**Wine of reduced alcohol content:**
Consumer and society demand vs industry willingness and ability to deliver

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Abstract: Since the 1980’s, the alcohol content of Australian wine has steadily increased from 12.5 to 13.0% for white wines and from 12.4 to 14.4% for red wines. This is largely due to winemakers’ preferences for riper grapes, which exhibit more intense fruit flavors, but which also contain more sugar and therefore lead to higher alcohol wines. However, given the various health, social and tax implications associated with alcohol production and consumption, it’s perhaps not surprising that wine consumers and winemakers alike, are interested in wine of reduced alcohol content. In this paper, the factors influencing consumer demand for low alcohol wine, together with methods for producing wine of reduced alcohol content, are discussed. The aims and objectives of a new Innovative Wine Production research program, underway at the University of Adelaide, Australia, are also outlined, to demonstrate industry’s willingness to develop and implement alcohol-reduction strategies.

Keywords: alcohol reduction, consumer preference, industry, low alcohol wine, winemaking

1. Introduction

The alcohol content of table wine typically ranges from near 10% for light bodied white or rosé wines, to in excess of 16% for full bodied red wines. Since the 1980’s, the alcohol content of Australian wine has steadily increased from 12.5 to 13.0% for white wines and from 12.4 to 14.4% for red wines (Godden and Muhlack, 2010), as shown in Figure 1. These trends are largely attributable to winemakers’ preference for riper grapes, which exhibit more intense fruit flavors, but which also contain more sugar and therefore lead to higher alcohol wines.

The issue of high alcohol wines is one of concern for winemakers, given the harmful effects of alcohol on health and behavior (Le Berre et al., 2007) and the potential implications for wine quality. Ethanol makes an important sensory contribution to wine, influencing viscosity and body (Pickering et al., 1998), and therefore wine style, but it can also influence our perceptions of astringency (due to tannin), sourness (due to acid), sweetness, and aroma and flavor (Martin and Pangborn, 1970; Fischer and Noble, 2004; Robinson et al., 2009). Many high alcohol wines also exhibit an unpleasant ‘hotness’ and can lack fruit flavor and freshness, possibly due to the increased solubility of wine volatiles which affects detection thresholds (Pineau et al., 2007) and headspace partitioning (Robinson et al., 2009). Not surprisingly, winemakers are interested in reducing the concentration of alcohol in wine.

Wines of reduced alcohol content have been classified as dealcoholized or alcohol free (< 0.5% v/v), low alcohol (0.5 to 1.2% v/v), reduced alcohol (1.2 to 5.5–6.5% v/v) and lower alcohol wine (5.5 to 10.5% v/v), by Pickering (2000) and Saliba et al. (2013a); albeit these...
ing (2000) and Saliba et al. (2013a); albeit these classifications, which are loosely based on labeling and legislative requirements, vary between different countries (Pickering, 2000). Until recently, the Australian New Zealand Foods Standard Code required wine produced in Australia to contain a minimum alcohol content of 8%, however, Standard 4.5.1: Wine Production Requirements was amended in 2011, and the minimum alcohol requirement is now 4.5% (Saliba et al., 2013b). As a consequence, some lower alcohol wines containing less than 8% alcohol that were previously designated as 'wine products', for example Moscato, now meet the requirements to be considered as wine (Rowley, 2013).

In a recent study investigating Australian wine consumers’ demand for low alcohol wine, the majority of consumers surveyed, i.e. almost 70%, considered low alcohol wine to contain between 3 and 8% alcohol (Saliba et al., 2013b); interestingly, of the 851 consumers surveyed, 21% did not know the alcohol content of the wine they normally consumed. In a similar study involving United Kingdom (UK) wine consumers, the alcohol content of a typical bottle of wine was estimated to be 12.1%, whereas the alcohol content of low alcohol wine was estimated to be 5.9% (Bruwer et al., 2013). It’s perhaps worth noting that the alcohol content reported on wine labels is often understated (Alston et al., 2011); i.e. labeling regulations typically allow alcohol to be reported within a percentage, e.g. 0.5%, of the actual alcohol content by volume.

Aroma and flavor are undoubtedly critical to the appeal of wine to the consumer, together with color, taste and mouthfeel. The human preference for flavor in fruits and, in turn, the products derived from these is universally self-evident. Such flavor comes from ripening – but ripening is a double-edged sword when making wine, since extended ripening results in the higher accumulation of sugars, which are dutifully converted to alcohol by Saccharomyces wine yeast during fermentation. However, winemaker demand for greater flavor is not the only reason for over-ripening of grapes. Global warming, evidenced by the earlier phenology of grapevines, and hot weather events are more common (Webb et al., 2007) and tend to compress vintage, causing transport and scheduling difficulties and fermentation bottlenecks. This inevitably leads to longer ripening. Coupled with the tendency of certain varieties such as Shiraz to dehydrate (Tilbrook and Tyerman, 2008), as well as restrictions on the availability of water for irrigation, the outcome is unintentional over-ripening of grapes and the over-accumulation of sugars; which ultimately results in highly alcoholic wines.

In this paper, the factors influencing consumer and society demand for low alcohol wine are discussed, together with an overview of methods for reducing the concentration of ethanol in wine and thus, the industry’s ability to deliver wines of reduced alcohol content. The aims and objectives of a new Innovative Wine Production research program, underway at the University of Adelaide in Australia, are also outlined, to demonstrate industry’s willingness to develop and implement alcohol-reduction strategies.

2. Consumer and society demand for wine of reduced alcohol content

Beverage preferences are tending toward lighter styles, i.e. light-bodied white, rosé and Moscato wines. Indeed, Wine Australia recently reported ‘substantial growth in the volume of wine exported with ‘lower’ alcohol content’ (Rowley, 2013), which suggests market opportunities analogous to low-alcohol beers.

However, frequent media reports continue to fuel concerns about alcohol abuse and societal effects; while the health benefits previously associated with moderate wine consumption are overshadowed by convincing and probable evidence that a causal relationship between alcohol consumption and some cancers exists (Allen et al., 2009). As a consequence, public health advocates are pushing for increased taxes on wine, as well as greater restrictions on how wine can be marketed (Evans, 2013), so as to reduce alcohol consumption. Whilst it is not clear that wine (vs. other alcohol) is the primary cause of these problems, wine producers strongly advocate responsible consumption of alcohol (Winemakers’ Federation of Australia, 2012; Evans, 2013). Thus, the observed changes in beverage preferences are likely to be at least partially attributable to a combination of media scrutiny, consumer education and the introduction of alcohol taxes.

However, these trends may also reflect changes in consumers’ attitudes towards low alcohol wines. In 2011, Mueller and colleagues (2011) reported Australian wine consumers’
relative acceptance for low alcohol wine was only 6-8%. In contrast, a more positive result, i.e. 16% relative acceptance, was reported in a more recent study (Saliba et al., 2013b); with responsible driving and health cited as the reasons most strongly influencing participants' interest in low alcohol wine.

Bruwer and colleagues (2013) investigated the importance of choice cues on UK wine consumers' wine purchasing decisions and found no significant difference in the importance ratings assigned by buyers and non-buyers of low alcohol wine. Alcohol content was ranked 7th for both groups, with promotional offers (i.e. price discount), grape variety, country of origin and brand familiarity considered to be of more importance. However, the authors still considered alcohol content to be an important consideration, since 43% of consumers assigned this cue a rating ≥4.0 (on a 5-point Likert scale).

High alcohol wines attract higher import duties and taxes; i.e. costs which must either be absorbed, thereby reducing profitability, or passed on to price-sensitive consumers. A significant proportion of exported Australian wine, i.e. 34%, is sold in the UK (Wine Australia 2012). At the key price point of £3.99 per bottle, 45% of the price is represented by typical excise duty of £1.81/bottle. This rises by 33% to £2.41/bottle (60% of total price) for wine exceeding 15% alcohol. As such, there are real economic incentives for industry to meet consumer demand for wines with reduced alcohol content, but these wines must also meet consumer expectations of quality.

Wine Intelligence conducted a survey of regular UK wine drinkers' experiences of 5.5% v/v wines (Halstead, 2013). Some 23% of UK wine drinkers indicated they had bought and would continue to buy these wines; while another 15% were open to purchasing 5.5% v/v wines, but were yet to do so. However almost half the participants indicated they would not buy 5.5% v/v wines; the majority (80%) on principle, because 'the product has no relevance or appeal', while the remainder had previously bought 5.5% v/v wines but would not do so again, presumably due to a poor experience. Indeed, Halstead suggests that the poor quality of many 5.5% v/v wines may have put some consumers off low alcohol wines for good. In some cases, consumers did not realise they were purchasing low alcohol wines, prompting retailers to flag the 5.5% alcohol content more prominently.

Attempts have been made to profile consumers who purchase low alcohol wines and several studies suggest a bias towards females, both younger (18-34) and older (45-55), of mid to low income, who drink wine about once a week or who drink wine with food, with a low to medium level of involvement with wine (Saliba et al., 2013b; Halstead, 2013; Bruwer et al., 2013). Consumers' motivations for buying or not buying low alcohol wine have also been studied (Bruwer et al., 2013). Concern for the health, liking of taste, lower price and staying in control were the main motivations for consumers who buy low alcohol wines; whereas the non-availability of low alcohol versions of consumers' favourite brands, the perception of low quality and disliking of taste were the main motivations given by consumers for not buying low alcohol wines. Taste was again considered an important driver of acceptability and preference, in agreement with earlier studies (Saliba et al., 2013b).

The consumer research undertaken to date confirms the opportunity market for low alcohol wine, in both Australia and the UK. It is perhaps worth noting that retailers such as Sainsbury's in the UK have publically set ambitious goals for growing the lowered-alcohol wine segment and reducing the average alcohol content of their wines (Sainsbury, 2011); i.e. actions which further demonstrate confidence in consumer demand for low alcohol wine.

3. Industry's ability to deliver wine of reduced alcohol content

A range of methods are available for achieving wines of reduced alcohol content; most alcohol reduction strategies are based on principles which either reduce the concentration of fermentable sugar present in grapes or juice, or remove alcohol from wine (Pickering, 2000). Several of these strategies are discussed below.

The simplest approach to sugar reduction involves harvesting grapes at an earlier stage of development, i.e. when sugar levels are still low. However, this has implications for grape, and therefore wine, composition and quality, due to the associated reduction in aroma, flavor and color intensity, and increased acid content. Wines made with unripe fruit are typically per-
ceived as thin, ‘green’, low intensity wines; i.e. wines which exhibit sensory attributes that tend to be less appealing to consumers than those of high alcohol wines.

Glucose oxidase has also been shown to be capable of reducing the glucose content of grape juice. In the presence of oxygen, this dehydrogenase enzyme catalyzes the oxidation of glucose to gluconolactone, which can then be hydrolyzed to gluconic acid (Pickering, 2000). Fermentation of the resulting glucose-depleted juice produces wines with up to 40 % lower ethanol concentrations; albeit wines which require sweetening or deacidification to address acid imbalances due to high levels of gluconic acid (Pickering et al., 1999). However, in many countries, glucose oxidase is not a permissible wine additive (Pickering, 2000).

The addition of water to grape must or wine can effectively dilute the concentrations of sugar and alcohol respectively; but the intensity of wine aroma, flavor and color is also diluted, and so quality is diminished. Furthermore, in many countries, Australia and France for example, the addition of water to juice or wine is not legally permitted. Alcohol dilution can instead be achieved via blending (Pickering, 2000); i.e. with either reduced alcohol or partially fermented wine, which are grape-derived and therefore legally permitted. However, there are limitations on the styles of wine that can be produced in this manner: typically sweeter wine styles. When fermentation is arrested early, i.e. before grape sugars are fully converted to ethanol, the resulting wines will have lower alcohol concentrations, but also perceptible levels of sweetness due to high residual sugar levels; being 7.5-20 g/L for semi-sweet wines and 20-150 g/L for sweet wines (Iland and Gago, 1997). Despite their reduced alcohol content, sweet wines are unlikely to appeal to health-conscious consumers, because of their inherent calorie count. Precautions must also be taken to ensure the stability of sweet wine styles; i.e. sterile filtration and/or sulfur dioxide additions.

Various distillation processes have been used to remove alcohol from wine, post-fermentation. Early distillation methods tended to reduce flavor and quality, through the co-evaporation of wine volatiles; but modern distillation processes can remove ethanol at lower temperatures, require much shorter processing times and incorporate aroma recovery techniques (Pickering, 2000). The spinning cone column is a popular example, but the capital investment in infrastructure is significant and while the technology is permitted in the USA it has not yet been approved for use in Europe (Halstead, 2013).

Reverse osmosis is a membrane separation process that has been successfully used to reduce the alcohol content of fermented beverages, including wine, beer and cider (Bui et al., 1986; Lopez et al., 2002), via pressure filtration through a membrane permeable to alcohol and water. The loss of flavor typically associated with distillation-based methods for alcohol reduction is largely overcome, because reverse osmosis is performed at low temperature; although some diffusion of aroma compounds, as well as organic acids and potassium has been reported (Pickering, 2000).

Modest reductions in alcohol, i.e. from 16% to below 14%, for example, to avoid import duties without detrimental side-effects on wine sensory properties, are possible if planned in advance, but are more difficult to achieve retrospectively. Industry has the ability to reduce the alcohol content of finished wine by several percent, using distillation or reverse osmosis methods. However, reducing alcohol even further, for example to 9 %, let alone 4.5 % (as in beer), whilst retaining other sensory attributes is simply not possible with any one current technology or approach. Thus, at present, industry cannot produce wines of markedly reduced alcohol content that are indistinguishable from the full alcohol strength equivalent.

Further research is still required to fully understand how alcohol reduction of wine modifies our perceptions of wine aroma, flavor, taste, mouthfeel and quality, from physico-chemical and perceptual perspectives. Research is also needed to determine wine consumers’ attitudes towards the different methods used to deaccelerate wine.

4. Industry’s willingness to deliver wine of reduced alcohol content: Innovative Wine Production at the University of Adelaide

Making and selling wine in Australia, even in a ‘good’ year, has become increasingly more challenging. Compounding the environmental stresses in vineyards, are challenges associated with rapidly changing consumer preferences, high labor costs, unfavorable exchange rates, and health and taxation impacts of high alcohol. To overcome these challenges, an unpreceden-
Ed combination of researchers and wine industry participants has been assembled to undertake research to address one of the major problems facing industry: that of high sugar accumulation during ripening, resulting in highly alcoholic wines, that are more difficult to achieve flavor and aroma balance in.

In 2013, the Australian Research Council awarded $2.4 million funding to the University of Adelaide to establish an Industrial Transformation Training Centre focused on Innovative Wine Production. This Centre will provide new knowledge, methods and technologies to help the wine industry develop profitable strategies for grape growing and winemaking that achieve the desired balance of taste, mouthfeel, aroma/flavor, color and alcoholic strength.

The specific aims of the project are:

• In the vineyard, to curb sugar accumulation and accelerate the accumulation of aroma and flavor compounds;
• In the winery, to remove sugar prior to fermentation, divert sugar away from alcohol production pathways, improve the reliability and reduce the duration of high sugar fermentations, and enhance the sensory properties of wine;
• Post-fermentation, to selectively remove alcohol and develop additives to adjust levels of sensory compounds in wines from under-ripened grapes or volatiles lost from wines of reduced alcohol content;
• To define current market and consumer perceptions and preferences for wines of reduced alcohol content and, in new markets, use this knowledge to inform the production process.

The Centre brings together researchers from the University of Adelaide, the Australian Wine Research Institute, the Commonwealth Scientific and Industrial Research Organisation and the South Australian Research and Development Institute, and industry partners spanning the entire production chain, i.e. grapegrowers, winemakers, suppliers, downstream/waste processors and retailers. This integrated whole-of-production-chain approach to Innovative Wine Production (Figure 2) is the key to success in achieving incremental alcohol reductions and/or flavor enhancement. In broad terms, the approaches to be used will: (i) reduce sugar or enhance flavor accumulation in the vineyard; (ii) remove sugar or maximize flavor in grape juice; (iii) avoid fermentation of sugar to alcohol; and (iv) remove alcohol post-fermentation.

Research topics fall into three broad areas. Grapegrowing is key to wine composition. Decades of effort honing ways to drive ripeness and sensory intensity need to be revised or reversed to produce the raw material needed for the wine products demanded by the market.

Microbiology remains the vehicle for turning grapes into wine. Understanding microbes, how they interact and how they can be used to improve process efficiency and drive vine behavior, or sensory/alcohol content will be critical for molding grapes into the required wines.

Studies into grape and wine processing and consumer insight will be key where grapes, wines and microbes fall short, and will afford another set of tools for tuning the finished product.

Industry is open to the adoption of innovative wine production practices that deliver economic benefit, without compromising wine quality or consumer acceptability, and the direct involvement of industry partners in the Centre demonstrates industry’s willingness to deliver wine of reduced alcohol content.

5. Conclusion

The wine industry is currently facing a number of significant challenges, one of which involves addressing the high alcohol content of wine. For some 30 years, the trend of using ripener grapes has contributed to the Australian wine industry’s international success, but ripener flavor also means grapes rich in sugars, which yeast dutifully convert to alcohol. Thus, red wines with in excess of 16% alcohol are not uncommon. Reducing alcohol content is therefore a priority for many winemakers and so the Innovative Wine Production research outlined in this paper will develop profitable strategies for grape growing and winemaking to achieve reduced alcohol content wines. In this way, the project will deliver both economic and social benefits: industry will be better placed to meet consumers’ expectations and demand for wines of reduced alcohol content; excise duty, which is typically applied according to alcohol content, will decrease with reductions in alcohol content; and the adoption of alcohol-reduction strategies will assist the wine industry to achieve its commitment to promote socially responsible alcohol consumption practices.
6. References


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