

Evaluating Return-on-Investment from Vine to Wine: Sensory Evaluation and Consumer
Willingness-to-Pay of Vineyard Management Strategies for Vancouver Island Pinot gris

by

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We acknowledge and respect the lək'wəŋən peoples on whose traditional territory the
university stands and the Songhees, Esquimalt and W̱SÁNEĆ peoples whose historical
relationships with the land continue to this day.

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Abstract

Cluster thinning, leaf removal and kaolin application are three commonly employed means of modifying fruit zone microclimates assumed to improve grape and wine quality. High labour costs in addition to the potential for location and varietal-specific responses make the benefits of these practices equivocal. To explore this question, I employed a stratified random block design in two Vancouver Island commercial vineyards where Pinot gris vines were manipulated with one of four experimental treatments: control, cluster thinning to one cluster per shoot, heavy leaf removal with a Kaolin clay application, or a combined heavy leaf removal – cluster thinning - Kaolin treatment. The resulting wines were subjected to detailed sensory evaluations, consumer valuation, and a cost-benefit analysis to determine their respective return-on-investment.

Results indicate that despite apparent sensory changes driven by vineyard treatments, the lack of any perceived added value suggests that regional producers of Pinot gris should avoid using the assessed treatments as strategies to increase wine quality. The cost-benefit analysis revealed that heavy leaf removal combined with Kaolin clay application may provide a benefit outside of changes to wine quality. The demonstrable improvement in growing conditions under this treatment resulted in a significant decrease in rot pressure. This suggests that the treatment may be a viable option for increasing usable yields of Pinot gris without placing an insurmountable financial cost on the producer.

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Acronyms

BC	British Columbia
ANOVA	Analysis of Variance
BCWI	British Columbia Wine Institute
CATA	Check-All-That-Apply
CI	Confidence Interval
CT	Cluster Thinning
CV	Contingent Valuations
DA	Descriptive Analysis
GC/MS	Gas Chromatography Mass Spectrometry
GDD	Growing Degree Days
Sub-GI	Sub-Geographical Indicator
HCK	Cluster Thinning + Heavy leaf removal and Kaolin clay
HK	Heavy leaf removal and Kaolin clay
LR	Leaf Removal
NAFTA	North American Free Trade Agreement
QMF&CI	Quartermaster's Food and Container Institute
RATA	Rate-All-That-Apply
ROI	Return-on-Investment
V1	Vineyard 1
V2	Vineyard 2
VQA	Vintner's Quality Alliance
WSET-3	Wine and Spirit Education Trust level 3
WTP	Willingness-To-Pay

Dedication

This research project could not have been completed without the constant support of my supervisor John Volpe. His dedication to his students was always evident, and his guiding hand motivated me through the several challenges that I faced along the way. I would also like to thank Andrew Watts, the experts at Unsworth Vineyard, Blue Grouse Winery, and the broader Wine Island Growers Association. Without these people there would be no project.

1. Chapter 1:

Introduction and context

1.1 Introduction

Wine production, like most endeavors, is a multiscale profession. In broad strokes, we often think of wine in terms of its region of origin and varietal; however, as the lens becomes evermore focused, the nuisances of vineyard management (Profio et al., 2011; Reynolds et al., 2007a, Reynolds et al., 2007b), winemaking decisions (Bueno et al., 2006; Perez-Prieto et al., 2003; Reynolds et al., 2001), and even microbial communities (Knight et al., 2015; Valero et al., 2002) are known to affect a wines' overall taste, aroma, and quality. Once a vineyard is established, many aspects of wine production remain outside of a producer's scope of influence. Short of creating an industrial scale greenhouse, most wine producers focus their efforts on what they can affect. Vineyard managers implore various techniques to manipulate the microclimate of grape clusters in hopes of promoting quality grape growing. In regions such as Vancouver Island, British Columbia, Canada, which sits at the northern edge of successful production latitudes (Hannah et al., 2013), much of the focus is on maximizing sun exposure, increasing yields, and creating vine balance. While there are generally accepted approaches to achieve these goals, to my knowledge, there has never been a quantitative examination of the efficacy of the specific techniques used on Vancouver Island. This work represents the first exploration of the relationship between two commonly used viticulture strategies and their relationship to wine style, quality, consumer preference, and return-on-investment (ROI).

1.2 Wine Production in British Columbia and the Role of Viticulture

British Columbia (BC) has seen a significant transformation of its wine industry over the past three decades, highlighted by an increase in local production, wine consumption, and regional tourism (Cartier, 2014; Hira & Bwenge, 2011). Many of these changes are attributed to the pursuit of *Vitis vinifera*-focussed foreign markets in the wake of the North American Free Trade Agreement (NAFTA) enactment in 1989.

Prior to NAFTA, non-vinifera varietals dominated the province's largest wine regions (Hira & Bwenge, 2011). During this period, producers were not incentivised to grow international vinifera varietals such as Merlot, Pinot Noir, or Chardonnay as tariff protections stagnated competition. Imported wines faced significant markups compared to the relatively small taxes placed on wines from British Columbia (Hira & Bwenge, 2011.). After NAFTA removed trade barriers for US products, the province's growers quickly shifted their production to remain competitive with the objectively higher quality American products entering the BC market (Hira & Bwenge, 2011). The resulting mass removal of 'vin ordinaire' and subsequent replanting of traditional European vinifera cultivars significantly changed BC's wine industry, forcing conventional notions of quality to the forefront of production. The changes NAFTA initiated culminated in the creation of the BC Wine Institute (BCWI), appellation standards, and the Vintner's Quality Alliance (VQA) as a means of ensuring a minimum quality standard (Hira & Bwenge, 2011).

By the end of the post-NAFTA decade, BC wines had begun to attract international recognition, especially in the province's most celebrated regions. Today, some 32 years after NAFTA, BC's wine industry is valued at close to three billion dollars in total economic impact (Frank, Rimerman + Co. LLP, 2017), and may continue growing long term as improved techniques, and warming climates increase the market suitability for less established regions such as Vancouver Island.

Vancouver Island and the Southern Gulf Island wineries, colloquially referred to as the Wine Islands, are located within the Coastal Douglas-fir moist maritime biogeoclimatic zone. By its nature, the area is defined as a cool climate wine region with a strong maritime influence. Summers are warm and dry while winters are mild and wet (ECCC, 2011). The growing season averages between 900 to 1200 Growing Degree Days (GDD, base 10°C) and experiences fewer than 10 days over 30°C, with an average maximum summer temperature of 25°C (Smith et al., 2019). The most suitable growing conditions are found in the recently recognized sub-Geographic Indication region (sub-GI) of Cowichan Valley, on southern Vancouver Island. Due to the prevalent cool conditions in even the warmest locations, historically successful *Vitis vinifera* cultivars are limited to those requiring around 1000 GDD to mature such as Ortega or Pinot gris (Jones, 2015; Smith et al., 2019). By comparison, the Okanagan Valley, on BC's mainland, sees GDD values ranging from 1200 to over 1500 allowing for a wider range of cultivars and wine styles (Rayne, et al., 2009).

Unlike the Okanagan Valley, the Cowichan Valley maintains substantial plantings of hybrid cultivars such as Maréchal Foch and Petite Milo, or lesser-known cool climate *V. vinifera* cultivars such as Ortega. Recent years have seen increasing production of Pinot Noir, Pinot gris in the region, with some vineyards planning to produce Chardonnay. Much as we saw with NAFTA in the 1990s, the Island region is experiencing a similar, yet delayed, shift in production to meet market demand for quality. While the vineyards have begun the shift towards these more traditional varietals, achieving adequate berry ripeness and quality with short growing seasons and mild summer temperatures remains the foremost the challenge for regional producers.

Short of waiting for the effects of climate change, the task falls on the vineyards to maximize the quality of their *vinifera* vines under the current, often challenging conditions. To overcome the many obstacles inherent to location, vineyard managers are equipped with several tools that can improve the overall quality, complexity and/or ripeness of the fruit. It is the goal of the vineyard manager to produce the highest quality of fruit possible, which in turn makes the job of the winemaker that much easier.

Testing claims of viticulture (grape vine cultivation) management is the subject of significant ongoing global research given the numerous sources of variance borne of interactions between cultivar, geography, seasonality, and oenology. While all growers seek maximum fruit quality and ripeness while minimizing costs, the relative youth and rapidly changing nature of the Vancouver Island wine industry means little empirical evidence is available to inform growers as to the relative merits of the various viticulture

strategies. While the potential of Cowichan Valley wines has recently been evidenced by the granting of a sub-GI appellation designation, much less has been done to provide regional producers with an informed region-specific toolbelt designed to improve the quality of their wines. This research provides the first systematic evaluation of viticulture strategies common in Vancouver Island (and BC) focussing on Pinot gris, the region's most planted white variety.

1.3 Assessing Wine Quality

Before assessing the effects of viticulture practices on the quality of grapes and wine, 'quality' in the context of wine must be defined. "Quality", in its many interpretations, is often subjective or even esoteric. Many consumers rely on the authoritative voices of "experts" such as Jancis Robinson, Robert Parker, Wine Enthusiast, or Wine Spectator, that convey quality via a 20- or 100- point scale. The utility of the system is self-evident, a wine scoring 95/100 is "higher quality" than one scored 89/100. The problem of course is that these consumer-facing scores are not, cannot, be objectively derived (Hopfer & Heymann, 2014; Cliff & King, 1999). In addition, by equating a wine to a single value, derived by an individual, we fail to capture much of what differentiates wines in terms of their quality, unique character and/or typicity of place. To provide a more nuanced perspective on wine and wine quality, researchers rely on a combination of sensory science and consumer testing to provide a much more granular level of detail and understanding.

1.4 Introduction to Food and Sensory Science for Wine

Sensory evaluation is used to evoke, measure, analyze, and interpret responses to products as perceived through sight, smell, touch, taste, and hearing (Stone & Sidel, 2004). The origins of modern sensory science can be traced back nearly 100 years to research in psychophysics and psychometrics (Heymann, 2019). The theories born from early experiments in these fields form much of the foundation for applied sensory science. The major deviation stems from the subject of study; where psychophysics studies the person as the object of interest, applied sensory evaluation uses people to understand the sensory properties of products (Heymann, 2019; Lawless & Heymann, 2010). The latter is the focus of this work.

Typically, sensory evaluation is a means of reducing risk and uncertainty in business decision making by leveraging and evaluating the human perception of changes on foods and materials and their respective properties (Lawless & Heymann, 2010). The key to successful sensory evaluation is that the test method should be matched to the objectives of the test (Lawless & Heymann, 2010). For example, a discrimination test, like the triangle test, would be used to objectively determine whether two products are noticeably different, but not for profiling the flavour of a product (Heymann, 2019)

Sensory evaluation protocols are divided into three methodological groups (Lawless & Heymann, 2010). The simplest, dating back to the early twentieth century,

are discriminatory analyses (Heymann, 2019) which ask if any perceptible difference exists between products. A classic example is the triangle test, mentioned above, in which panelists receive three samples, of which two are identical and one is different. They are asked to identify the odd sample, and the tabulated results are compared to random odds of one in three (Heymann, 2019).

Descriptive analyses, which as the name implies, are used to curate flavour and aroma profiles for food products based on the perceived intensities of its sensory characteristics (Lawless & Heymann, 2010). Descriptive analyses are considered the most comprehensive and informative sensory tool, as results can be related to both consumer acceptance (e.g., market research) and instrumental measures (e.g., Gas-chromatography/Mass Spectrometry [GC/MS]). This approach gives more flexibility to researchers; however, that flexibility comes at the cost of being the most labour-intensive method for both researchers and participants (Lawless & Heymann, 2010).

Lastly, hedonic or consumer analyses (Lawless & Heymann, 2010) were derived by the Food Acceptance Branch of the Armed Forces Quartermaster's Food and Container Institute (QMF&CI) in the early 1950s (Peryam & Girardot, 1952). The nine-point hedonic scale (Table 1.1) used adjectives to prescribe preferences for food products in the military (Lawless, 2019). The scale was quickly adopted by the food industry, becoming the most widely used scale to assess food acceptability in consumer populations (Lawless, 2019).

Table 1.1: Word anchors for the 9-point hedonic scale from Lawless, 2019.

Like Extremely

Like Very Much

Like Moderately

Like Slightly

Neither Like nor Dislike

Dislike Slightly

Dislike Moderately

Dislike Very Much

Dislike Extremely

Deciding which of the above methodologies is most appropriate is governed by the type of research question, defined as either Type I or Type II, and how the researcher chooses to reconcile the trade-off between reliability of results, and information extrapolation (Lawless & Heymann, 2010; O'Mahony, 1988). In a Type I design, the participant is analogous to an analytical instrument and is used to detect and measure changes in a product (O'Mahony, 1988). Here, the reliability of the results is paramount to interpreting the test outcomes. As such, researchers invest significant effort calibrating panels and refining methods to reduce variability within and between participant responses. In contrast, Type II designs view participants as analogous to the consumer population (O'Mahony, 1988), and tend to evaluate products under more natural conditions to predict the consumer response. The research presented here spans the divide between analytical and consumer responses, thus both Type I and II protocols are employed.

As alluded to previously, it is desirable for sensory evaluations to yield reliable results; however, the instrument being leveraged (i.e., the human olfactory system) is subject to a wide degree of variability (Mainland et al., 2014; Reed et al., 2006). Differences in individual sensitivities or preferences, often borne of genetic predisposition, limit the degree to which a panel of tasters can be calibrated to yield consistent responses (Lawless & Heymann, 2010). In the context of Type I analyses that utilizes descriptive analysis methods, panel participants are screened and trained to reduce this inherent variance (Lawless & Heymann, 2010). Additionally, environmental cues, such as ambient lighting (Oberfeld et al., 2009; Spence et al., 2014), colour (Morrot et al., 2001), serving vessels (Hirson et al., 2012), and sound (Spence et al., 2014), have been demonstrated to influence the perception of products, and are thus standardized to minimize these extraneous sources of variance (Lawless & Heymann, 2010).

Once a panel is trained on a product, it is unwise to then ask them for their preference of the same product. Just as problems arise when untrained consumers are asked to assess specific information about product attributes, so too do they arise when a trained panel is asked to forget their calibration training (Lawless & Heymann, 2010). Since I employed both Type I (participant as instrument) and Type II (participant as consumer) protocols, I used different groups of participants for the respective analyses. Experienced, semi-trained wine tasters were recruited for a Type I evaluation, in which modern descriptive analysis methods were used to create a sensory profile for each experimental wine. To predict consumer responses (Type II), I utilized real consumers

and elicited their willingness-to-pay using contingent valuation to state their preferences in a hypothetical market. By combining the two protocols I was able to evaluate how the experimental wines differed from one another, and if those perceived differences were differentially valued or preferred at the consumer level.

1.5 Understanding willingness-to-pay and return-on-investment

This research deviates from traditional hedonic evaluations and the 9-point preference scale described above (Lawless & Heymann, 2010; Peryam & Girardot, 1952). Rather than simply evaluating wine via ranking or preference mapping, the intent was to provide practical value to regional producers. Due to the high variable costs incurred by the experimental treatments, the wines needed to demonstrate a substantial increase in perceived value. This meant examining preference through an economic lens, by eliciting consumer Willingness-to-Pay (WTP) in place of rank and order. The dollar values generated from these surveys could in turn be used to evaluate the potential ROI of the viticultural treatments through a simple cost-benefit analysis.

WTP is defined as the maximum price a customer is willing to pay for a product or service. The value is not necessarily what the customer thinks is a fair price, as an individual's aim is to maximize surplus (Lewis & Zalan, 2014), rather it indicates that they will pay any price up to this WTP value (Corts & Rivkin, 1999). While the price is driven by a product's value proposition, it can vary significantly between individuals, often caused by differences in extrinsic (i.e., age, gender, education, etc.) or intrinsic

factors (i.e., sensitivity to taste, lifestyle, etc.). By determining customers' WTP, a company can maximize profits and customer satisfaction by appropriately setting prices near this threshold. For the purposes of my research, the goal is to determine whether the intrinsic differences in the wines (sensory differences), manifested via vineyard manipulations intended to improve quality, shift consumer WTP enough to recover the additional cost of scaling the vineyard treatments to a commercial level.

Contingent Valuation (CV) is a survey-based stated-preference economic technique used to elicit a consumer's WTP for a non-market good (Carson and Hanemann, 2005). Historically used to estimate the value/utility of environmental services or natural resources (Carson & Hanemann, 2005; Echeverría et al., 2014), CV has been adopted widely in areas such as agricultural economics, to estimate the marginal value associated with changing one or more attributes of an existing good (Mergenthaler et al., 2009; Romano et al., 2016; Tozer et al., 2015;). Notably, this method has been used to connect sensory attributes to consumer WTP for consumable products including craft cider (Tozer et al., 2015), beer (Gabrielyan et al., 2014), and wine (Holmquist et al., 2011).

While widely used, the primary challenge of CV is that it provides hypothetical answers to hypothetical questions. In other words, no real payment is taken, and respondents may overlook their budget constraints, consequently leading to an overestimate in their WTP (Markandya & Ortiz, 2011). While strategies to confront this

philosophical limitation exist (Carson, 2000), this research pertains to the relative value of goods rather than their absolute values, thus circumventing this limitation.

The general study design for a CV survey requires at minimum three parts: (1) a detailed description of what is being valued and any hypothetical change regarding it, (2) questions about willingness-to-pay for that good or service, (3) questions about the respondents' characteristics (age, income, education, etc.) and their preferences regarding the good or service (Healy et al., 2012). The structure of my model follows these core elements, with less emphasis on a description of the product being evaluated. This was justified as participants were directly assessing the products. Thus, to avoid bias, minimal descriptions were provided beyond a general overview of the project scope.

1.6 Hypotheses

Chapter 2 explores the effects of cluster thinning, and basal leaf removal (in conjunction with the application of Kaolin clay) as means of changing the sensory profile and subsequent consumer preference for Pinot gris grown on Vancouver Island. Given the inherent matrix of this study design, there are several hypotheses that emerge; however, they can effectively be summarised as follows:

- 1) Do the viticultural strategies of cluster thinning, basal leaf removal with Kaolin clay application, or the combination of treatments significantly change the sensory profile of the resulting wines?

- 2) Do the viticultural strategies of cluster thinning, basal leaf removal with Kaolin clay application, or the combination of treatments significantly alter consumer WTP of the resulting wines?

To answer these questions, I used techniques from the fields of sensory science and economics. To evaluate potential sensory changes, I leveraged an emerging sensory technique known as Rate-All-That-Apply (RATA), a rapid evaluation method gaining popularity for its ease of use and high data fidelity. This was followed up with Contingent Valuation (CV) to evaluate if the experimental treatments imparted a significant increase in consumer WTP.

Chapter 3 is a cost-benefit analysis that incorporates the additional costs attributed with vineyard scale treatment implementation. These values are ultimately compared to any significant change in consumer WTP imparted by the vineyard treatments on the resulting wines. This chapter answers the questions about treat viability and the potential benefits for Vancouver Island wine producers.

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2. Chapter 2:

The sensory and consumer impacts of leaf removal with Kaolin clay and cluster thinning on Vancouver Island Pinot gris wines

ROI from Vine-to-Wine: Evaluating the Impact of Leaf removal with Kaolin Clay and Cluster Thinning on Pinot gris using Rate-All-That-Apply Sensory Evaluations and Consumer Willingness-to-Pay Estimates

2.0 Abstract:

Cluster thinning, leaf removal and kaolin application are three commonly employed means of modifying fruit zone microclimates assumed to improve grape and wine quality. High labour costs in addition to the potential for location and varietal-specific responses make the benefits of these practices equivocal. To explore this question, I employed a stratified random block design in two British Columbia commercial vineyards where Pinot gris vines were manipulated prior to veraison with one of four experimental treatments: control, cluster thinning (CT) to one cluster per shoot, heavy leaf removal with a Kaolin clay application (HK), or a combined heavy leaf removal – cluster thinning - Kaolin treatment (HCK). Harvested fruit from each treatment were vinified separately under identical conditions to produce eight finished wines (four treatments x two vineyards). These wines were subjected to detailed sensory evaluations using a panel of 29 wine professionals via Rate-All-That-Apply (RATA) analysis to produce sensory profiles for each wine. Principal Components Analysis (PCA) and Hierarchical Cluster on Principal Components (HCPC) determined the significance of treatment on the sensory profile for each wine. Results indicate that sensory profiles were primarily driven by inherent difference between vineyard locations, and that treatment effects were only significant for HK and HCK wines for one

of two locations. HK wines from this vineyard demonstrated more complex and riper fruit attributes than the respective control wines, whereas HCK wines demonstrated potential faults.

To assess whether the vineyard manipulations were likely to affect consumer choice, the experimental wines were then assessed via a modified double-bound dichotomous choice contingent valuation (DB-CV) survey with a nested open-ended (OE) response, whereby 154 consumer tasters sampled 2 or 3 randomly chosen experimental wines to elicit a mean consumer Willingness to Pay (WTP) value. Regression modeling using both DB-CV and OE responses suggests that there is a significant difference at $\alpha = .05$ between vineyards, but that treatments did not impart any change in value compared to the respective control wines.

Despite apparent sensory implications for these costly vineyard treatments, the lack of any perceived added value suggests that both cluster thinning, and heavy leaf removal in conjunction with Kaolin clay application should only be implemented on an as needed basis, or for benefits beyond the scope of this research.

2.1 Introduction:

British Columbia (BC) has seen a significant growth in its wine industry over the past three decades, characterized by an increase in local production, wine

consumption, and regional tourism (WGBC, 2021). Today, BC's wine industry is valued at close to three billion dollars in total economic impact (Canada, 2018; Frank, Rimerman + Co. LLP, 2017), and continues to grow as favorable markets, improved techniques, and warming climates increase the suitability for regions historically limited by short growing seasons and mild summer temperatures (Frank, Rimerman + Co. LLP, 2017; Hannah et al., 2013).

In BC's coastal regions, such as Vancouver Island, European *vinifera* varieties can sometimes struggle to ripen. However, increasing market demand for these cultivars has driven increased plantings of Pinot gris, Pinot noir, and Chardonnay. To mitigate environmental challenges, vineyard managers utilize various techniques to reduce rot pressure, achieve vine balance, and optimize grape cluster microclimate. On Vancouver Island it is common for several strategies to be utilized simultaneously. The aim of these interventions is to improve the vine balance and ripeness of grapes, while incurring minimal cost to producers. While these techniques have been credited with driving steady improvement in the past decade, the benefits of these specific interventions on grape and wine quality remain assumed but untested.

The literature on viticultural management and its subsequent effects on grape quality and wine sensory characteristics is diverse and spans several decades (Condurso et al., 2016; Freeman & Kliewer, 1983; Noar et al., 2002; Ough & Nagaoka, 1984; Palliotti & Cartechini, 2000; Spayd et al., 1994); however, generalizations are difficult to find. Effect size often depends on a multitude of factors including varietal,

region, timing of intervention, and vintage (Condurso et al., 2016; Keller et al., 2005; Tardáguila et al., 2008), demonstrating the need for region and varietal specific research. Despite the lack of clear trends, strategies such as cluster thinning, basal leaf removal, and increasingly, Kaolin application, remain a staple in the viticulturalist's toolbelt, as they are thought to increase the rate of fruit ripening, and thus positively affect a wine's flavour profile and perceived quality. While the upside is an objectively better wine that can demand a higher price, these viticulture strategies are time and labour intensive. To be cost effective, such practices must yield a finished wine that commands a price sufficient to offset costs. To date, investigation into the sensory implications and subsequent return-on-investment (ROI) for these three viticulture practices has not been completed in BC.

Cluster thinning (CT) is the intentional removal of some grape clusters at an early developmental stage to alter the vine nutrient source-to-sink ratio, with the aim of improving the rate of fruit maturation and increase the soluble solids in the remaining grapes (Dami et al., 2006; Garrido et al., 2016). This may in turn improve the finished wine by altering its aroma and complexity of flavours (Reynolds et al., 2007a; Rutan et al., 2018). Wines produced from lower-yielding vines have frequently been rated as higher quality than those produced from higher-yielding vines (Avizcuri-Inac et al., 2013; Condurso et al., 2016; Dami et al. 2006); however, the efficacy of CT may depend on varietal, climate, soils, timing, and the intensity of intervention (Diago et al., 2010; Keller et al., 2005). In some instances, cluster thinning yields no significant effect on berry or

wine quality (Keller et al., 2005) leaving questions to its efficacy for unstudied regions and varieties.

Basal leaf removal (LR) is the removal of leaves from the fruit zone of a plant (Poni et al., 2006). LR is used to increase sunlight exposure on the fruit and ambient temperature in the fruit zone (Bledsoe et al., 1988; Cortell and Kennedy, 2006), subsequently leading to increased levels of total soluble solids (TSS) (Kemp, 2010), anthocyanins (Price et al., 1995; Tardáguila et al., 2010), decreased titratable acidity (TA) (Petrie et al., 2003), and a change in the volatile composition (Zoecklein et al., 1998) for various *vinifera*. When early leaf removal is applied to white varieties such as Chardonnay and Gewürztraminer, the resulting wines can demonstrate higher citrus, tropical, and floral qualities than the control wines (Reynolds et al., 2007b; Reynolds & Wardle, 1989). However, as with CT, the effects of LR on wine sensory attributes and quality in BC are equivocal.

Kaolin is an inert mineral with reflective properties in the ultraviolet and infrared radiation spectrum (Conde et al., 2018; Shellie & King, 2013). In wine regions with excessive temperatures and solar radiation, the application of Kaolin has been used to reduce the risk of fruit sunburn (Coniberti et al., 2013; Frioni et al., 2019). Another possible benefit of Kaolin is the potential to reduce mildew infection (Lamb et al., 2002; Reyad & Attia, 2016), a serious challenge faced by many grape growers on Vancouver Island. In this research, the decision to apply Kaolin in conjunction with LR was made to offset any potential negative effects of excessive cluster exposure from additional leaf

removal. Concurrent to the research presented here, we are investigating the effects of Kaolin on berry composition independent and in conjunction with leaf removal.

In this project we investigate the effects of LR in combination with Kaolin application (HK), CT, and a combined treatment (HK + CT [HCK]) as a means of changing the sensory profile and perceived quality of Vancouver Island Pinot gris from two commercial Cowichan Valley vineyards. To evaluate these wines, we used both expert and consumer wine tasters in sensory and economic assessments respectively. Using an iterative process, a vocabulary generation session informed the sensory evaluations, which in turn generated sensory profiles for each of the finished wines. Any perceived changes in the wines were then evaluated from a consumer standpoint to evaluate if the experimental treatments imparted a significant change in consumer value and preference.

2.2 Method:

2.2.1 *Vineyard Location and Study Design*

This study was conducted in two *Vitis vinifera* L. cv. Pinot gris vineyards located 11 km apart in the Cowichan Valley of Vancouver Island, British Columbia, Canada. Both vineyards are irrigated, have vines oriented north/south, and have similar planting densities, however the sites differed in bloc maturity as vineyard 1 (V1) and vineyard 2 (V2) had mean vine ages of 10 and 25 years respectively. The inclusion of multiple

locations permits identification of possible interactions between vineyard and treatment. To correlate these possible interactions, we collected climate data from both sites throughout the growing season (Appendix A; Figure 5.1).

Within each vineyard we used a stratified random design to assign one of four experimental conditions to a panel of vines: control group (i.e., conventional leaf thinning on only one side of the vine, no cluster thinning, and no Kaolin clay application), cluster thinning (CT) to one cluster per shoot, heavy leaf removal with a Kaolin Clay application (HK), or combined treatment of both (HCK). Each panel consisted of five or six vines (vineyard dependent), and each of the four treatments was replicated across five different panels yielding a total of 20 experimental panels per vineyard.

Treatments were conducted over the 2019 growing season. All treatments were applied after fruit set, prior to veraison when berries were roughly pea sized. Cluster thinning was completed down to one cluster per shoot. Kaolin Clay was applied at the fruit zone at the start of veraison and re-applied after each rain event throughout the growing season. Grapes were harvested in October of 2019, during which yield (kg) and botrytis occurrence were recorded (Appendix A; Tables 5.1 & 5.2).

2.2.2 *Wines*

At harvest, whole cluster fruit from each treatment was transported to the University of Victoria's research winery. Fruit from each vineyard and treatment remained separated from harvest to finished wine. A small subsample of 100 berries was haphazardly collected from each treatment for Brix and TA analysis (Appendix A; Tables 5.3 & 5.4). Fruit was manually crushed and destemmed, dosed with 30 mg/L sulphur dioxide (SO₂), and given cold soak (< 10°C) skin contact for 4 h. After cold soaking, grapes were transferred to a bladder press (Speidel 90-litre Hydraulic Press) for juice extraction at 300 KPa into 18.92 L (5 US gal) glass carboys, and sulphated up to 50mg SO₂/L. Each carboy was inoculated with 5g of Lalvin EC-1118 yeast (Lallemend, Montreal, QC), and 0.75 g/L of pectic enzyme. Fermentation was completed in a 16°C temperature-controlled space. After 6-7 days of fermentation, each wine was racked into 11.78 L (3 US gal) glass carboys and fermented until residual sugars were between 500 – 1000 mg/L. After fermentation was complete, the wine was racked a second time, and sulphated to 30 mg SO₂/L to prevent any further fermentation. Headspace was purged using food grade CO₂ to prevent oxidation. After 5 months aging at 16°C, the wine was racked a third time and cold stabilized at 4°C for 4 weeks, racked again, and like vineyard-treatment carboys were combined. Finally, the wines were filtered at 0.5 micron (Buon Vino Manufacturing Incorporated; #3 filter pads) before bottling. The wine was then stored in bottle for 6 – 11 months at ~ 16 °C prior to sensory and consumer analyses. The small sample of each wine was set aside for pH and TA analysis (Appendix A; Tables 5.5 & 5.6).

2.2.3 Sensory Evaluations – Vocabulary generation

Nine UVic wine students (4 male, 5 female) with experience in formal wine evaluation were recruited to generate a descriptive vocabulary for the experimental wines. The students tasted a total of 10 wines over two rounds (five same-vineyard wines per round, one wine per treatment plus a replicate). Modified Free-choice Profiling (Williams & Langron, 1984) and Projective Mapping (Risvik et al., 1994) methods were utilised for (dis)similarity term elicitation. Participants were given 40 mL of the first five wines each labelled with a random 3-digit code. All wines were served at 20°C. Participants were provided water and rice crackers to cleanse their palates between assessments.

For the first round of evaluation, the wines were evaluated from left-to-right. Participants were instructed to agitate the wine by swirling the glass for 3 seconds prior to aromatic assessment. Each participant would then generate a list of terms that described the aroma of the wine. The participants were then asked to taste the wine and add any additional descriptors to their list. This process was repeated for each wine, with a palate cleanse between each assessment.

After the participants had generated their list of terms, they were provided with a standard list of Pinot gris descriptors (Appendix A; Table 5.7), from which they selected terms they deemed equivalent to their own. This was done to standardise as many terms as possible while leaving room for unique descriptors.

To further condense the number of terms, a modified Projective Mapping method (Kemp et al., 2018; Risvik et al., 1994) was used to focus on sample (dis)similarity of within-vineyard wines. Participants were asked to evaluate the wines using the same aromatic and tasting technique described above, and to then orient the wines spatially on a blank A4 sheet of paper. Wines would be clustered or separated based on their relative (dis)similarity. Participants were then instructed to write descriptors next to each wine sample or group of samples, which they marked with the respective 3-digit code on the paper. The descriptors the panelists used were from their own list and explained the reason for their proximity. A minimum of five descriptors were required for each clustering of wines.

After completing the first round, the group was given a 20-minute break before repeating the elicitation process for the remaining five wines from the other vineyard. A total of 105 terms were generated by the nine participants. To reduce the number of terms we selected only terms that were cited five or more times (Kemp et al., 2018). This yielded 21 unique sensory descriptors that were used for the later sensory evaluations. Additionally, the Wine and Spirit Education Trust level 3 (WSET-3) evaluation protocols were included for assessing perceived acidity, sweetness, body, and length of finish (Table 2.1).

Table 2.1: Finalized list of 21 attribute descriptors used in Rate-All-That-Apply (RATA) sensory evaluation of Vancouver Island Pinot gris. Nose and Palate descriptors were derived using a combination of Free-choice profiling and Projective Mapping from a panel of nine semi-experienced wine tasters. Additional WSET-3 standards for acid, sweetness, body, and length of finish were added to the finalized list.

<i>Category</i>	<i>Rate-All-That-Apply (RATA) Terms</i>	<i>Scale</i>
Nose and Palate <i>(the same terms were used to assess both nose and palate of each wine)</i>	Apple	1 – 9 intensity scale
	Earth	
	Floral	
	Grapefruit	
	Herbs	
	Honey	
	Honeysuckle	
	Lemon	
	Lime	
	Mushroom	
	Musk/Barnyard	
	Pear	
	Saline /Brine	
	Slate/Stone/Gravel	
	Smoke	
	Spice	
	Stone Fruit	
	Tropical Fruit	
	Vegetal	
	Wet Dog	
	Yeast/Bread	
WSET palate	Acidity	WSET standardized scale
	Sweetness	
	Body	
	Length of Finish	

Sensory Evaluations – RATA

Sensory science relies on a highly calibrated panel of judges to produce reliable data; however, due to public health orders surrounding COVID-19, Descriptive Analysis (DA) and other conventional methods were not possible. Recent advances in rapid sensory profiling techniques offered an alternative approach that maintained high data

fidelity while abiding by public health protocols. These methods are increasingly popular due to being more easily understood, flexible and efficient relative to conventional alternatives (Danner et al., 2018). Rate-All-That-Apply (RATA) is an update of Check-All-That-Apply (CATA) that combines presence/absence response with perceived intensity scores (Ares et al., 2014) while leveraging untrained panelists to produce data congruent with DA sensory evaluations (Ares et al., 2014; Meyners et al., 2016).

The RATA method has demonstrated a high degree of discrimination and agreement with DA methods for commercial wines (Danner et al., 2018; Souza Gonzaga et al., 2020), but to our knowledge not been used to assess the effects of within vineyard experiments. This method was selected for its ability to extract quality data without requiring excessive training for participants (Meyners et al., 2016), and the potential for remote data collection.

A total of 29 wine professionals (14 female, 15 male) holding at least a WSET-3 certification or equivalent were recruited for sensory analysis of the experimental wines. Each panelist evaluated a total of 10 wines, 4 from each vineyard representing the treatments plus a single replicate from each vineyard. Sensory evaluations were conducted in 2020, amid the COVID-19 global pandemic. At that time, British Columbia regulations prohibited in-person research. Accordingly, we conducted sensory evaluations remotely. A 'sensory package' (Appendix B) was delivered to each panelist with the necessary equipment and instructions to complete a formal evaluation over supervised teleconference meetings (Zoom Video Communications, Inc). A total of 4

teleconferences were hosted over the course of 7 days in December of 2020. Each virtual session lasted approximately one hour, during which panelists were guided through evaluations.

Panelists were given 25 minutes to complete the assessment of the initial five wines. Wine was served at room temperature (~20°C) in ISO tasting glasses. Each wine was labeled with a unique 3-digit colour-coded identifier. Panelists were asked to consume water and neutral crackers between each wine.

Analyses followed the Rate-All-That-Apply (RATA) protocol described in Ares et al., 2014. The wine was agitated by swirling the glass for 3-seconds prior to aromatic assessment, followed by palate assessment. Panelists were asked only to select attributes from the provided list of terms (Table 2.1). The list order of sensory attributes presented to each taster were randomized to eliminate selection bias. After selecting an attribute, they were then required to rate the relative intensity of that attribute on a 9-point scale ranging from “low intensity” to “high intensity”. Attributes that were not selected were given scores of 0. Following completion of the first round of five wines, panelists were given a short break prior to repeating the process on the second flight of five wines.

2.2.4 Data analysis of RATA

Multivariate statistical methods were used to discriminate between the prescribed sensory profiles for each of the eight experimental wines. We first evaluated the performance of the sensory panel using duplicates, and later dimensional-reduction methods and cluster analysis to discriminate between the wines.

Data analysis was completed in R 4.0.3 (R Core Team, 2020), using the *SensoMineR* package (Husson et al., 2020) and the *FactoMineR* packages (Le et al., 2008). Analysis of Variance (ANOVA) was completed to assess the performance of the sensory panel and its panelists at $\alpha = .05$. Panelists were treated as a random effect and wines a fixed effect.

Principal Component Analysis (PCA) was applied to RATA data using all 42 sensory traits (combined nose and palate sensory data) and the additional WSET-3 standards across the eight experimental wines. A bootstrap analysis was completed using functions in *SensoMineR* (Husson et al., 2020) to generate 95% confidence ellipses around each experimental wine.

Hierarchical Clustering on Principle Components (HCPC) was completed to identify and group wines that were statistically alike relative to the rest of wines (i.e., organoleptically proximate).

2.2.5 Consumer Willingness-to-Pay (WTP):

We employed consumer tasters to equate treatment effect under natural conditions and predict the average consumer response. While expert tasters are used to explain how changes manifest in the wines, it is this corollary that substantiates their results by exploring preference and the economic impact of the experimental treatments for the average wine consumer. A total of 154 participants (96 females, 58 males) ranging in ages from 19 to over 75, were recruited, with 70 participants completing the survey in person and 84 remotely.

During live in-person consumer sampling (completed at a local winery in September 2020), 750 mL wine bottles were kept at $\sim 4^{\circ}\text{C}$ and participants received 30 mL of two blind, sequential wine samples presented in ISO tasting glasses. Consumer sampling was continued remotely when COVID-19 protocols precluded in-person sampling (January 2021). Participants were recruited using a snowball method and were given curated packages with all necessary materials to complete a web-based survey that replicated the in-person consumer survey experience. Participants were given detailed written instruction inclusive of sample storage, either two or three wine samples (~ 30 mL per sample) coded using the same 3-digit colour coding system utilised during sensory evaluations, a standard ISO tasting glass, and a quiz card which coded the randomized initial bid for each wine sample they had, and a link to the online survey (Appendix B, Figure 6.1).

Participants were asked to blindly evaluate wine samples in a manner which produced a WTP dollar amount. A double-bounded dichotomous choice contingent

valuation (DB-CV) model was selected for its efficacy in estimating consumer WTP for non-market goods (Hanemann et al., 1991). The method is an extension of the single bid approach devised to improve the statistical efficacy of contingent valuation (CV) surveys (Hanemann et al., 1991). This is done by asking a follow up question to the initial bid that is dependent on the response to the first bid. Despite several internal inconsistencies inherent in DB-CV design (Bateman et al., 2001), this remains a widely used method and has been used to estimate the value of differences in beer (Gabrielyan et al., 2014), wine (Holmquist et al., 2011), and craft cider (Tozer et al., 2015).

We utilised a modified version of the DB-CV survey outlined in Tozer et al., 2015 and Hanemann et al., 1991 coupled with an open-ended (OE) WTP value question. The survey was constructed and housed on SurveyMonkey (SurveyMonkey Inc.), and was conducted over the course of 6 months, and utilized by both in-person and remote participants.

The survey structure was the exact same for both in-person and remote consumer sampling. At the beginning of the survey, participants were asked a series of questions covering gender, age, income, education, drinking habits, and wine preferences (Table 2.2). Participants were then asked to select which wine (three-digit alphanumeric code) they would be evaluating and the assigned matching quiz code. After tasting the wine sample participants were taken through a modified DB-CV questionnaire aimed at eliciting their WTP for an equivalent 750 mL bottle of the

sampled wine. The tasting portion of the survey was repeated for each of the two or three wine samples a participant was given.

Table 2.2: Definitions and summary statistics of the demographic, consumption, and preference variables from consumer survey extracted from double bound dichotomous choice contingent valuation (DB-CV) survey. A total of 154 participants participated in the consumer survey to generate consumer willingness-to-pay (WTP) values for the eight experimental Pinot gris wines.

<i>Variable</i>	<i>Description</i>	<i>Percentage (%)</i>
Age (years)	19 to 24	9.09
	25 to 34	27.27
	35 to 44	8.44
	45 to 54	17.53
	55 to 64	24.68
	65 to 74	9.74
	75 or older	3.25
Gender	Male	37.66
	Female	62.34
Formal Wine Training	Yes	11.76
	No	88.24
Student	Yes	12.34
	No	87.66
Education (Highest level of education completed)	High School	12.99
	College Diploma	12.99
	Technical School	6.49
	Undergraduate Degree	42.21
	Advanced Degree	25.32
Household Income CA\$	\$0-\$24,999	7.14
	\$25,000-\$49,999	11.69
	\$50,000-\$74,999	16.88
	\$75,000-\$99,999	14.94
	\$100,000-\$124,999	18.18
	\$125,000-\$149,999	8.44
	\$150,000-\$174,999	7.14
	\$175,000-\$199,999	3.90
	\$200,000 and up	7.79
Prefer not to answer	3.90	
Drink Frequency (How often do you drink a glass of wine?)	Less than once a month	8.50
	Once a month	4.58
	A few times a month	15.69
	About once a week	23.53
	A few times a week	35.29
	Every day	12.42
Style (Preferred style of wine)	No preference	27.27
	Red	42.21

Table 2.2 (continued): Definitions and summary statistics of the demographic, consumption, and preference variables extracted from double bound dichotomous choice contingent valuation (DB-CV) survey. A total of 154 participants participated in the consumer survey to generate consumer willingness-to-pay (WTP) values for the eight experimental Pinot gris wines.

<i>Variable</i>	<i>Description</i>	<i>Percentage (%)</i>
Style <i>(Preferred style of wine)</i>	Rose	3.25
	White	27.27
Sweetness <i>(Preferred sweetness of wine)</i>	Don't know	3.25
	Dry	48.70
	Semi-dry/Semi-sweet	34.42
	Sweet	7.14
	No preference	6.49
Price <i>(typical price paid per 750 mL bottle)</i>	Less than \$10	2.60
	\$10 - \$20	54.55
	\$21 - \$30	38.31
	\$31 - \$40	2.60
	\$41 - \$50	1.30
	more than \$50	0.65
Region <i>(Where does most of your wine come from?)</i>	Australia	0.65
	Canada - British Columbia	46.10
	Canada - other	3.90
	Don't know	4.55
	Europe	25.32
	Other	3.25
	South America	5.84
	USA	10.39
Reason to buy <i>(How do you choose your wine?)</i>	Brand	1.95
	Label design	3.25
	Price	9.09
	Production location	19.48
	Taste/flavour	64.29
	Other	1.95

DB-CV creates four bins within which an individual's WTP can exist based on the participant's conditional response to the previously proposed bid. If the participant's response to this initial bid (B_0) was negative (i.e., would not pay that much), the participant is offered a lower bid (B_1). If the response to B_1 was also negative, then the respondent's WTP is bounded by the interval $(0, B_1)$. If the second lower bid was accepted, then the WTP bounded by the interval B_1 and B_0 . Conversely, a positive

response to the initial bid B_0 , leads to a second, higher bid (B_H). If the participant responds negatively to B_H , the WTP for that respondent is bounded by B_0 and B_H . Accepting the higher second bid (B_H) indicates the participant's WTP bounded by B_H with no upper limit bound.

The estimated WTP for an individual (Y_i) assessing a specific wine will fall within one of four possible cost intervals:

$$Y_i = \{ \begin{array}{l} 1 \text{ if } WTP_i < B_L \\ 2 \text{ if } B_L < WTP_i < B_0 \\ 3 \text{ if } B_0 < WTP_i < B_H \\ 4 \text{ if } WTP_i > B_H \end{array} \}$$

To elicit a stated WTP we followed DB-CV methods but expanded the survey to incorporate additional branching bid values, culminating in a question that explicitly asked for a stated WTP value after the final bid response was given. This framework combines dichotomous choice (DC) methods with open-ended (OE) methods to extract a continuous WTP value. The combined model was used to curtail so-called *protest zeros* and extremely high responses, as the OE value had to fall between the lower and upper bounds of the WTP bin that each participant finished in. Initial bids were randomized between the set values of \$12.99, \$16.99, and \$20.99 CAD. These values span the average wholesale price and the average retail price for BC VQA Pinot gris wine (750 mL) sold in British Columbia for 2019 (<http://www.bcliquorstores.com>). Contingent bid values spanned all possible lower and higher bids between \$8.99 –

\$24.99 CAD regardless of the initial bid. Each bid was made in \$4.00 increments, either higher or lower to the previous bid contingent on the participant's previous response. Responses could be as few as two (i.e., yes, no; no, yes) or as many as four (i.e., yes, yes, yes; no, no, no, no). All end points ($WTP_i < \$8.99$ up to $WTP_i > \$24.99$, in \$4.00 increments) could be reached regardless of the initial bid randomly offered to the participant.

In this model, WTP of an individual assessing a specific wine can be give as:

$$Y_i = \left\{ \begin{array}{l} 1 \text{ if } WTP_i < \$8.99 \\ 2 \text{ if } \$8.99 < WTP_i < \$12.99 \\ 3 \text{ if } \$12.99 < WTP_i < \$16.99 \\ 4 \text{ if } \$16.99 < WTP_i < \$20.99 \\ 5 \text{ if } \$20.99 < WTP_i < \$24.99 \\ 6 \text{ if } WTP_i > \$24.99 \end{array} \right\}$$

To evaluate WTP through DB-CV statistical methods, only the first two responses from each participant (i.e., yes, no; no, yes; etc.) were used. The expanded OE framework was used to elicit a continuous WTP value for each wine, allowing us to assess the treatment effect on WTP using simple regression models. While participants could state OE WTP values of less than \$5.99, the rare occurrences of prices below this amount were deemed equivalent to this value as it represented the lowest price for a commercially available wine in British Columbia at the time of data collection (<http://www.bcliquorstores.com>). As such, \$5.99 was used as the lower limit of possible OE WTP values to avoid zero inflation.

2.2.6 Data Analysis of Consumer Willingness-to-Pay

To estimate WTP using the CV method, we used a double-bound dichotomous choice model described in Aizaki et al. (2014), Hanemann et al. (1991), and Lopez-Feldman (2012). The model was selected for its ability to predict consumer WTP for nonmarket goods. The estimates were produced using the functions from the *DCchoice* package (v0.0.17; Nakatani et. al., 2020) in R 4.0.3 (R Core Team, 2020). 95% confidence intervals for WTP were calculated using the Krinsky and Robb simulation method (Krinsky and Robb, 1986).

Linear models were constructed with the OE WTP values using functions from the *stats* package in R 4.0.3 (R Core Team, 2020). Significance was evaluated at alpha = .05. The model examined elicited consumer WTP as a function of treatment, vineyard, and an interaction term. To assess the significance of anchoring effects, linear regression models were constructed at the vineyard level to compare the effect of initial bid on final WTP values.

2.3 Results:

2.3.1 *Sensory Analysis*

The trained panelists failed to differentiate any acid, sweetness, body, and length of finish differences among the wines using the WSET protocol, and therefore these attributes were removed from subsequent analysis. Only sensory descriptors for both the nose (.n) and palate (.p) were used in the final analysis.

Assessment of reliability among of the expert panelists revealed participants were inconsistent in evaluating attribute intensity (Appendix A, Tables 5.8 & 5.9). Despite the likely reduction of differentiating power, significant sensory differences are observed at both the vineyard and treatment levels.

2.3.1.1 *Principal Component Analysis using RATA sensory data*

RATA data were analyzed using PCA. This method ordinated all 42 sensory attributes based on their correlated intensity and compressed the data to seven dimensions (Figure 2.1). In turn, the wines were projected along these compressed dimensions based on their respective sensory data allowing for further relational analysis (Figure 2.2). Full results from PCA analyses are presented in Appendix A; Table 5.10.

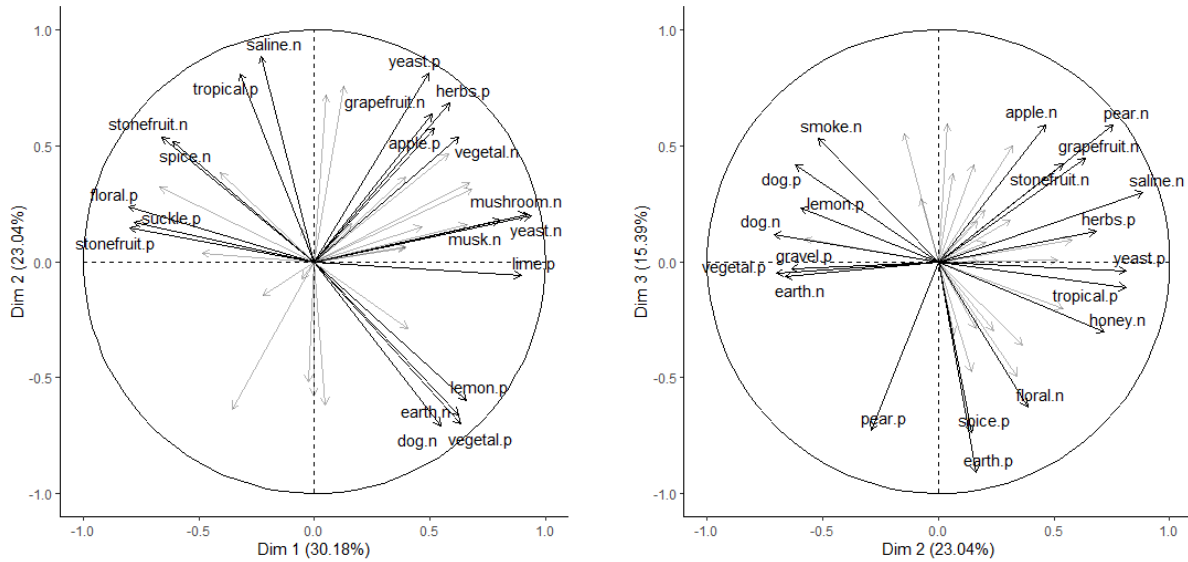


Figure 2.1: Principal components analysis (PCA) of the 20 most significant sensory attributes ascribed to the eight experimental Pinot gris wines. Wines were evaluated using the Rate-All-That-Applies sensory technique and a panel of expert tasters. Left figure shows the significant sensory attributes across dimensions 1 and 2 (Dim 1, Dim 2); the right figure shows attributes across along dimensions 2 and 3 (Dim 2, Dim 3). Data indicate an element of fruit ripeness that increases from right to left along dimension 1 of the PCA.

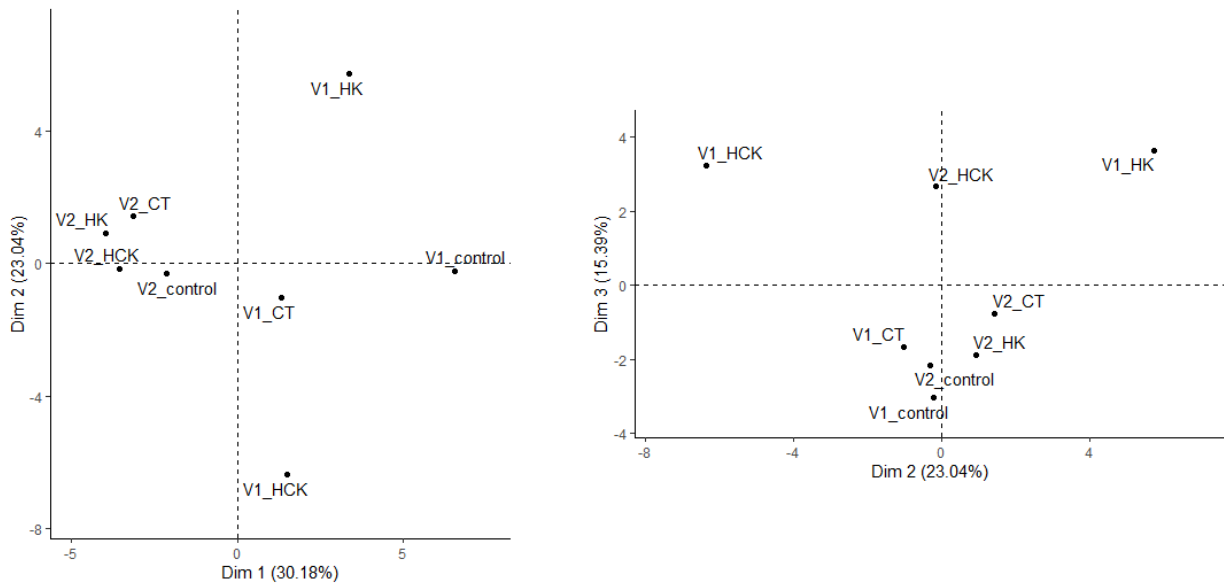


Figure 2.2: Principal components analysis (PCA) of the eight experimental Pinot gris wines. Wines were evaluated using the RATA sensory technique and a panel of expert tasters. Left figure shows the organoleptic (dis)similarity using dimensions 1 and 2 (Dim 1, Dim 2); the right figure using dimensions 2 and 3 (Dim 2, Dim 3). Wines are coded by Vineyard site (i.e., V1 or V2) and the relevant treatment (i.e., control, CT, HK, or HCK). Trends show that wines are separated along Dim 1 by vineyard, indicating that they can be differentiated at the vineyard level. Data also suggests that there is more variation among wines produced from V1 relative to V2.

Dimension 1 of the PCA describes the degree of fruit ripeness and savouriness in the wines (Figure 2.1). Wines that occupy the positive space along this axis demonstrate more citrus and herbaceous attributes, whereas wines in the negative space are described by ripe fruit attributes. Dimension 2 separates wines based on presence of tropical notes (+), or potential faults (-), and dimension 3 further distinguishes wines on the relative intensity of three less prescriptive sensory attributes.

After overlaying the eight wines on the PCA, the data suggest that wines for V2 are more similar than V1 wines (Figure 2.2). This also reveals a noticeable vineyard effect due to the separation of wines along dimension 1 (Figure 2.2). The results of the subsequent bootstrap analysis (Figure 2.3) further underscore the vineyard effect due to a lack of vineyard overlap even after simulated resampling. At V1 there is clear and significant dissimilarity among all wines along dimensions 1 and 2, with a marginal overlap of V1 CT wine and the larger clustering of wines from V2. These results suggest the magnitude of treatment effect is largely vineyard specific.

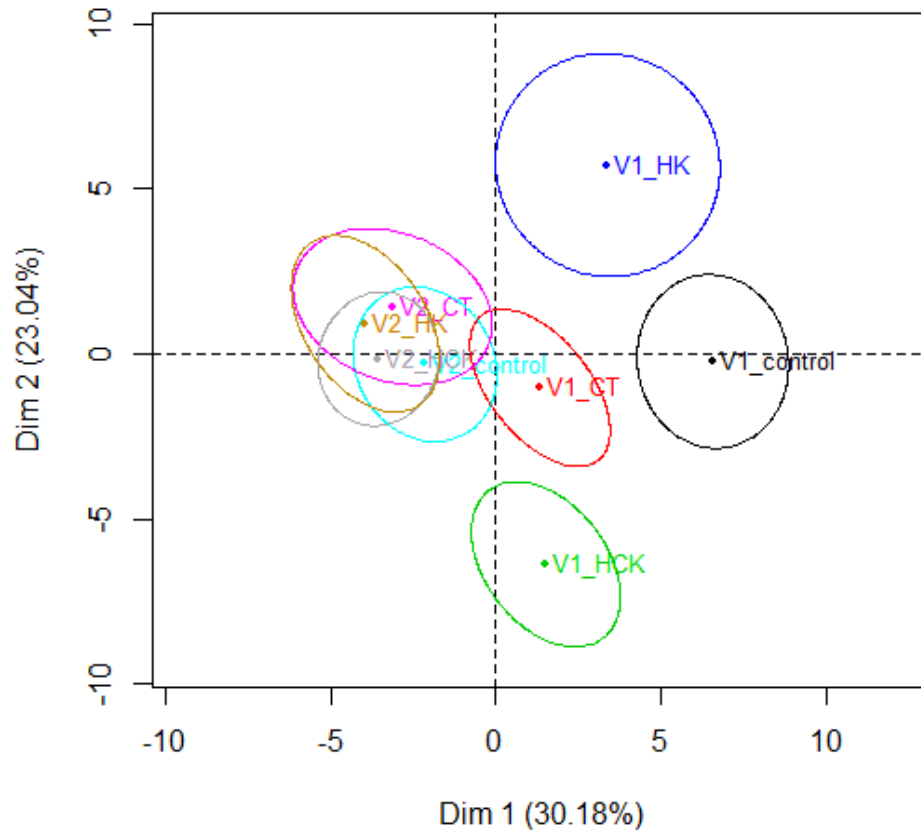


Figure 2.3: Principal component analysis (PCA) with bootstrap generated 95% confidence ellipses for all eight experimental Pinot gris wines evaluated using the Rate-All-That-Apply (RATA) sensory technique and a panel of expert tasters. Outputs are shown across dimensions 1 and 2 (Dim1, Dim 2). Wines are coded by Vineyard site (i.e., V1 or V2) and the relevant treatment (i.e., control, CT, HK, or HCK). There is substantial overlap in wines from V2, but clear differentiation between all wines at V1, indicating the likelihood of a vineyard and treatment interaction effect on the perceived sensory attributes.

2.3.1.2 Hierarchical Clustering on Principal Components using RATA sensory data

To group the wines based on their relative sensory proximities, HCPC was completed using the default slicing point to generate four unique clusters (Figure 2.4). Attribute significance was calculated using a v.test based on the hypergeometric distribution of attributes. The test compares the proportion of ascribed sensory attributes

in a cluster to the proportion in the population. Significant attributes of each cluster are summarised in Table 2.3.

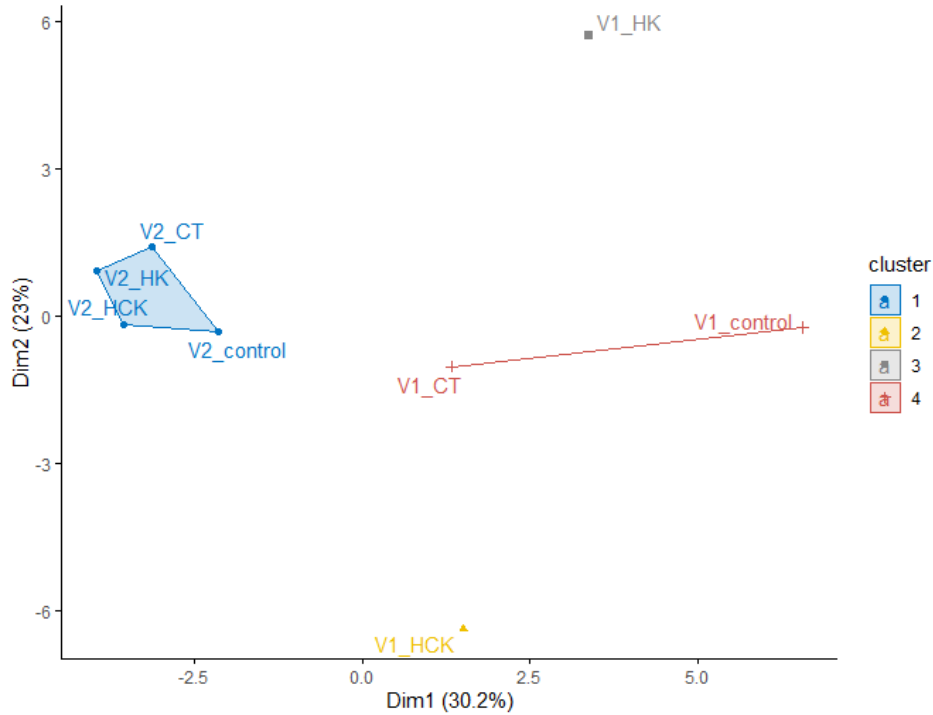


Figure 2.4: Hierarchical Clustering on Principal Components (HCPC) using Rate-All-That-Apply (RATA) sensory data for the eight experimental Pinot gris wines. Analysis generated 4 unique clusters displayed across dimensions 1 and 2 (Dim1, Dim2). Wines are coded by Vineyard site (i.e., V1 or V2) and the relevant treatment (i.e., control, CT, HK, or HCK). V2 wines are grouped into a single cluster suggesting that that treatment bore no effect on the sensory attributes of these wines. Contrasting, V1 wines are grouped into three unique clusters. These results indicate an apparent vineyard and treatment interaction on the perceived sensory attributes.

Table 2.3: Summary of significant sensory attributes and their influence on clusters generated from Hierarchical Clustering on Principal Components (HCPC) using Rate-All-That-Apply (RATA) sensory data for the eight experimental Pinot gris wines. V.test values greater than 1.96 correspond to a p-value less than $\alpha = .05$; the sign (+/-) indicates if the mean of the cluster is lower (-) or greater (+) than the overall mean.

Cluster	Sensory Attribute	v.test	p.value
1	<i>stonefruit.p</i>	2.03	0.04
	<i>floral.p</i>	1.96	0.05
	<i>lemon.p</i>	-2.02	0.04
	<i>yeast.n</i>	-2.13	0.03
	<i>lime.p</i>	-2.30	0.02
2	<i>dog.n</i>	2.22	0.03
	<i>smoke.n</i>	2.04	0.04
3	<i>grapefruit.n</i>	2.47	0.01
	<i>herbs.p</i>	2.21	0.03
	<i>pear.n</i>	2.19	0.03
	<i>yeast.p</i>	2.10	0.04
	<i>apple.n</i>	2.09	0.04
	<i>saline.n</i>	2.04	0.04
4	<i>lime.n</i>	2.16	0.03
	<i>lemon.n</i>	2.15	0.03
	<i>pear.p</i>	2.13	0.03
	<i>suckle.p</i>	-2.08	0.04

Cluster 1, composed solely of V2 wines, is positively associated with stone fruit and floral attributes, and demonstrates less lemon, lime, and yeast attributes. This suggests that wines from V2 are riper than the wines from V1. Cluster 2, defined by the V1 HCK wine, is associated with *wet dog* and *smoke* odorants, suggesting that a fault may have occurred during the winemaking process. Cluster 3, defined by the V1 HK wine, is associated with grapefruit, pear, apple, and saline odorants, as well as herbs and yeast on the palate. This is distinguished from cluster 4 (comprised of the V1 control and CT wines) which demonstrates stronger citrus attributes.

2.3.2 *Economic Assessment and Willingness-to-Pay (WTP)*

2.3.2.1 *Double-Bound Dichotomous Choice Contingent Valuation (DB-CV) WTP*

To reduce bias in the DB-CV model, some demographic and wine preference categories were modified. Average price paid per 750 mL bottle was reduced to a binary bin ($x \leq \$20$; $x > \$20$), the 'Australia' region was merged with 'Other', and the 'Brand' choice category was merged with 'Other' (Table 2.2).

At the global level the most significant demographic/preference variables driving WTP were age, highest level of education, purchase region, and reason to buy (Table 2.4). A correlation matrix comparing the ordinated variables (i.e., Age, Household Income, Highest level of education, and Drink frequency) shows that an increase in consumer age has a modest negative effect on WTP (Appendix A; Table 5.11). There was no significant treatment effect detected, but a vineyard effect is noted. The significant quiz effect indicates that the initial bid may influence final consumer WTP, the extent of which is investigated using OE WTP values below.

Table 2.4: Double bound dichotomous choice contingent valuation (DB-CV) global regression model outputs for all eight experimental *Pinot gris* wines. No significant treatment effect is evidenced; however, an apparent vineyard effect is observed. Several demographic factors demonstrate a significant effect on the global estimate, suggesting factors other treatment were more important in determining average Willingness-to-Pay (WTP).

Coefficients	Estimate	Std. Error
Treatment: Control (<i>intercept</i>)	11.08 ^{***1}	1.18
Treatment: HCK	- 0.14	0.29
Treatment: HK	- 0.10	0.29
Treatment: CT	- 0.14	0.29
Vineyard (2)	0.60 ^{**}	0.21
Formal Training (Yes)	- 0.06	0.37
Drink Frequency	0.07	0.09
Student (Yes)	- 0.60	0.39
Age	- 0.28 ^{***}	0.08
Highest Education	- 0.21 ^{**}	0.08
Sweetness	- 0.20.	0.12
Avg. purchase region	0.15 ^{**}	0.05
Avg. price paid/bottle	0.02	0.21
Reason to buy	0.16 [*]	0.07
Income	0.02	0.05
Gender (male)	0.34	0.22
Log of initial bid value	- 4.22 ^{***}	0.28
Mean WTP (CA \$)	15.30	
Truncated Mean WTP (CA \$)	14.67	
Median WTP (CA \$)	13.93	

¹ ^{***}, ^{**}, ^{*} significantly different from zero at $p < 0.01$, 0.05 , and 0.10 , respectively

To estimate mean consumer WTP for each of the wines, the global model was re-run for each of experimental wines without the vineyard, treatment, wine training, drink frequency, and student terms (Tables 2.5 & 2.6; 95% confidence intervals [CI] presented in Appendix A; Table 5.12). Mean WTP for V1 ranged from \$13.11 - \$14.90 per 750 mL bottle, and from \$14.70 - \$17.30 per 750 mL bottle for V2. The eight separate models revealed no discernable trends nor any consistent treatments effect across vineyards. These results are consistent with the global model estimates indicating that the most significant drivers of consumer WTP does not include treatment.

Table 2.5: Double bound dichotomous choice contingent valuation (DB-CV) regression model outputs for the four experimental *Pinot gris* wines from vineyard 1. Models estimate the mean consumer Willingness-to-Pay (WTP) value for each wine as a function of treatment, bid and demographic factors.

Coefficients	Control		CT		HK		HCK	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
(Intercept)	9.00 ^{*1}	3.74	15.25 ^{***}	3.53	10.48 ^{**}	3.87	6.83 [*]	2.90
Age	0.25	0.24	0.08	0.22	0.14	0.23	- 0.08	0.25
Highest Education	0.03	0.24	- 0.43	0.30	- 0.65 [*]	0.27	- 0.24	0.27
Sweetness	0.08	0.37	- 0.25	0.30	- 0.04	0.42	0.06	0.31
Avg. purchase region	0.42 [*]	0.18	- 0.02	0.14	0.3	0.18	0.39 [*]	0.18
Avg. price paid/bottle	0.44	0.68	0.23	0.70	1.51	0.81	0.52	0.62
Reason to buy	0.33	0.24	0.30	0.24	0.13	0.29	0.16	0.19
Income	- 0.10	0.18	- 0.05	0.15	0.02	0.14	-0.01	0.16
Gender (male)	- 0.10	0.70	- 0.62	0.69	- 0.47	0.76	0.01	0.65
Log of initial bid value	- 5.65 ^{***}	1.16	- 5.52 ^{***}	1.00	- 5.23 ^{***}	1.04	- 3.81 ^{***}	0.72
Mean WTP (CA \$)	13.79		14.89		13.11		13.66	
Truncated Mean WTP (CA \$)	13.49		14.66		12.81		13.11	
Median WTP (CA \$)	13.09		14.10		12.33		12.17	

¹ ^{***}, ^{**}, ^{*} significantly different from zero at $p < 0.01$, 0.05 , and 0.10 , respectively

Table 2.6: Double bound dichotomous choice contingent valuation (DB-CV) regression model outputs for the four experimental *Pinot gris* wines from vineyard 2. Models estimate the mean consumer Willingness-to-Pay (WTP) value for each wine as a function of treatment, bid and demographic factors.

Coefficients	Control		CT		HK		HCK	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
(Intercept)	20.17 ^{***1}	5.20	5.75	3.05	17.44 ^{***}	4.06	15.19 ^{***}	3.64
Age	- 0.79 ^{**}	0.25	- 0.54 [*]	0.23	- 0.58 [*]	0.27	- 0.39.	0.23
Highest Education	- 0.32	0.22	0.81 [*]	0.34	- 0.20	0.28	- 0.47 [*]	0.22
Sweetness	- 1.36 [*]	0.64	0.01	0.34	- 0.79	0.54	- 0.54	0.38
Avg. purchase region	0.32	0.18	0.21	0.14	- 0.01	0.17	0.47 [*]	0.24
Avg. price paid/bottle	- 0.29	0.66	0.00	0.63	- 0.48	0.64	- 1.20.	0.69
Reason to buy	0.56 [*]	0.26	0.19	0.20	0.18	0.22	0.40.	0.24
Income	0.20	0.14	- 0.14	0.12	0.15	0.15	0.41 [*]	0.18
Gender (male)	0.99	0.65	0.92	0.62	0.40	0.62	- 0.04	0.72
Log of initial bid value	- 6.65 ^{***}	1.41	- 3.51 ^{***}	0.66	- 4.92 ^{***}	0.81	- 5.893 ^{***}	1.07
Mean WTP (CA \$)	16.43		14.70		17.30		15.35	
Truncated Mean WTP (CA \$)	16.22		13.79		16.59		15.14	
Median WTP (CA \$)	15.82		12.82		16.15		14.64	

¹ ^{***}, ^{**}, ^{*} significantly different from zero at $p < 0.01$, 0.05 , and 0.10 , respectively

2.3.2.2 Open-Ended (OE) WTP

As with the global DB-CV model, there was no significant treatment effect detected from OE regression models. On average V2 wines yielded a higher WTP value than V1 wines (Table 2.7). Despite OE models consistently producing lower value estimates than DB-CV outputs, a similar pattern emerges, whereby the notable difference in consumer WTP is driven by a vineyard effect.

Table 2.7: Three regression model outputs using open-ended (OE) elicited values to estimate consumer WTP values for the eight experimental *Pinot gris* wines. A significant vineyard effect is noted; however, no significant change in values were attributed to vineyard treatments.

Coefficients	Full Model		V1 Model		V2 Model	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Treatment: Control (Intercept)	11.44 ^{***1}	0.81	11.44 ^{***}	0.73	13.86 ^{***}	0.84
Treatment: HCK	1.14	1.15	1.15	1.03	0.32	1.22
Treatment: HK	0.36	1.14	0.36	1.03	1.09	1.21
Treatment: CT	0.76	1.15	0.76	1.03	- 0.91	1.16
Vineyard (2)	2.42 ^{**}	1.12	-	-	-	-
Treatment HCK: Vineyard (2)	- 0.83	1.61	-	-	-	-
Treatment HK: Vineyard (2)	0.73	1.60	-	-	-	-
Treatment CT: Vineyard (2)	- 1.67	1.57	-	-	-	-

¹ ^{***}, ^{**}, ^{*} significantly different from zero at $p < 0.01$, 0.05 , and 0.10 , respectively

2.3.3 Anchoring Bias

The quiz effect suggested by the analysis of DB-CV models above (Tables 2.4 – 2.6) prompted an explicit test of anchoring bias on final consumer WTP (Figure 2.5). This was assessed using a simple linear regression comparing OE estimates across the three initial bid values for the wines from both vineyards (Table 2.8). Results indicate that being presented with the highest initial bid (\$20.99) had a significant effect on increasing the final consumer WTP value regardless of the wine presented to the participant. This effect was observed across both vineyards. On average, being presented with the highest initial bid increased consumer WTP by over \$2.00 when compared to the estimates generated from the lowest initial bid value (\$12.99). Notably, the effect size was comparable to the observed vineyard effect, suggesting that both factors were among the largest drivers of consumer WTP, and not treatment.

Table 2.8: Regression model estimates comparing quiz effect (anchoring bias) on open-ended (OE) consumer willingness-to-pay (WTP) estimates across vineyards 1 (V1) and 2 (V2). Estimated WTP increases across the three different initial bid values (A = \$12.99, B = \$16.99, C = \$20.99) indicating that being presented with a higher initial bid will increase the final consumer WTP.

Coefficients	V1		V2	
	Estimate	Std. Error	Estimate	Std. Error
Quiz A (<i>intercept</i>)	10.97 ^{***1}	0.62	12.85 ^{***}	0.73
Quiz B	0.91	0.88	0.85	1.02
Quiz C	2.18 ^{**}	0.87	2.41 ^{**}	1.04

¹ ^{***}, ^{**}, ^{*} significantly different from zero at $p < 0.01$, 0.05 , and 0.10 , respectively

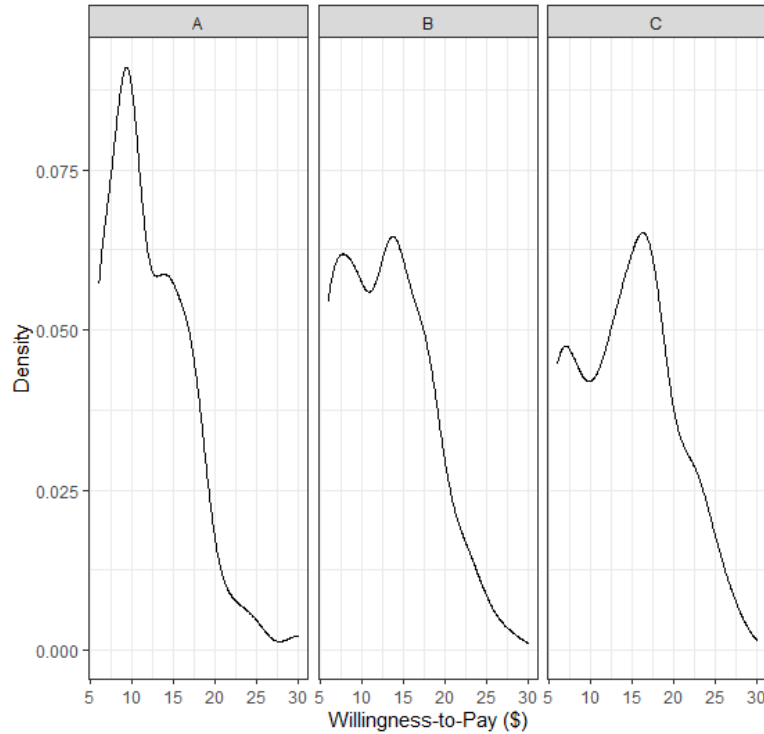


Figure 2.5: Density plot highlighting the observed phenomenon of anchoring bias in consumer survey responses using open-ended (OE) willingness-to-pay (WTP) values. WTP represent the maximum price a consumer would pay for an equivalent 750 mL bottle of the experimental Pinot gris wine. Peak density for OE WTP increases across the three different initial bid values (A = \$12.99, B = \$16.99, C = \$20.99) indicating that a higher initial bid will increase the final consumer WTP.

2.4 Discussion:

2.4.1 Sensory

HCPC suggests that the primary difference between experimental wines stems from a vineyard effect rather than the assigned treatments. V2 is differentiated from V1 by sensory attributes typically associated with warmer climates and riper fruit. This pattern is corroborated by weather and harvest data from V2, which despite its proximity to V1, had a warmer growing season and lower yields than V1 (Appendix A; Figure 5.1

& Table 5.1). While we do consider these extrinsic factors to be the primary drivers of sensory differentiation, they also indicate that there is a potential relationship between fruit ripeness and treatment effect.

If the end goal is to create riper fruit, yielding more complex wines, then V2 represents the ideal growing conditions for this style of wine. Under these conditions we can conclude that our vineyard treatments are not effective in changing the fundamental sensory attributes of the wines. Conversely, V1 produced wines that were less complex under control conditions but were more readily discriminated by treatment. These results suggest that under more challenging growing conditions these treatments may be effective at creating wines with more complex and ripe fruit attributes. The remainder of this portion of the discussion only focuses on the effects of treatment and sensory attributes for wines from V1, as there was no differentiation between the wines from V2.

Heavy leaf removal and Kaolin clay had a significant effect on both the nose and the palate of the finished wine. The wines demonstrated more complex qualities than the control wines, deviating from simple citrus notes to include attributes such as pear, saline, and apple. This indicates that heavy leaf removal and kaolin clay shifted the profile of the resulting wines towards traditionally riper characteristics. This is congruent with results from both Reynolds et al., (2007b) and Reynolds and Wardle, (1989). A detailed chemical analysis of the harvested fruit is recommended to assess if the fruit grown under this treatment was measurably riper than our control fruit.

Interestingly, CT alone seems to have had no significant effect on the perceived sensory attributes at either vineyard; however, while not significant, the observed effect is demonstrably greater at V1. Despite hierarchical clustering grouping CT wines with our control wines, it is differentiated by the bootstrap CIs along the first two dimensions of the PCA. In this case, the process of calibrating the tasting panel may have granted more discriminatory power between the control and CT wines. Despite the lack of significant differentiation, CT wines from V1 were more similar in their sensory profile to the average V2 wine than the control wine was. To better understand this observation and to parse any potential significance, we recommend further research with a more calibrated sensory panel for wines made from grapes grown under CT conditions.

An important caveat not investigated here is the fact that V2 had recently converted from conventional to organic practices. While the sensory effects of organic farming are not consistent across locations or products (Bourn & Prescott, 2002; Brazinskiene et al., 2014; Dupin et al., 2000; Martin & Rasmussen, 2011) it is constantly associated with lower yields compared to conventional farming practices (de Ponti et al., 2012; Seufert et al., 2012). When we consider that the goal of CT is to intentionally reduce the yield per vine, the effects of organic management may undermine the effect of this treatment. Because of this, it difficult to attribute the sensory clustering of V2 simply to its microclimate without considering the potential interaction effects of organic farming and its tendency to reduce yield.

The results from the reliability ANOVAs (Appendix A; Tables 5.8 & 5.9) suggest a general lack of calibration for the panel of experienced tasters. This result is not surprising given that no training sessions were conducted prior to formal analysis; however, tasters were able to significantly distinguish between vineyard sites, and between treatments at V1. The likely diminished discriminatory power makes this a conservative assay and therefore suggests the observed differences between wines are real. Any calibration would only increase the magnitude and significance of these differences.

2.4.2 *WTP*

Both DB-CV and OE regression models suggest that treatment had no effect on consumer WTP; however, both methods revealed significant differences at the vineyard level. Considering the lack of a clear sensory difference for wines at V2, it was expected that consumer tasters would not find a significant difference in preference or value added for these same wines. Despite this, the observed increase in mean WTP for V2 wines does indicate that the more complex and riper sensory attributes are valued at a higher price point over the simpler sensory attributes of V1 wines.

It is worth noting that while the same patterns and conclusions can be made from both methods of analysis (DB-CV and OE regression), there is a clear difference in WTP estimates between the two approaches. DB-CV produced mean WTP estimates that are on average \$2.02 higher than OE regression models. However, this pattern has

generally been observed when comparing continuous (i.e., OE) and discrete (i.e., CV) WTP estimates for the same goods (Ready et al., 1996) and should not detract from our conclusions.

Perhaps unsurprisingly, there is evidence to suggest that initial bid value does influence final consumer WTP. This phenomenon is referred to as anchoring bias (Bateman et al., 2001; Herriges and Shogren, 1996). On average, higher initial bids resulted in higher maximum WTP regardless of what wine was presented to the respondent. The pattern of anchoring bias holds between both analysis techniques, which may suggest poor bid design. Unfortunately, sample sizes for each quiz, vineyard, and treatment combination were not significant enough to reliably study the interactive effect between quiz and treatment on WTP estimates. Further research should be conducted to better understand these effects with a larger sample size in each category. An anchoring effect may also arise when respondents are asked to elicit several WTP values in a single session (Longo et al., 2015; Payne et al., 2000). Self-anchoring may occur subconsciously given the tendency for respondents to rely on their previous answers. To investigate this effect, order of evaluation could be considered in regression modeling (Champonnois et al., 2018); however, we believe that adequate steps were taken to reduce this source of bias by randomizing sample order at the respondent level.

2.4.3 Things to consider

While results from sensory and preference analysis indicate marginal changes to wine profile and negligible improvements in consumer valuation, harvest data does suggest a potential benefit from heavy leaf removal in conjunction with Kaolin clay application as a means of reducing rot occurrence. These results were nearly equivalent between vineyards, despite difference in growing conditions between vineyard sites. LR treatments (i.e., HCK and HK) drastically reduced superficial botrytis occurrences by as much as 65%. These data are in line with results from similar studies (English et al., 1989; Mosetti et al., 2016; Percival et al., 1994; Wolkovich et al., 2013) and indicate that this treatment is effective at protecting fruit at rot sensitive vineyards. Given the apparent difference in efficacy between locations, we recommend further research be conducted across multiple regional vineyards, over several years, alongside a detailed cost-benefit analysis to evaluate return-on-investment at a commercial level. Despite some data gaps we cautiously suggest the use of heavy fruit zone LR and regular Kaolin clay application as a means of increasing usable fruit yields without negatively affecting the sensory profile or the perceived value of the resulting wines.

The full treatment (HCK) appeared to have a negative effect on the finished wines, as it was significantly differentiated solely based on the presence of an apparent dog and smoke smell. However, the nature of these attributes indicate that spoilage may have occurred during the wine making process, as they are typically associated with wine faults. Unfortunately, these attributes likely mask any actual differences in the wine, leading us to recommend a re-evaluation of this treatment in which there are stronger controls for external contamination and spoilage.

2.5 Conclusions:

Sensory differences were significant at V1, but equivocal at V2. This suggests that *in situ* vineyard treatments are effective at changing the character of the resulting wines when growing conditions are less than optimal. However, the lack of increase in consumer WTP indicates that these costly management strategies should only be adopted on an as needed basis and not as a means of improving a wine quality.

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3. Chapter 3:

Cost-benefit evaluation of leaf removal and cluster thinning
as viable management practices for Vancouver Island Pinot
gris

3.1 Introduction

In British Columbia's (BC) coastal regions, such as Vancouver Island, traditional *vinifera* varieties can sometimes struggle to ripen. However, increasing market demand for these cultivars has driven increased plantings of Pinot gris, Pinot noir, and Chardonnay. To mitigate environmental challenges, vineyard managers utilize various techniques sympatrically to reduce rot pressure, achieve vine balance, and optimize the grape cluster microclimate. While these techniques have been credited with driving the steady improvement of regional wines over the past decade, the benefits of these interventions remain assumed but untested.

Strategies such as cluster thinning, basal leaf removal, and increasingly, Kaolin application, are generally thought to positively affect a wine's flavour profile and perceived quality. While the upside is an objectively better wine that can demand a higher price, these viticulture strategies are time and labour intensive. To be cost effective, such practices must demonstrate sufficient and quantifiable added value to offset their otherwise prohibitive costs. To date, an investigation into return-on-investment (ROI) for these three viticulture practices has not been completed in BC.

This brief chapter builds on the results of the previous and evaluates the realized financial implications that each experimental treatment incurs. The treatments of interest are cluster thinning (CT) to one cluster per shoot, heavy leaf removal from the fruit zone in conjunction with Kaolin clay application (HK), and a combined treatment (HCK). Here

the additional labour and material costs are combined with any significant changes in yield associated with each treatment to evaluate the distilled per tonne and per bottle costs of industrial implementation. Since the consumer evaluations did not reveal any significant changes to the perceived value under any treatment condition, the analysis does not account for any potential changes in wine quality.

In this scenario, a simple cost-benefit analysis is completed for each wine and scaled to account for the possibility of practical application.

3.2 Method:

To assess the suitability of implementing our treatments at a practical scale, we must consider the associated costs and benefits for each. To effectively do so, we must compare net returns (i.e., gross revenue minus the variable costs of production) with and without treatment. Preszler et al., (2010) presented a financial model to evaluate the economic suitability of CT designed to give growers the ability to calculate their optimal yields and prices. This model is designed to influence key management decisions ahead of their implementation, but it can also be easily modified to account for the realized changes in yield and cost post harvest. The production and cost parameters of these realized changes are summarized in Table 3.1. By simplifying the Preszler et al., model we are left with the following equation:

$$P_x = (P_o * Q_o + B_x) / Q_x$$

Table 3.1: Summary of model variables used in cost-benefit analysis to evaluate the return-on-investment for heavy leaf removal and Kaolin clay, cluster thinning, and a combination treatment. Cost-benefit was completed to evaluate these treatments as viable management strategies for Vancouver Island Pinot gris.

Model	Units	Value	Description
P_x	CA \$/tonne	calculated	Min. price needed for treatment x (<i>i.e.</i> , CT, HK, HCK)
P_o	CA \$/tonne	2000	Grape price under control conditions
Q_o	tonnes/acre	measured	Grape yield under control conditions
B_x	CA \$/acre	estimated	Variable cost for treatment x (<i>i.e.</i> , CT, HK, HCK)
Q_x	tonnes/acre	measured	Grape yield under treatment x (<i>i.e.</i> , CT, HK, HCK)

Using the above equation, we can input the relevant changes on a per treatment and per vineyard basis to estimate the market price required for producers to break even under a given set of conditions. In other words, we can calculate how much a producer would need to charge per tonne of grapes, and per bottle, to recover the added costs for each treatment.

3.3 Assumptions and Variable Costs

By relaxing the statistical thresholds to $\alpha = .10$ it allows for a more conservative estimate of the economic impacts of treatment. This modest increase helps to address the inherently lower yields at vineyard 2 (V2) (Appendix A; Table 5.1) while simultaneously capturing the potential benefit of botrytis reduction (Appendix A; Table 5.2). Given the extent of botrytis reduction observed under all leaf removal and Kaolin treatments (*i.e.*, HK, HCK), the affect was included in the yield calculation (Q_x). This assumes that winemakers are removing all botrytis affected grapes clusters prior to beginning vinification.

B_x , variable costs, were estimated based on a combination of actual costs paid, literature sources, and information provided by regional grape growers. Additional labour costs were calculated assuming an 80:20 ratio between general and operator/supervisor labour for each unit of work (Geldart et al., 2012). Regional labour rates were estimated at CA \$17/hr for general labour and CA \$30/hr for a supervisor role. Further breakdown of the variable costs per treatment are provided below.

3.3.1 *Cluster Thinning*

Under CT conditions, variable costs were solely comprised of the added labour required to remove fruit by hand. Sources indicate around 40 hours of work per acre (Julian et al., 2008); however, based on discussions with a regional expert, this value was reduced to around 32 hours per acre. Under our differential labour assumption B_{CT} is estimated at CA \$627.20/acre of CT.

3.3.2 *Leaf Removal and Kaolin Clay*

Under HK conditions the variable costs included both added labour, machinery, and material costs. Julian et al., estimated that leaf removal requires around 20 hours per acre when done by hand (2008). Since our control conditions removed leaves from

only one side of the vine, we estimated that an additional 20 hours would be required to remove the leaves under our treatment conditions.

Kaolin clay was purchased at a unit price of CA \$50/11.34 kg. Using a dilution factor and recommendations like those cited by Skinkis et al., 2021, a total of 11.34 kg of Kaolin was applied (via solution and sprayer) per acre for the first two applications during the growing season. This value was reduced by half (i.e., 5.67 kg Kaolin/acre) for the third and final application. Note: re-application would be required on an as needed basis following any significant rain events. Machine costs were estimated assuming that Kaolin application would be completed using a tractor mounted sprayer. The costs for this were based on discussions with a regional vineyard manager and were estimated at CA \$90/acre. Under these assumptions B_{HK} is estimated at CA \$787/acre of HK.

3.3.3 Full Treatment

The estimated variable costs for HCK (B_{HCK}) are simply a combination of B_{CT} and B_{HK} . Based on these values B_{HCK} is estimated at CA \$1,414.20/acre of HCK.

3.4 Results and Discussion

Despite apparent discrepancies at the vineyard level, similar trends are observed at both sites (Table 3.2). Results indicate that most treatments will require an increase

in the price per tonne (or per bottle) to recuperate the added variable costs and/or changes in yield.

Table 3.2: Estimated minimum price (CA \$) required to recover the additional costs of treatment application for Vancouver Island Pinot gris grown under the eight experimental conditions. Recovery costs were calculated using a simplified cost-benefit model presented in Preszler et al., 2015 using realized changes in yield and costs.

	Vineyard 1		Vineyard 2	
	<i>per tonne</i>	<i>per bottle¹</i>	<i>per tonne</i>	<i>per bottle¹</i>
P _o	\$ 2,000.00	\$ 2.40	\$ 2,000.00	\$ 2.40
P _{CT}	\$ 3,036.26	\$ 3.65	\$ 2,829.38	\$ 3.40
P _{HK}	\$ 1,934.58	\$ 2.33	\$ 2,236.34	\$ 2.69
P _{HCK}	\$ 3,141.48	\$ 3.78	\$ 3,801.26	\$ 4.57

¹Conversion assumes an average of 832 bottles of finished wine per tonne of grapes (Gerling, 2011)

The only incidence of added value is observed under HK conditions at vineyard 1 (V1) (Table 3.2). Despite the relatively high variable cost of CA \$787/acre, the significant reduction in botrytis occurrence (Appendix A; Table 5.2) more than compensates for the added labour costs. When we examine the results from V2, HK still represents the smallest increase to the minimum recovery price. This indicates that, from a grower's perspective, the benefits of HK (i.e., increase in useable yield) can outweigh the incurred costs. This observation is of note when we consider the pervasive rot conditions on Vancouver Island.

Conversely, inherent decrease in yield coupled with the increase in labour costs suggests that cluster thinning of any kind (i.e., CT, HCK) will substantially increase the minimum price required to financial account for the treatment. Even when yields are less effected by this treatment (i.e., V2), our results indicate that CT demands a

minimum 141% increase in value to justify its application. While CT has been shown to produce grapes with high TSS under certain conditions, indicating quicker ripening and potential more favourable wines (Kemp, 2010), the sensory and consumer analysis conducted on the finished wines made from these grapes indicates that there is no added value to the wines imparted by CT (Chapter 2; Tables 2.4 -2.7). Without evidence to suggest that these prices can be justified, it must be concluded that the broad application of CT is not recommended for Vancouver Island Pinot gris; rather, CT should be approached on a as needed based to assist in vine balance.

3.5 Conclusions:

Despite relatively high labour, machine, and material costs, the reduction in botrytis suggests that heavy leaf removal in conjunction with Kaolin clay can effectively benefit production under conditions with a high likelihood of rot. Conversely, cluster thinning to one cluster per shoot provides no measurable benefit and should only be applied on an as-needed basis.

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4. Chapter 4

Concluding remarks

4.1 Summary

The intention of this research was to provide helpful insight to producers on Vancouver Island who have historically been left out such quantitative examinations. Here I explored the efficacy of two common vineyard management techniques believed to improve both grape and wine quality. Despite a wealth of research on both techniques, it was evident that the results hinged on the interactions between both location and varietal.

Cluster thinning is often thought to improve the rate of fruit maturation by altering a vine's source to sink ratio (Dami et al., 2006; Garrido et al., 2016), ultimately changing the resulting wine's aroma and complexity of flavours (Reynolds et al., 2007a; Ruan et al., 2018). Basal leaf removal, in conjunction with Kaolin Clay application, serves as a means of increasing sunlight exposure and ambient temperature in the fruit zone of a vine (Bledsoe et al., 1988; Cortell & Kennedy, 2006). Like cluster thinning, this has been shown to alter both fruit and wine characteristics (Kemp, 2010; Price et al., 1995; Reynolds et al., 2007b; Reynolds & Wardle, 1989; Tardáguila et al., 2010). While changes to quality and character can occur under the right conditions, these treatments have a significant financial downside when considering the additional costs required for operable implementation. This inherent dichotomy between costs and perceived benefits, combined with the general lack of regional data, set the stage for my research.

To recommend either treatment to Vancouver Island wine producers, they needed to demonstrate an added value greater than the incurred costs. Exploring this potential value proposition required examining the effect of treatment on wine character and quality through the lens of sensory science and consumer preference. It also meant translating any recorded changes incurred by treatment into a return-on-investment cost-benefit analysis.

As my research has shown, these *in situ* vineyard treatments were effective at changing the character of the resulting wines under specific conditions; however, the lack of a demonstrable increase in consumer WTP indicates there is little value added from a quality perspective. Only when I accepted a broader definition of benefit, one which looked beyond wine quality, did I find substantial added value.

Despite the relatively high costs of basal leaf removal and Kaolin Clay, this treatment significantly reduced the percentage of grape clusters affected by botrytis. Accounting for the subsequent increase in usable yields, this treatment demonstrates an added value that is at least equivalent, if not greater, than its incurred costs. Furthermore, it does so without negatively impacting wine quality. Based on these results, I recommend that producers on Vancouver Island strongly consider the use of basal leaf removal and Kaolin clay as management tools to reduce rot pressure and increase usable yields.

4.2 Caveats

While the results of my research indicate that these treatments can affect a change in the resulting wine while simultaneously adding value, there are several caveats that must be considered before accepting the totality of these results. In addition to what is already noted at the end of Chapter 2 (Section 2.4.3), the following sections summarise a few of the challenges and shortcomings of this research.

4.2.1 *Winemaking*

Winemaking served as the initial bottleneck and challenge for this project. There were limited means of control during fermentation to account for temperature variation and headspace in the replicates. These factors combined with a limited prior knowledge of fermentation best practices may have resulted in the contamination or oxidation of some wines. The possibility of a fault was indicated during the sensory evaluations, wherein HCK wines from vineyard 1 were significantly differentiated from all other wines by the presence of wet dog and smoke characteristics. These elements tend to indicate that a fault has been introduced to the wine (Puckette, 2012). To prevent contamination or runaway fermentations in future projects, I recommend a procedure with smaller batch ferments that eliminates headspace and allows for easier temperature control. While I did use replicates as a means of accounting for poor fermentation, additional resources and tools are necessary to assess the purity of the wine during this process.

Building on the challenges of winemaking at this scale, I was unable to assess titratable acidity (TA) prior to the addition of yeast out of fear of spontaneous fermentation. Had the foresight and the necessary equipment been available at these early stages, I would have run the pressed juice through a single salt deacidification procedure to marginally lower the acid (Kaiser, 2012). The challenges associated with post vinification deacidification ruled out the option of addressing high TA after fermentation. As a result, the finished wines were largely defined by their acidity. While the expert tasters were able to see past this, it is likely that some elements of the wine were masked by the dominate acid characteristics. The practice of deacidification is common in this region due to the challenging growing conditions, indicating that the use chemical deacidification would be a justifiable addition to the experimental procedure. In future projects, early interventions are recommended to account for the inherently high acid levels in the grapes grown on Vancouver Island. Addressing this issue early on could lead to a more effective sensory analysis of the finished wines.

4.2.2 COVID-19

The global pandemic and subsequent health measures triggered by the outbreak of COVID-19 greatly affected my ability to conduct research. Rather than using classical sensory techniques, I was forced to adopt and modify a rapid virtual approach for both sensory and consumer analysis. While I would argue that these adaptations were

successful, the reliance on the participants' ability to exactly follow instructions will have likely introduced unmeasurable error into my results. I will never know the true extent to which doing this research in person would have affected the outcomes; however, the added layers of control afforded by this approach is preferred over remote data collection.

In addition to drastically changing the methodology of the research, the pandemic introduced a delay component into data collection. As noted in Chapter 2 (section 2.2.6), some of the consumer WTP data was collected in-person and some was collected remotely. Not only are these different methodologies, but the data were also collected several months apart. While it would be interesting to measure the effect of methodology on WTP, it was assumed a nonfactor in the conclusions given that values were compared in relative terms and not as absolutes. However, despite using a sterilization filter (i.e., 0.5 micron), changes in the wine may have occurred in the months between the sample dates ultimately affecting the wines and changing preference. Unfortunately, I was not able to address this possibility, as the sample size was too small to accurately compare WTP values across methodologies.

4.2.3 Willingness-to-Pay

There are several of challenges associated with trying to accurately elicit consumer WTP. Some of these are highlighted in section 2.4.2; however, most of the

inherent challenges were not considered relevant to my research questions, as they tend to arise when dealing with less tangible or non-market goods and services. The methods used were selected for their adaptability and precedence in the literature. While acknowledging each method's shortcomings, I believe they represented the best option for my research questions.

Discrepancies between the estimates are clearly observed when I compared the WTP values across methods (i.e., OE vs DB-CV); but the general patterns and takeaways held true regardless of approach. Given the results of this study, it would be interesting to complete a traditional hedonic assessment for each of the experimental wines. There is no evidence to suggest that the results would be any different from current analysis; however, a hedonic approach can generate preference data using the same scale as the sensory data. This would allow for a more in-depth correlative comparison of sensory and preference relationships (e.g., Multifactorial Analysis).

4.3 Final Message

Every year BC's largest wine authority reviews their long-term goals for the region (WGBC, 2021). While much of the conversation surrounds the largest production regions, the ever-evolving industry continues to focus on improving wine quality and identity, while simultaneously expanding their share in the international market (WGBC, 2021). The future of production in the face of several recent and ongoing challenges

(i.e., climate change, supply and demand, COVID-19 pandemic) can cast doubt on the long-term viability of BC's wine industry. While these factors may ultimately decide the fate of the region, trends suggest a healthy and growing industry (WGBC, 2021).

If business goals are to be achieved, resources must be allocated to assist in building BC's wine identity outside of the Okanagan. Vancouver Island represents an area of significant potential growth over the coming decades, as international businesses begin to invest into the region (Waters, 2020). With this influx of attention and resources, producers will have the capacity to seek out viable solutions to the challenging growing conditions.

Despite seemingly endless research on techniques to promote quality grape growing, the numerous sources of variance borne of interactions between cultivar, geography, seasonality, and oenology make it challenging to find generalizable results. This fact alone highlights the need for researchers and producers to work in collaboration to develop region specific tools for maximizing fruit and wine quality. It is my hope that this research represents the first in a long line of projects geared towards benefitting the Vancouver Island wine industry.

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5. Appendix A;

Additional tables and figures

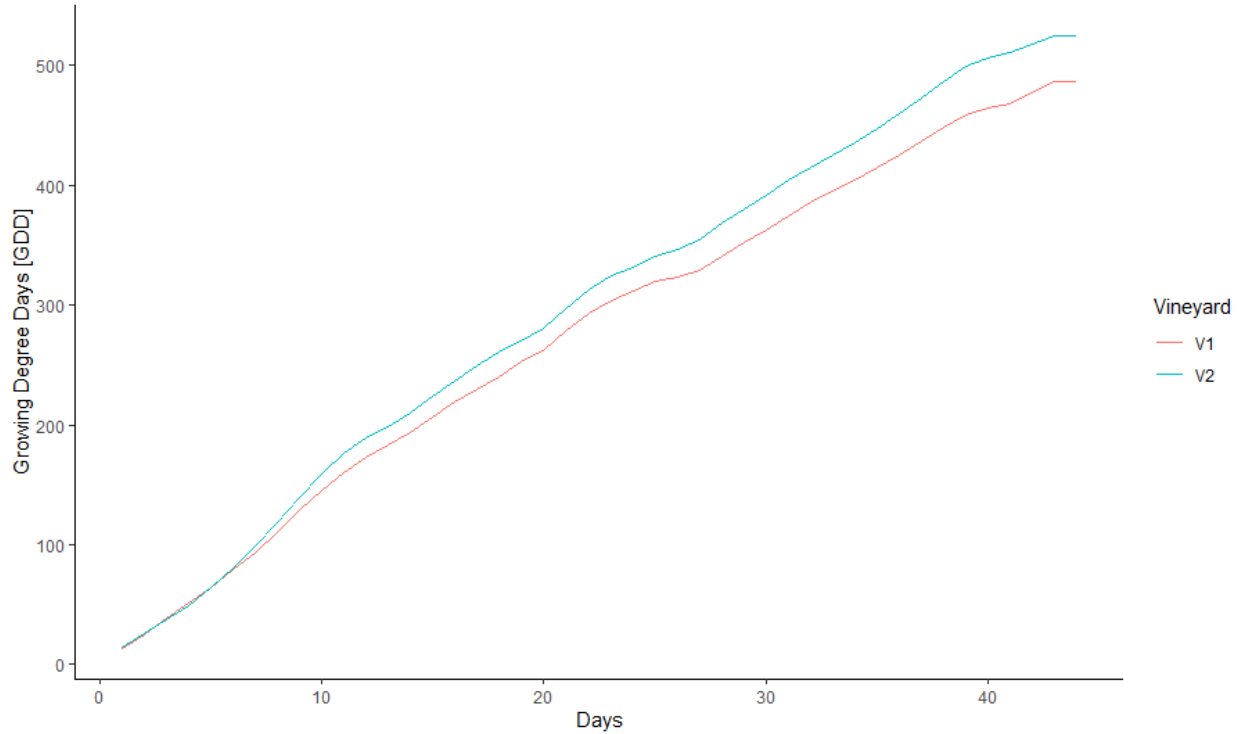


Figure 5.1: Cumulative growing degree days (GDD) recorded from July 31 to September 13, 2019. Temperatures were continuously recorded using iButton® data loggers suspended in the cluster region of vines grown in the experimental blocks of both vineyards (i.e., V1 and V2). GDD calculations were completed using a minimum temperature threshold of 10°C. V2 accumulated 37.73 more GDDs than V1 during the sampling period.

Table 5.1: Linear regression estimates for yield (kg) as a function of treatment for Pinot gris clusters harvested from vineyard 1 (V1) and 2 (V2) under the eight experimental conditions. Yield per vine was calculated by measuring total clusters weight per vine at the time of harvest.

	V1		V2	
	Estimate	Std. Error	Estimate	Std. Error
Control	3.78*** ¹	0.2	1.91***	0.14
HCK	- 1.30***	0.28	- 0.64***	0.2
HK	- 0.26	0.28	- 0.10	0.2
CT	- 1.16***	0.29	- 0.39*	0.2

¹ ***, **, * significantly different from zero at $p < 0.01$, 0.05 , and 0.10 , respectively

Table 5.2: Linear regression estimates for superficial botrytis occurrence as a function of treatment for the eight experimental Pinot gris grape clusters grown at vineyards 1 (V1) and 2 (V2). Botrytis occurrence was measured at the time of harvest by visually assessing each cluster during harvest.

	V1		V2	
	Estimate	Std. Error	Estimate	Std. Error
Control	0.18*** ¹	0.02	0.06***	0.01
HCK	- 0.09***	0.03	- 0.03*	0.01
HK	- 0.10***	0.03	- 0.04**	0.01
CT	0.05	0.03	0.00	0.01

¹ ***, **, * significantly different from zero at $p < 0.01$, 0.05 , and 0.10 , respectively

Table 5.3: Linear regression estimates comparing measured Brix content of berries as a function of treatment. Brix was recorded from a sub sample of 100 berries for each treatment of Pinot gris at both vineyards (V1 and V2).

	V1		V2	
	Estimate	Std. Error	Estimate	Std. Error
Control	16.88*** ¹	0.39	20.68***	0.29
HCK	0.04	0.55	0.72*	0.39
HK	- 0.4	0.55	0.35	0.42
CT	0.72	0.55	1.12**	0.41

¹ ***, **, * significantly different from zero at $p < 0.01$, 0.05 , and 0.10 , respectively

Table 5.4: Linear regression estimates comparing measured Titratable acidity (TA) as a function of treatment for harvested Pinot gris berries from both vineyards (V1 and V2). TA was measured using a subsample of 100 berries from each treatment and vineyard combination.

Coefficients	V1		V2	
	Estimate	SE	Estimate	SE
Control	8.98*** ¹	0.58	7.30***	0.14
HCK	- 1.51*	0.83	- 0.33*	0.18
HK	- 0.53	0.83	- 0.22	0.20
CT	- 0.67	0.83	- 0.4*	0.19

¹ ***, **, * significantly different from zero at $p < 0.01$, 0.05 , and 0.10 , respectively

Table 5.5: Linear regression estimates with interaction terms comparing measured Titratable acidity (TA) in wine juice as a function of treatment and vineyard for the eight experimental Pinot gris wines. TA was measured in grams per liter (g/L) by titrating 0.1 mol sodium hydroxide (NaOH) into a prepared sample of finished wine prior to being cold stabilization.

Coefficients	Estimate	Std. Error
Control	9.68 ^{***1}	0.12
HCK	- 1.02 ^{***}	0.18
HK	0.28	0.18
CT	- 0.5 ^{**}	0.18
Vineyard (2): Control	- 2.03 ^{***}	0.2
Vineyard (2): HCK	0.80 ^{**}	0.28
Treatment HK: Vineyard (2)	- 0.57 [*]	0.28
Treatment CT: Vineyard (2)	0.2	0.28

¹ ^{***}, ^{**}, ^{*} significantly different from zero at $p < 0.01$, 0.05 , and 0.10 , respectively

Table 5.6: Linear regression estimates with interaction terms comparing measured pH as a function of treatment and vineyard for the eight experimental Pinot gris wines. pH was measured using calibrated pH meter.

Coefficients	Estimate	Std. Error
Control	2.9 ^{***1}	0.00
Treatment HCK	0.01 ^{**}	0.01
Treatment HK	0.00	0.01
Treatment CT	0.06 ^{***}	0.01
Vineyard (2)	0.25 ^{***}	0.01
Treatment HCK: Vineyard (2)	0.03 ^{**}	0.01
Treatment HK: Vineyard (2)	- 0.02 [*]	0.01
Treatment CT: Vineyard (2)	- 0.02 [*]	0.01

¹ ^{***}, ^{**}, ^{*} significantly different from zero at $p < 0.01$, 0.05 , and 0.10 , respectively

Table 5.7: List of common Pinot gris sensory descriptors provided to the vocabulary generation tasting panel. A total of 9 panelists were guided through modified Free-Choice profiling and Projective Mapping methods to generate descriptive sensory attributes for the eight experimental Pinot gris wines. The following list was presented to the panellists after completing the exercises as a means of data reduction. Panelists were instructed to select terms from this list that they deemed equivalent to their own.

Almond	Mineral
Apple, baked	Mineral, flint
Apple, Green	Mineral, river stone
Apple, Yellow	Mineral, slate
Clove	Melon
Cinnamon	Musk
Floral	Mushroom
Floral, orange blossom	Nectarine, White
Ginger	Peach, Yellow
Grapefruit	Peach, White
Herb, wild	Pear
Honey	Pear, Asian
Honeycomb	Pineapple
Honeysuckle	Quince
Kiwi	Saline
Lemon	Saffron
Lemon, grilled	Spice, savoury / wild
Lemon, Meyer	Spice, sweet
Linden	Vanilla
Lime	Wheat
Lime, Kaffir	Yeast / lees / bread / brioche
Lime, Key	

Table 5.8: ANOVA results evaluating panel performance as whole with respect to each sensory attribute. Attributes are defined either palate (.p) or nose (.n) identifiers. Results indicate that the panel is able to significantly differentiate wines using the lime attribute.

<i>Sensory attribute</i>	<i>Wine (W)</i>	<i>Panelist (P)</i>	<i>Session (S)</i>	<i>W:P</i>	<i>W:S</i>	<i>P:S</i>
yeast.p	0.84	0.00***	0.34	0.00***	0.09*	0.43
suckle.p	0.48	0.00***	0.76	0.01**	0.5	0.32
tropical.p	0.48	0.00***	0.14	0.27	0.25	0.46
stonefruit.p	0.23	0.00***	0.72	0.07*	0.72	0.5
earth.p	0.47	0.00***	0.8	1	0.38	1
herbs.p	0.16	0.00***	0.02**	0.05**	0.54	0.09*
gravel.p	0.88	0.00***	0.47	0.03**	0.07*	0.00***
smoke.p	0.57	0.00***	1	0.18	0.07*	0.22
mushroom.p	0.6	0.00***	0.35	0.07*	0.71	0.67
lime.p	0.00***	0.00***	0.83	0.54	0.54	0.6
lemon.p	0.12	0.00***	0.69	0.87	0.19	0.44
floral.p	0.36	0.00***	0.04**	0.4	1	0.7
spice.p	0.27	0.00***	0.17	0.07*	0.44	0.03**
grapefruit.p	0.53	0.00***	0.67	0.42	0.36	0.23
dog.p	0.52	0.00***	0.85	0.77	0.83	0.25
honey.p	0.83	0.00***	0.21	0.00***	0.67	0.06*
saline.p	0.08	0.00***	0.9	0.57	0.45	0.41
musk.p	0.35	0.00***	0.57	0.56	0.08*	0.69
apple.p	0.04	0.00***	0.48	0.01***	0.02**	0.31
pear.p	0.27	0.00***	0.36	0.01***	0.67	0.05*
vegetal.p	0.02**	0.00***	1	0.33	0.58	0.64
yeast.n	0.13	0.00***	0.59	0.26	0.28	0.63
suckle.n	0.15	0.00***	0.15	0.37	0.03**	0.9
tropical.n	0.33	0.00***	0.21	0.01***	0.06*	0.09*
stonefruit.n	0.73	0.00***	0.53	0.81	0.66	0.54
earth.n	0.38	0.00***	0.36	0.99	0.04**	0.96
herbs.n	0.54	0.00***	0.9	0.56	0.61	0.07*
gravel.n	0.12	0.00***	0.55	0.29	0.15	0.58
smoke.n	0.33	0.00***	0.54	0.16	0.41	0.86
mushroom.n	0.05	0.00***	0.66	0.31	0.62	0.98
lime.n	0.53	0.00***	0.65	0.07*	0.87	0.35
lemon.n	0.57	0.00***	0.73	0.73	0.21	0.98
floral.n	0.2	0.00***	0.91	0.08*	0.03**	0.35
spice.n	0.54	0.00***	0.13	0.45	0.46	0.59
grapefruit.n	0.19	0.00***	0.79	0.88	0.69	0.98
dog.n	0.16	0.00***	0.53	0.88	0.57	0.68
honey.n	0.84	0.00***	0.89	0.48	0.45	0.69
saline.n	0.9	0.00***	0.85	0.09*	0.57	0.45
musk.n	0.12	0.00***	0.44	0.4	0.49	0.17
apple.n	0.04**	0.00***	0.53	0.17	0.62	0.05*
pear.n	0.71	0.00***	0.3	0.89	0.51	0.47
vegetal.n	0.1*	0.00***	0.09*	0.88	0.43	1

¹ ***, **, * significantly different from zero at $p < 0.01$, 0.05 , and 0.10 , respectively

Table 5.9: Panelist reliability ANVOA summarizing the (dis)agreement between each panelist and the panel result using a standard deviation threshold of 2. Trends suggest no significant deviation across panelists with respect to attribute use or perceived intensity. Descriptors are labeled with the suffix “.p” or “.n” to indicate palate or nose attributes respectively.

Panelist	<i>earth.p</i>	<i>herbs.p</i>	<i>smoke.p</i>	<i>dog.p</i>	<i>musk.p</i>	<i>smoke.n</i>	<i>dog.n</i>	<i>mushroom.p</i>	median
2I	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00	0.00
2G	2.5*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1M	0.00	0.00	1.00	2*	0.50	0.00	0.00	2*	0.00
2H	0.00	2*	0.00	0.00	0.00	1.00	0.00	0.00	0.25
1H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
1C	0.00	0.00	0.71	0.00	0.00	0.50	0.00	0.00	0.50
1G	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.50	0.50
2B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
1L	0.00	0.00	0.00	2*	1.12	0.00	0.00	0.00	0.50
1O	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.00	0.50
1F	0.00	0.00	2*	0.00	0.00	0.00	0.00	1.50	0.50
3A	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50
3B	0.00	1.58	0.00	0.00	0.00	0.00	0.00	1.00	0.50
4A	0.00	0.00	0.00	0.50	1.12	0.00	0.00	0.00	0.50
4B	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
1I	0.00	1.58	0.50	0.00	1.50	0.00	0.50	0.50	0.50
1J	1.00	0.00	0.00	0.50	1.00	0.00	1.50	0.00	0.50
2F	1.00	0.00	1.00	0.00	0.00	0.50	1.50	1.12	0.60
1K	0.00	0.00	2.06*	0.00	0.00	0.00	0.71	0.00	0.71
2C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71
3C	0.00	0.71	0.00	0.50	1.12	0.00	0.00	1.00	0.71
2E	3.20*	1.80	0.00	0.00	0.00	0.00	2.5*	0.00	0.75
1A	0.00	1.41	0.00	0.00	0.00	0.50	0.50	0.00	1.00
1D	0.50	1.00	1.00	1.00	1.00	0.00	0.00	0.71	1.00
1E	0.00	0.50	1.12	0.00	0.00	1.58	0.00	0.00	1.00
2D	0.00	2.5*	0.00	3*	0.00	0.50	0.00	0.00	1.00
1N	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	1.06
2A	0.00	0.50	1.12	1.00	1.50	0.00	0.00	0.71	1.12
1B	2.828*	1.50	1.50	1.80	1.80	1.50	1.80	1.80	1.50
median	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50

* Residuals greater than 2 standard deviations

Table 5.9 (continued): Panelist reliability ANVOA summarizing the (dis)agreement between each panelist and the panel result using a standard deviation threshold of 1.96. Trends suggest no significant deviation across panelists with respect to attribute use or perceived intensity. Descriptors are labeled with the suffix “.p” or “.n” to indicate palate or nose attributes respectively.

Panelist	<i>earth.n</i>	<i>mushroo m.n</i>	<i>vegetal. n</i>	<i>saline.n</i>	<i>yeast.p</i>	<i>spice.p</i>	<i>spice.n</i>	<i>musk.n</i>	median
2I	0.00	0.00	0.00	1.41	1.00	0.00	0.00	0.50	0.00
2G	0.00	0.50	0.00	0.00	0.00	1.50	0.00	0.00	0.00
1M	1.00	2.69*	0.00	0.00	0.50	1.00	0.00	1.80	0.00
2H	2.5*	0.00	0.00	1.50	0.00	0.50	2.55*	0.00	0.25
1H	0.50	0.00	0.00	0.00	0.00	1.12	0.00	0.50	0.25
1C	0.00	0.00	0.00	3*	0.50	0.50	2.55*	0.00	0.50
1G	0.00	0.00	0.00	0.00	0.00	1.80	1.50	0.50	0.50
2B	0.00	0.00	0.00	0.00	1.00	0.00	0.50	1.58	0.50
1L	0.00	0.00	0.50	0.00	0.00	0.00	2.5*	0.00	0.50
1O	0.50	0.00	0.00	0.00	0.00	1.00	1.00	0.50	0.50
1F	0.00	0.00	0.00	0.00	0.00	1.80	0.00	0.00	0.50
3A	0.00	1.00	0.00	0.00	1.00	0.00	0.50	1.58	0.50
3B	1.80	1.12	0.50	0.50	0.50	0.00	0.71	0.50	0.50
4A	0.00	0.00	0.50	0.00	1.58	0.00	0.00	0.00	0.50
4B	0.50	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.50
1I	0.00	0.00	0.00	0.50	0.00	0.71	0.00	0.50	0.50
1J	0.00	0.00	4.30*	0.50	0.50	0.50	0.50	0.00	0.50
2F	0.00	1.12	2.06*	0.00	0.50	0.00	0.50	2.24*	0.60
1K	0.00	0.00	1.50	0.50	1.00	0.00	2.5*	0.00	0.71
2C	1.80	0.00	0.00	0.00	0.00	0.00	2.5*	0.00	0.71
3C	0.00	0.00	0.00	0.00	1.12	0.50	0.00	0.00	0.71
2E	0.00	0.00	0.00	1.58	0.00	2*	0.00	0.50	0.75
1A	0.50	0.00	1.00	1.80	1.00	0.00	0.00	0.50	1.00
1D	0.00	0.00	0.00	1.00	1.12	1.00	2.24*	0.00	1.00
1E	0.00	0.00	0.00	1.00	0.71	1.00	0.00	0.00	1.00
2D	1.50	0.00	1.00	0.00	0.50	4.95*	0.50	1.00	1.00
1N	0.00	0.50	2.06*	0.00	0.00	0.00	1.00	2.06*	1.06
2A	2.24*	1.80	1.00	2*	1.58	2.24*	0.50	0.50	1.12
1B	1.12	1.80	1.00	0.50	1.58	1.50	1.00	1.12	1.50
median	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.50

* Residuals greater than 2 standard deviations

Table 5.9 (continued): Panelist reliability ANVOA summarizing the (dis)agreement between each panelist and the panel result using a standard deviation threshold of 1.96. Trends suggest no significant deviation across panelists with respect to attribute use or perceived intensity. Descriptors are labeled with the suffix “.p” or “.n” to indicate palate or nose attributes respectively.

Panelist	<i>vegetal.</i> <i>p</i>	<i>herbs.n</i>	<i>yeast.n</i>	<i>grapefruit</i> <i>.n</i>	<i>suckle.</i> <i>p</i>	<i>lime.n</i>	<i>honey.</i> <i>p</i>	<i>pear.p</i>	median
2I	0.00	0.00	1.00	1.00	0.00	0.71	0.00	0.00	0.00
2G	1.50	0.50	0.00	0.00	0.00	0.71	2*	1.12	0.00
1M	2.24*	0.00	1.41	0.00	0.00	0.00	0.00	0.00	0.00
2H	2*	0.00	2*	0.00	0.00	0.00	0.50	2.5*	0.25
1H	0.00	0.00	1.41	0.50	0.00	0.00	1.00	0.50	0.25
1C	0.00	0.00	0.50	1.58	0.00	0.00	0.00	1.00	0.50
1G	1.00	0.00	0.00	0.00	0.50	0.00	0.71	0.00	0.50
2B	0.00	0.00	0.00	0.00	0.50	1.00	0.00	0.00	0.50
1L	0.00	2.5*	0.00	2.83*	0.00	2*	1.12	3.20*	0.50
1O	0.00	0.71	0.50	0.71	0.00	0.50	0.00	1.50	0.50
1F	0.00	0.00	0.00	0.50	1.12	0.00	1.12	0.50	0.50
3A	0.00	0.00	0.50	0.00	1.50	0.71	1.80	0.50	0.50
3B	0.50	1.12	0.50	0.50	1.00	0.00	1.00	0.00	0.50
4A	0.00	1.00	1.00	0.00	0.71	1.50	0.50	0.50	0.50
4B	0.00	0.00	0.50	0.50	1.80	0.50	2.5*	2.12*	0.50
1I	0.71	0.00	2.06*	0.50	0.71	0.00	1.41	2*	0.50
1J	0.00	3*	3.5*	4.03*	0.00	3*	0.50	0.71	0.50
2F	1.80	0.00	1.12	0.00	0.00	0.00	0.00	0.71	0.60
1K	1.00	2.92*	1.80	0.00	0.50	1.58	0.71	0.71	0.71
2C	1.12	1.00	0.00	1.00	1.00	0.00	1.00	1.80	0.71
3C	0.50	0.00	0.00	1.80	0.71	1.00	0.50	0.50	0.71
2E	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.75
1A	0.00	3*	1.00	1.50	0.50	1.50	0.00	1.80	1.00
1D	1.00	0.50	1.12	1.50	1.50	1.41	1.00	1.50	1.00
1E	0.00	1.00	0.00	1.12	1.80	2*	0.50	0.71	1.00
2D	0.50	0.71	0.00	0.00	3.5*	2.5*	0.00	0.00	1.00
1N	0.00	1.00	2*	1.12	2.24*	1.12	1.00	1.58	1.06
2A	1.00	2.12*	1.58	3.04*	1.58	1.12	1.50	1.80	1.12
1B	2.12*	1.00	1.50	1.12	0.00	0.50	1.58	0.50	1.50
median	0.50	0.50	0.50	0.50	0.50	0.71	0.71	0.71	0.50

* Residuals greater than 2 standard deviations

Table 5.9 (continued): Panelist reliability ANVOA summarizing the (dis)agreement between each panelist and the panel result using a standard deviation threshold of 1.96. Trends suggest no significant deviation across panelists with respect to attribute use or perceived intensity. Descriptors are labeled with the suffix “.p” or “.n” to indicate palate or nose attributes respectively.

Panelist	<i>gravel.</i> <i>p</i>	<i>apple.p</i>	<i>suckle.</i> <i>n</i>	<i>lemon.</i> <i>p</i>	<i>floral.p</i>	<i>tropical.</i> <i>n</i>	<i>gravel.</i> <i>n</i>	<i>lemon.</i> <i>n</i>	median
2I	1.00	0.71	0.00	1.12	0.00	0.00	0.50	0.50	0.00
2G	0.50	1.12	0.00	1.12	0.00	0.00	1.00	1.12	0.00
1M	0.00	1.00	0.50	3.00	0.00	0.00	0.00	1.00	0.00
2H	0.00	0.50	0.00	0.00	0.50	0.00	1.50	0.00	0.25
1H	0.00	1.00	1.00	1.00	0.00	1.80	0.00	1.00	0.25
1C	1.00	0.50	1.12	1.80	1.12	1.00	0.00	0.00	0.50
1G	1.50	1.12	0.00	1.00	1.12	1.50	1.50	3.20*	0.50
2B	0.50	1.12	1.80	1.80	0.00	1.50	1.50	1.00	0.50
1L	0.50	2.06*	2*	1.00	0.00	0.00	2.55*	1.58	0.50
1O	0.00	2*	0.50	3.64*	0.00	1.12	0.00	0.50	0.50
1F	1.12	0.71	1.80	1.00	1.80	1.80	0.50	1.58	0.50
3A	2.69*	0.71	0.00	1.12	1.50	1.12	0.00	0.00	0.50
3B	1.12	0.71	1.00	0.50	0.00	0.00	1.50	0.00	0.50
4A	2.50	0.00	1.41	3.64*	0.00	1.00	1.50	0.00	0.50
4B	1.00	1.58	1.41	0.00	2.5*	0.71	1.41	0.71	0.50
1I	0.71	1.00	0.00	0.50	1.00	2.12*	1.00	0.00	0.50
1J	0.50	2.12*	3.5*	0.71	1.00	0.00	0.50	3*	0.50
2F	1.00	1.12	0.00	1.00	0.00	0.00	0.00	2*	0.60
1K	0.71	0.50	1.50	0.71	1.80	0.00	1.50	2*	0.71
2C	0.00	1.00	1.00	0.71	1.80	1.00	3.16*	0.00	0.71
3C	0.50	0.50	0.71	1.00	1.12	4.74*	1.12	1.12	0.71
2E	1.58	2.06*	0.00	3.81*	0.00	0.00	0.50	2.5*	0.75
1A	1.58	1.00	1.58	3.35*	1.00	1.00	1.00	1.41	1.00
1D	0.50	0.71	0.71	0.50	0.71	1.12	0.50	0.50	1.00
1E	1.50	0.50	1.00	1.12	1.80	1.00	1.58	0.71	1.00
2D	5.32*	0.00	2.50	4.95*	4*	2*	1.80	1.12	1.00
1N	0.00	1.12	2.83*	2.5*	1.12	2.06*	0.50	1.41	1.06
2A	2.06*	1.41	2.24*	0.71	2.06*	0.00	1.12	1.12	1.12
1B	2.5*	1.12	1.12	2.24*	2.83*	1.12	0.50	1.12	1.50
median	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50

* Residuals greater than 2 standard deviations

Table 5.9 (continued): Panelist reliability ANVOA summarizing the (dis)agreement between each panelist and the panel result using a standard deviation threshold of 1.96. Trends suggest no significant deviation across panelists with respect to attribute use or perceived intensity. Descriptors are labeled with the suffix “.p” or “.n” to indicate palate or nose attributes respectively.

Panelist	<i>tropical.n</i>	<i>gravel.n</i>	<i>lemon.n</i>	<i>saline.p</i>	<i>tropical.p</i>	<i>honey.n</i>	<i>lime.p</i>	<i>floral.n</i>	median
2I	0.00	0.50	0.50	2.5*	0.00	0.50	1.12	0.00	0.00
2G	0.00	1.00	1.12	1.12	0.00	0.00	2.24*	0.00	0.00
1M	0.00	0.00	1.00	1.50	1.00	1.00	3.81*	0.00	0.00
2H	0.00	1.50	0.00	2.5*	0.00	1.12	4.03*	1.58	0.25
1H	1.80	0.00	1.00	0.50	1.80	1.12	0.50	1.50	0.25
1C	1.00	0.00	0.00	0.71	1.00	1.00	0.50	1.12	0.50
1G	1.50	1.50	3.20*	0.00	1.41	0.00	0.50	2.83*	0.50
2B	1.50	1.50	1.00	1.12	1.12	1.00	1.50	1.12	0.50
1L	0.00	2.55*	1.58	0.00	0.00	2.24*	2*	1.00	0.50
1O	1.12	0.00	0.50	0.00	2.50	0.50	3.16*	1.00	0.50
1F	1.80	0.50	1.58	1.12	0.50	0.00	1.00	0.00	0.50
3A	1.12	0.00	0.00	2*	3.04*	1.12	1.00	1.12	0.50
3B	0.00	1.50	0.00	0.00	2.00	1.50	2.5*	0.00	0.50
4A	1.00	1.50	0.00	2.5*	0.00	2.5*	0.71	1.12	0.50
4B	0.71	1.41	0.71	0.00	1.58	1.58	0.50	1.58	0.50
1I	2.12*	1.00	0.00	0.50	1.50	0.00	1.12	0.71	0.50
1J	0.00	0.50	3*	0.71	0.50	0.00	1.41	3.91*	0.50
2F	0.00	0.00	2*	2.24*	0.00	1.00	1.12	1.50	0.60
1K	0.00	1.50	2*	0.50	0.00	1.50	1.58	3.16*	0.71
2C	1.00	3.16*	0.00	0.71	1.00	1.50	1.00	0.00	0.71
3C	4.74*	1.12	1.12	2.06*	1.12	0.50	1.50	2.06*	0.71
2E	0.00	0.50	2.5*	2*	1.00	2.00	1.41	2.5*	0.75
1A	1.00	1.00	1.41	0.50	1.50	1.00	0.50	2.06*	1.00
1D	1.12	0.50	0.50	0.50	1.00	2.55*	1.00	2.06*	1.00
1E	1.00	1.58	0.71	1.58	1.50	1.12	2.06*	0.50	1.00
2D	2.00	1.80	1.12	3.5*	3*	1.12	0.00	2.69*	1.00
1N	2.06*	0.50	1.41	0.00	2.12*	2.69*	2.24*	1.12	1.06
2A	0.00	1.12	1.12	1.12	2.55*	1.12	0.00	0.71	1.12
1B	1.12	0.50	1.12	1.50	2.5*	1.58	0.50	1.00	1.50
median	1.00	1.00	1.00	1.12	1.12	1.12	1.12	1.12	0.50

* Residuals greater than 2 standard deviations

Table 5.9 (continued): Panelist reliability ANVOA summarizing the (dis)agreement between each panelist and the panel result using a standard deviation threshold of 1.96. Trends suggest no significant deviation across panelists with respect to attribute use or perceived intensity. Descriptors are labeled with the suffix “.p” or “.n” to indicate palate or nose attributes respectively.

Panelist	<i>apple.n</i>	<i>pear.n</i>	<i>grapefruit.p</i>	<i>stonefruit.n</i>	median
2I	0.00	0.00	1.12	0.00	0.00
2G	1.12	0.50	1.00	0.00	0.00
1M	0.00	0.00	0.00	0.00	0.00
2H	2.693*	3.905*	3.162*	3.00	0.25
1H	0.00	3.905*	1.50	1.12	0.25
1C	1.12	1.41	1.00	2.5*	0.50
1G	0.00	3.354*	2.5*	2.00	0.50
2B	1.12	1.00	1.80	1.50	0.50
1L	1.00	1.12	3.00	0.00	0.50
1O	0.50	0.00	2.5*	0.50	0.50
1F	0.71	2.55*	1.12	2.693*	0.50
3A	0.00	2.236*	2.915*	0.50	0.50
3B	0.71	0.50	1.00	0.00	0.50
4A	2.5*	1.50	1.58	1.58	0.50
4B	1.58	1.80	1.00	1.80	0.50
1I	1.58	0.00	2.236*	1.58	0.50
1J	3.536*	0.00	0.50	3.5*	0.50
2F	2.00	2.828*	0.00	3.905*	0.60
1K	2.915*	0.00	0.71	3.00	0.71
2C	1.00	0.00	1.80	4.50	0.71
3C	1.12	1.12	1.58	1.00	0.71
2E	2.693*	3.606*	1.58	3.606*	0.75
1A	2.5*	0.00	1.00	1.80	1.00
1D	1.00	1.50	1.12	1.12	1.00
1E	1.00	2.236*	1.12	0.00	1.00
2D	2.55*	1.00	3.5*	1.00	1.00
1N	3.905*	0.50	1.50	1.80	1.06
2A	0.50	1.50	1.12	1.80	1.12
1B	1.12	0.50	2.55*	0.00	1.50
median	1.12	1.12	1.50	1.58	0.50

* Residuals greater than 2 standard deviations

Table 5.10: Summary of significant sensory attributes identified across dimensions 1:3 from principal components analysis (PCA) on the eight experimental Pinot gris wines using rate-all-that-apply (RATA) sensory data.

Principal Component (dimension)	Sensory Attribute	Correlation	p. value
Dim 1	<i>yeast.n</i>	0.94	0.00
	<i>mushroom.n</i>	0.92	0.00
	<i>lime.p</i>	0.90	0.00
	<i>musk.n</i>	0.80	0.02
	<i>suckle.p</i>	- 0.78	0.02
	<i>stonefruit.p</i>	- 0.80	0.02
	<i>floral.p</i>	- 0.80	0.02
Dim 2	<i>saline.n</i>	0.88	0.00
	<i>yeast.p</i>	0.81	0.01
	<i>tropical.p</i>	0.81	0.01
	<i>pear.n</i>	0.76	0.03
	<i>honey.n</i>	0.72	0.05
	<i>dog.n</i>	- 0.71	0.05
	Dim 3	<i>pear.p</i>	- 0.73
<i>spice.p</i>		- 0.74	0.04
<i>earth.p</i>		- 0.91	0.00

Table 5.11: Correlation matrix of ordinated demographic/preference drivers of consumer willingness-to-pay (WTP). Data was collected using a double-bound dichotomous choice contingent valuation (DB-CV) survey to evaluate the change in consumer valuation for Vancouver Island Pinot gris grown under experimental conditions. Patterns suggest that an increase in respondent age resulted in a lower average WTP.

	Age	Level of education	Income	Drink Frequency	Open-Ended WTP
Age	1.00	-0.08	0.40	0.46	-0.17
Level of education	-0.08	1.00	0.18	0.14	-0.07
Income	0.40	0.18	1.00	0.29	0.03
Drink Frequency	0.46	0.14	0.29	1.00	-0.04
Open-Ended WTP	-0.17	-0.07	0.03	-0.04	1.00

Table 5.12: Mean and median consumer WTP estimates and 95% confidence intervals with upper (UB) and lower bounds (LB) for all eight experimental Pinot gris wines. Values were generated from linear regression model using double-bound dichotomous choice contingent valuation (DB-CV) survey responses collected from 154 consumer tasters.

5	Vineyard 1											
	<u>Control</u>			<u>CT</u>			<u>HK</u>			<u>HCK</u>		
	Est.	LB	UB	Est.	LB	UB	Est.	LB	UB	Est.	LB	UB
Mean WTP (CA \$)	13.79	12.21	15.80	14.90	13.46	17.15	13.11	11.35	15.01	13.61	11.74	17.30
Median WTP (CA \$)	13.10	11.26	14.65	14.11	12.50	15.73	12.33	10.23	13.98	12.17	9.99	14.37
	Vineyard 2											
	<u>Control</u>			<u>CT</u>			<u>HK</u>			<u>HCK</u>		
	Est.	LB	UB	Est.	LB	UB	Est.	LB	UB	Est.	LB	UB
Mean WTP (CA \$)	16.60	15.11	18.62	14.90	12.80	18.99	17.52	15.58	20.56	15.75	14.10	18.22
Median WTP (CA \$)	15.86	14.20	17.42	12.86	10.67	15.08	16.15	14.17	18.27	14.84	13.12	16.65

6. Appendix B:

Supplemental information and images



Figure 6.1: In person consumer willingness-to-pay (WTP) sampling station. A total of 70 consumers completed the double-bound dichotomous choice contingent valuation (DB-CV) survey in person. An Additional 84 were completed remotely.

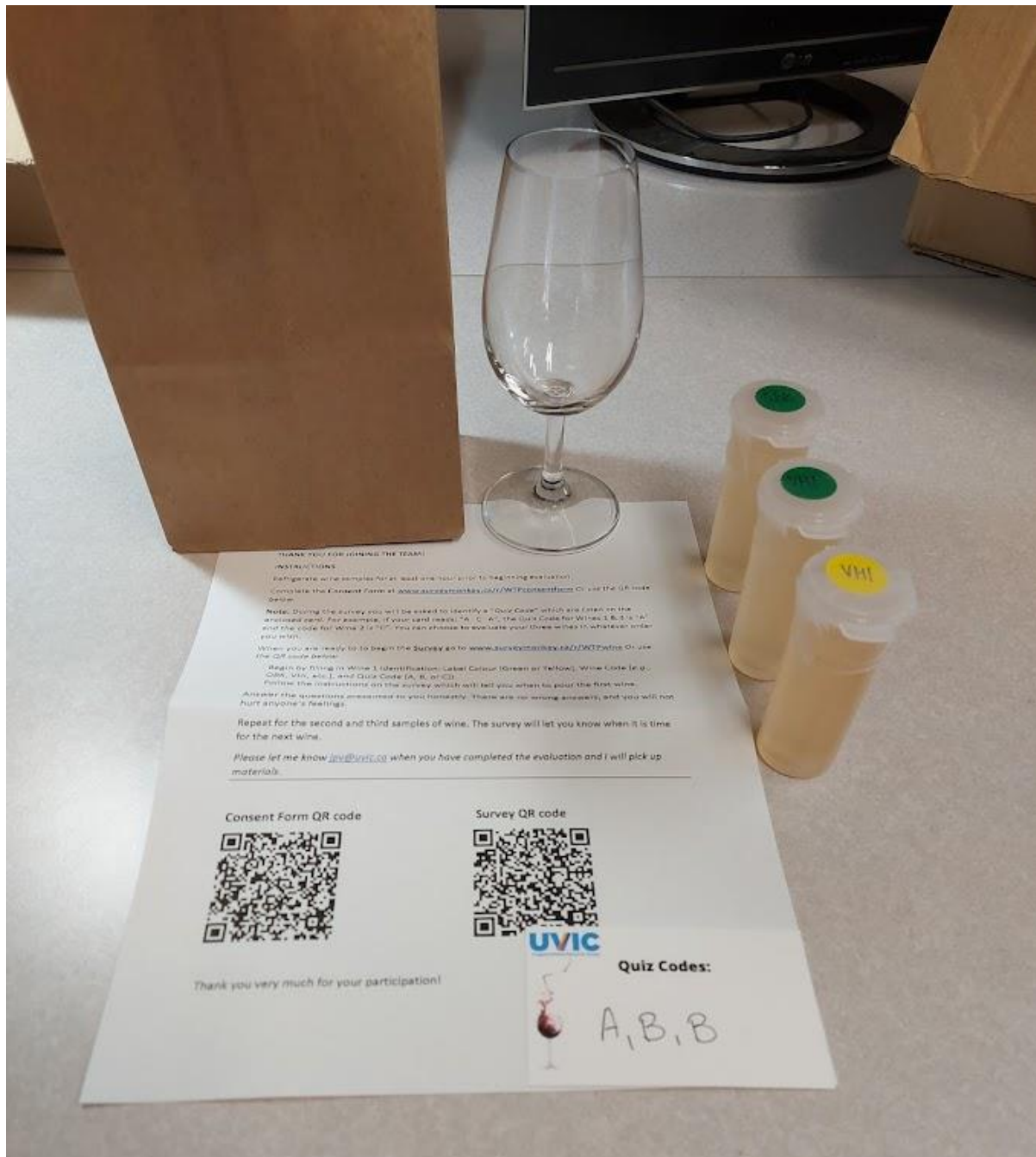


Figure 6.2: An example of a remote consumer willingness-to-pay (WTP) survey sample kit. All participants were provided detailed instructions to complete the survey, a link to a consent form, an ISO tasting glass, 2-3 wine samples, and randomized quiz codes. Similar sample kits were curated for sensory panelists; however, a total of 10 wines were provided and responses were recorded on paper (see below).

Aromatic Assessment

Please agitate the wine for 3-seconds prior to beginning your evaluation. **Only circle characteristics that are applicable to the wine you are evaluating.** If a characteristic is selected, rate its relative intensity.

(1 = very weak; 9 = extremely strong)

STONE FRUIT	1	2	3	4	5	6	7	8	9
APPLE	1	2	3	4	5	6	7	8	9
SLATE/STONE/GRAVEL	1	2	3	4	5	6	7	8	9
TROPICAL FRUIT	1	2	3	4	5	6	7	8	9
HERBS	1	2	3	4	5	6	7	8	9
PEAR	1	2	3	4	5	6	7	8	9
GRAPEFRUIT	1	2	3	4	5	6	7	8	9
LEMON	1	2	3	4	5	6	7	8	9
YEAST/BREAD	1	2	3	4	5	6	7	8	9
VEGETAL	1	2	3	4	5	6	7	8	9
WET DOG	1	2	3	4	5	6	7	8	9
SPICE	1	2	3	4	5	6	7	8	9
HONEY	1	2	3	4	5	6	7	8	9
HONEYSUCKLE	1	2	3	4	5	6	7	8	9
SMOKE	1	2	3	4	5	6	7	8	9
EARTH	1	2	3	4	5	6	7	8	9
MUSK/BARNYARD	1	2	3	4	5	6	7	8	9
SALINE/BRINE	1	2	3	4	5	6	7	8	9
FLORAL	1	2	3	4	5	6	7	8	9
MUSHROOM	1	2	3	4	5	6	7	8	9
LIME	1	2	3	4	5	6	7	8	9

Palate Assessment

You may aerate the wine in your mouth. Begin by completing an assessment of the wine's acidity, sweetness, body, and the length of finish. Rate the relative intensity.

ACIDITY	LOW		MEDIUM (-)		MEDIUM		MEDIUM (+)		HIGH		
SWEETNESS	DRY		OFF-DRY		MED-DRY		MED-SWEET		SWEET		LUSCIOUS
BODY	LIGHT		MEDIUM (-)		MEDIUM		MEDIUM (+)		FULL		
LENGTH OF FINISH	SHORT		MEDIUM (-)		MEDIUM		MEDIUM (+)		LONG		

Palate Flavour Assessment

You may aerate the wine in your mouth. **Only circle characteristics that are applicable to the wine you are evaluating.** If a characteristic is selected, rate its relative intensity.

(1 = very weak; 9 = extremely strong)

STONE FRUIT	1	2	3	4	5	6	7	8	9
APPLE	1	2	3	4	5	6	7	8	9
SLATE/STONE/GRAVEL	1	2	3	4	5	6	7	8	9
TROPICAL FRUIT	1	2	3	4	5	6	7	8	9
HERBS	1	2	3	4	5	6	7	8	9
PEAR	1	2	3	4	5	6	7	8	9
GRAPEFRUIT	1	2	3	4	5	6	7	8	9
LEMON	1	2	3	4	5	6	7	8	9
YEAST/BREAD	1	2	3	4	5	6	7	8	9
VEGETAL	1	2	3	4	5	6	7	8	9
WET DOG	1	2	3	4	5	6	7	8	9
SPICE	1	2	3	4	5	6	7	8	9
HONEY	1	2	3	4	5	6	7	8	9
HONEYSUCKLE	1	2	3	4	5	6	7	8	9
SMOKE	1	2	3	4	5	6	7	8	9
EARTH	1	2	3	4	5	6	7	8	9
MUSK/BARNYARD	1	2	3	4	5	6	7	8	9
SALINE/BRINE	1	2	3	4	5	6	7	8	9
FLORAL	1	2	3	4	5	6	7	8	9
MUSHROOM	1	2	3	4	5	6	7	8	9
LIME	1	2	3	4	5	6	7	8	9

IMPORTANT:

Please take at least 1-minute to cleanse your palate with water and crackers break before moving on to the next wine