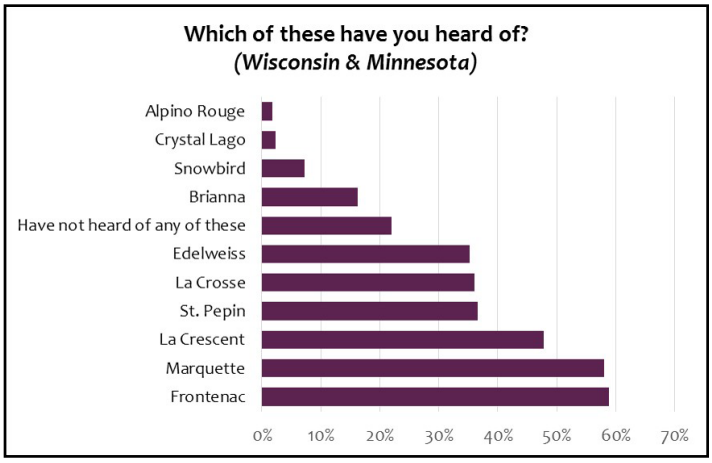


Figure 3. *Percent of survey participants who have heard of various cold-hardy grape cultivars, including the 'made-up' names Alpino Rouge, Crystal Lago, and Snowbird, in the 2015 Wisconsin/Minnesota survey.*

As the graphs show, many more people in Michigan (59%) had not heard of any of the cold-hardy varieties than in Wisconsin and Minnesota (22%). Additionally, in Wisconsin and Minnesota, the varieties people had heard of the least were the bogus ones; in Michigan, however, more respondents indicated that they had heard of the bogus variety Snowbird than the actual varieties Brianna, La Crosse, St. Pepin and La Crescent.

These results seem to confirm the suspicion that most consumers don't have an accurate understanding of the term "cold-hardy wines." The results also show that tasting room visitors to the regions that primarily use cold-hardy grapes to make wine (Wisconsin and Minnesota) recognize these varieties much more than tasting room visitors to an area (Michigan) that doesn't make very much wine with cold-hardy grapes. This finding suggests that generating recognition of cold-hardy wines is not only possible, but can be done rather quickly. Marquette, for instance, which was only patented in 2006, was the second most recognized cold-hardy wine.

Enjoyment of Cold-Hardy Wines. Beyond simply recognizing cold-hardy varietals, the tasting room visitors in Wisconsin and Minnesota who had tried cold-hardy wines indicated enjoyment of them, as 32% indicated they liked it a little, and 44% indicated they liked it a lot. Further, Figure 4 shows the percentage of respondents who indicated they either "liked" or "liked a lot" individual cold-hardy wine varietals, further displaying that consumers enjoy these wines.

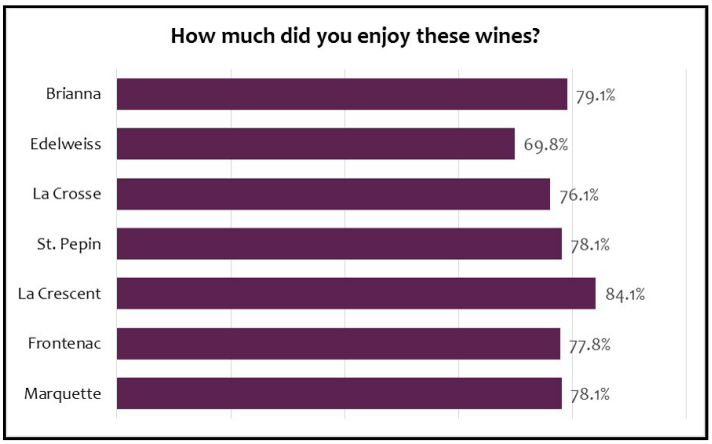


Figure 4. *Percent of survey participants in the 2015 Wisconsin/Minnesota study who "liked" or "liked a lot" each wine varietal.*

Conclusions. It is clear from the results that consumers are unaware of the term "cold-hardy wine," which is used by the wine industry. However, where cold-hardy cultivars are grown, such as Wisconsin and Minnesota, consumers have begun to recognize their names, which shows potential for promoting wine varietals made from cold-hardy grapes.

Additionally, tasting room visitors who had tried cold-hardy wine varietals indicated that they liked them. This too is a promising finding, especially in the context of an earlier study for the Northern Grapes Project by Miguel Gomez and Erin Kelley (http://northerngrapesproject.org/wp-content/uploads/2013/04/Tasting-Room-and-Customer-Satisfaction.pdf). In that study, Gomez and Kelley found that satisfaction with a tasting room experience will lead to greater wine sales, and that factors such as customer service and ambiance are more important predictors of satisfaction than wine quality. If tasting room visitors to wineries that produce cold-hardy varietals enjoy these wines and have a good tasting room experience, *Northern Grapes Project* research suggests that there is a potential market for wineries that produce cold-hardy wines. Our study of tasting room visitors also provided insights that will help wineries to provide better tasting room experiences to visitors, and thus, increased sales.

In Memoriam
William R. Nail IV

Bill was a member of the *Northern Grapes Project* from its start until his retirement from the Connecticut Agricultural Experiment station in 2013. The American Society for Enology and Viticulture-Eastern Section (ASEV-ES) will be honoring him at the 41st Annual ASEV-ES Conference July 18-21, 2016 in St. Louis, MO. To commemorate his quiet passion for grapes and wine, and his hopes for the future of the industry, ASEV-ES is accepting donations for a student scholarship in Bill's memory. Donations can be made at http://www.asev-es.org/PaypalASEVES.php, and all funds received will be used to support a new viticulture student scholarship to be awarded at the meeting.

William R. Nail IV died on April 10, 2016 at the young age of 59. Bill was born and raised in Dallas along with his sister, Nancy, by loving parents, Will and Sue Gilbert Nail. Bill was the fourth William Rogers Nail and when he was born on June 14, 1956, all four were alive, including his great-grandfather, a retired physician from Crawford, Texas (born in 1861, the year Lincoln was inaugurated as President). Bill's grandfather and father were dentists while Bill chose to become a scientist experienced in horticulture and viticulture. Beyond his B.M. degree from Southern Methodist University, he earned an M.S. in Horticulture at Texas A&M and a Ph.D. in Horticulture at Michigan State University. He retired from the Connecticut Agricultural Experiment Station after a career in teaching and government research in oenology, the study of winemaking. In addition to his love of classical music, Bill especially enjoyed bluegrass and country music (Emmylou Harris and Ronnie Dunn were favorites) and he annually attended Jerry Jeff Walker's Birthday Bash in Austin. His love of music was deep (in the early 1980s he played drums and guitar in a commercial band). His best friend was his sister, who died suddenly only 18 months ago. Bill's immediate family, his parents and sister, predeceased him, and he is survived by his aunt, Virginia Nail Moore, four first cousins (Dr. Marilyn Stewart, Richard A. Gump, Gina Moore Eben, and Robert Moore), and his brother-in-law, David Myers. We will all miss Bill's soft-spoken demeanor, gentle smile and love of family, friends, and animals. A former girlfriend said he was genuinely the kindest and most generous person she ever knew. Bill will be cremated in Connecticut and his ashes flown back to Dallas. The family will celebrate his life with a private dinner in his memory. Donations in his memory may be sent to the charity of your choice or a favorite non-profit of Bill and Nancy, Bonaparte's Retreat (founded and run by Emmylou Harris), which focuses on rescuing dogs whose time has run out at Metro Nashville Animal Care and Control. Go to www.bonapartesretreat.org for donation instructions.

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http://www.legacy.com/obituaries/nhregister/obituary.aspx?n=william-r-nail&pid=179873591&

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