Influence of Serving Temperature and Wine Type on Perception of Ethyl Acetate and 4-ethyl Phenol in Wine

Article in Journal of Wine Research · March 2009
DOI: 10.1080/09571260902978535

Available from: Margaret Anne Cliff
Influence of Serving Temperature and Wine Type on Perception of Ethyl Acetate and 4-ethyl Phenol in Wine

Margaret A. Cliff & Marjorie C. King

Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, 4200 Highway 97, Summerland, BC, Canada, V0H 1Z0

Published online: 18 Jun 2009.

To cite this article: Margaret A. Cliff & Marjorie C. King (2009) Influence of Serving Temperature and Wine Type on Perception of Ethyl Acetate and 4-ethyl Phenol in Wine, Journal of Wine Research, 20:1, 45-52, DOI: 10.1080/09571260902978535

To link to this article: http://dx.doi.org/10.1080/09571260902978535

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the “Content”) contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at http://www.tandfonline.com/page/terms-and-conditions
Influence of Serving Temperature and Wine Type on Perception of Ethyl Acetate and 4-ethyl Phenol in Wine

MARGARET A. CLIFF and MARJORIE C. KING

Original manuscript received, 23 January 2008
Revised manuscript received, 25 March 2009

ABSTRACT  This research explored the effect of temperature on the perception of two chemical compounds (ethyl acetate, 4-ethyl phenol) in four base wines (Gewurztraminer, Chardonnay, white blend, red blend). The perceived aroma intensity was evaluated at three serving temperatures (5°C, 10°C, 22°C) with wines which were spiked with 200 ppm ethyl acetate and 1000 ppm 4-ethyl phenol, using a panel of eight judges. Special attention was paid to the insulation of the wine glasses to maintain the temperature of the wine samples. The panel was required to wear wool scarves and gloves to eliminate cognitive and physical clues. The relationships between temperature and perceived intensity for fruit, ethyl acetate and 4-ethyl phenol were between 0.951 and 0.991, with all base wines. The perception of ethyl acetate was most noticeable in the neutral wines (white, red blends) and least noticeable in the highly aromatic Gewurztraminer and Chardonnay wines at 20°C. In contrast, 4-ethyl phenol was least noticeable at 20°C in the wines with greater phenolic constituents, Chardonnay and the red blend. The chemical 4-ethyl phenol appeared to suppress the perception of fruit in all base wines at all temperatures.

Introduction

Few articles have been reported that investigated the olfactory response to aromas at different temperatures. Stone (1963) found no significant difference in olfactory sensitivity with varying solution temperatures (12.5 to 35°C). This was thought to be due to a temperature equilibrium of the sample with body temperature since the temperature of inhaled and exhaled air in the nasal cavity was found to equilibrate rapidly with body temperature.

Voirl and Daget (1986) investigated the nasal and retro-nasal olfactory perception of beef flavour at three concentrations and three temperatures. For all attributes a linear regression was obtained between perceived intensity and temperature, with the slopes varying for the different attributes. The meaty intensity decreased with increasing temperature while the vegetable intensity increased with increasing...
temperature. They concluded that olfactory pathways provoke slight changes in aroma intensity and quality under different temperature conditions.

Accepted wine serving temperatures (white 8 – 12°C; red 18 – 22°C) are based on optimising wine flavour. For red wines the temperature range enhances aromas yet diminishes perceived bitterness and astringency (Jackson, 2002).

It is widely recognised that volatility of compounds is temperature dependent. The temperature response is quantified by measuring the vapour pressure of the molecules in a closed system at a fixed temperature. Molecules with a weaker intermolecular attraction typically have steeper temperature response curves (Mortimer, 1971). Jackson (2002) has noted that a variation in wine temperature will change the relative proportion of the headspace aromatics. Perhaps differences in vapour pressures for these compounds may affect the perception of the wine aroma. Little work has been conducted to determine if this would apply to specific wine compounds that may be perceived as contributing to wine defects.

It is speculated that temperature changes may enhance or suppress the detection of specific wine aromas, but little is known about the interaction of aroma in the headspace of a wine. Anecdotally, wine judges have reported that oak aromas can dominate chilled white wines, while at room temperatures the fruit becomes more apparent and the oak appears to be more integrated into the wine’s aroma.

Therefore, the objective of this research was to evaluate the effect of temperature on the perception of two specific compounds, ethyl acetate and 4-ethyl phenol. At higher levels, these compounds have been identified as contributing to the two wine faults volatile acidity (Gibereau-Gayon et al., 2000) and Brettanomyces (Chatonnet, 1993). In order to accomplish this objective, special effort was taken to control and maintain wine temperature and to eliminate cognitive and psychological clues.

Materials and Methods

Wines Used

Four composite wine blends (Chardonnay, Gewurztraminer, white blend and red blend) were prepared from bottled British Columbia (BC) Vintners Quality Alliance (VQA) commercial wines. The wines utilised for the white blend were chosen to give a clean lightly fruity composite wine. The Chardonnay wines had been barrel aged so they had a strong oak character. The Gewurztraminer blend was very aromatic with a lychee, muscat, and floral character, while the red blend was prepared entirely from Bordeaux grape varieties. Blends were then partitioned into four equal volumes, two to be used as controls and the other two to be treated with 200 ppm ethyl acetate and 1000 ppm 4-ethyl phenol, respectively. The defect levels were chosen to be slightly above reported threshold levels, so that they would be detectable by all judges but would not be so dominant in the wines that temperature differences would not be detectable. All wines and wine glasses were stored at the treatment temperatures (0, 10 or 22°C) for eight hours prior to assessment. All treatments were assigned three-digit random numbers.

Sensory Panel

The tasting panel consisted of eight staff members (four males, four females) from Agriculture and Agri-Food Canada (Summerland, BC), who had been selected based on availability, motivation, and previous sensory experience. Triangle and paired
comparison tests were used to train the judges and ensure that they were able to detect the added compounds in all four of the base wines. For both ethyl acetate and 4-ethyl phenol, judges were asked to identify the wine that was different in a set of three wines and to indicate if the duplicate or the single wine contained the added compound. They were also asked to identify the wine with the added compound from paired samples. Judges were given feedback and clarification on the correctness of their responses. Compound levels for the practice wines were at the same concentration as the experimental wines. Judges were allowed to practice until they were able, in all of the base wines, correctly identify those that had added ethyl acetate and 4-ethyl phenol.

Wine Glasses

Black 8 oz tulip shaped wine glasses were used for this research. Each was individually wrapped with 1 cm thick milar bubble film and secured with duct tape. Film was pre-cut to a configuration which would lay flat against the wine glass. Glasses were placed in temperature controlled rooms at 0°C and 10°C (Envirocon, USA) or left at room temperature (22°C). The effectiveness of the milar film was demonstrated using a thermocouple (Omega Engineering, MA); sample temperature (0°C) was maintained for a period of four minutes.

Experimental Design and Procedures

Sensory analysis was conducted on the wines spiked with ethyl acetate and 4-ethyl phenol using separate evaluations, but the same sensory panel. In each sensory evaluation session, one of the wine types was evaluated at all three temperatures. The judges then took a break before evaluating another set of wine samples at all three temperatures. At each temperature, the base wine and treated wine (base wine with added compound) were evaluated in random order. The base wine was included in each evaluation to provide a reference for the assessment of the treated samples. The presentation order for wine types (Chardonnay, Gewurztraminer, white blend, red blend) and temperature (0, 10, 22°C) were completely randomised. Judges evaluated all samples in duplicate.

Both the wines and glasses were stored at the desired temperature prior to assessment, then 30 ml wine samples were poured into the glasses just prior to the arrival of the judges. Judges had a prearranged schedule. Under these conditions, each pair of wines was evaluated within three minutes of being removed from the controlled temperate storage. All glasses were covered with 6 cm plastic Petri dishes. Judges wore gloves on the hands and scarves over their mouths, to eliminate thermal clues from the stems and rims of the wine glasses.

Judges swirled the glass and held the glass to their nose, without touching their face. The wool scarf and gloves acted as a physical barrier from the cold. Judges evaluated all wines for intensity of fruit and volatile acidity (ethyl acetate) or intensity of fruit and *Brettanomyces* (4-ethyl phenol). Evaluations were conducted on unstructured 10 cm line scales, anchored at 1, 5 and 9 cm, with the terms low, moderate and high intensity, respectively.

Statistical Analysis

Data were quantified by measuring the distance in cm from the origin of each line scale. Data were analyzed using a two-step process using the general linear model (GLM) in
SAS (Statistical Analysis System) (SAS Institute, Cary, NC). A preliminary three-way Analysis of Variance (ANOVA) (judge, temperature, and replication) was used to evaluate judge performance, using $F$-value for judge-by-replication and judge-by-temperature to evaluate reproducibility and consistency (data not shown). When there were no significant judge-by-replication differences, a second ANOVA (wine, temperature) was used to evaluate the experimental treatments. Fisher’s least significant difference (LSD) was used to evaluate statistical differences among the means at $p \leq 0.05$. The statistical subscripts from these analyses were used to embellish the plots of the linear regressions, as described below.

Linear regression \[ PI = m(T) + c \] was used to characterise the relationship between perceived intensity (PI) and temperature (T), with $m$ and $c$ as the slope of the linear and intercept respectively. All plots and regressions were calculated using MS Excel (Seattle, WA).

The effect of 4-ethyl phenol on the fruit aroma intensity was calculated as the change in fruit intensity between the control wine and the treated wine, at the corresponding temperature.

**Results and Discussion**

The chemical compounds that were added to the wines in this study had very different physical and chemical characteristics (Table 1). Ethyl acetate has a distinctly lower boiling point and markedly higher vapour pressure than 4-ethyl phenol, but humans can detect 4-ethyl phenol at much lower levels. These compounds were chosen because they were recognised as contributing to wine defects (Gibereau-Gayon et al., 2000), they were commercially available, and they were stable when added to wine. Supra-threshold concentrations were selected for this research to permit scaling and scoring of perceived intensities.

Analysis of variance (ANOVA) showed that temperature was a significant source of variation for the perceived fruit intensity ($F = 33.25$, $p \leq 0.001$; $F = 34.28$, $p \leq 0.001$) and the perceived fault ($F = 7.99$, $p \leq 0.001$; $F = 13.28$, $p \leq 0.001$) in wines spiked with 200 ppm ethyl acetate and 1000 ppm 4-ethyl phenol, respectively. However, the wine-by-temperature effects were not significant ($F = 0.27 – 0.84$, $p \geq 0.05$), indicating that the temperature response was similar for both compounds in all wines.

Wines differed in fruitiness in the ethyl acetate spiked ($F = 3.46$, $p \leq 0.05$) and 4-ethyl phenol spiked ($F = 15.30$, $p \leq 0.001$) wines. Fruitiness was higher in Gewurztraminer (4.23a, $n = 192$) than the other wines (3.0 – 3.3b, $n = 162$), which did not differ.

Temperature significantly influenced perception of fruitiness as well as the perceived intensity of the defects from the added compounds, ethyl acetate and 4-ethyl phenol (Figure 1). The relationships between perceived intensities and temperature were

| Table 1. Physical-chemical specifications for defect compounds (Sigma-Aldrich, 2006) |
|---------------------------------|-----------------|-----------------|
| ethyl acetate                  | 4-ethyl phenol  |
| Molecular weight               | 88.11           | 122.17          |
| Boiling point                  | 76.5°C          | 218°C           |
| Vapor pressure                 | 73 mm Hg @ 20°C | 0.13 mm Hg @ 20°C |
| Odour threshold                | 0.96 – 176.9 mg/L | 0.42 – 0.72 mg/L.a |

*Gibereau-Gayon et al. (2000).*
Table 2. Summary of F-values* for ANOVA main and interaction effects for wine treated with 100 ppm ethyl acetate and with 1000 ppm 4-ethyl phenol

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Wines with ethyl acetate (200 ppm)</th>
<th>Wines with 4-ethyl phenol (1000 ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fruit</td>
<td>Defect</td>
</tr>
<tr>
<td>Wine</td>
<td>3.46*</td>
<td>0.80</td>
</tr>
<tr>
<td>Temp</td>
<td>33.25***</td>
<td>7.99***</td>
</tr>
<tr>
<td>Wine*temp</td>
<td>0.65</td>
<td>0.46</td>
</tr>
</tbody>
</table>

* * * indicate significance at $p < 0.05$, $p < 0.01$ and $p < 0.001$, respectively.

linear for fruitiness ($r = 0.979$) and ethyl acetate ($r = 0.980$) (Figure 1a) in the ethyl acetate spiked wines, as well as, fruitiness ($r = 0.991$) and 4-ethyl phenol ($r = 0.951$) (Figure 1b) in the 4-ethyl phenol spiked wines.

In this study the fruity volatile components of wines, as well as the added compounds were more noticeable at higher temperatures. The pattern of response for both ethyl

![Figure 1](image1.png)

**Figure 1.** Linear regression of mean intensity scores ($n = 128$) for fruit (solid line) and faults (dashed line), for base wines served at 0, 10 and 22°C. Base wines were spiked with 200 ppm ethyl acetate (1A) and 1000 ppm 4-ethyl phenol (1B). For a given regression, mean intensity scores marked with different subscripts are significantly ($p \leq 0.05$) different.
acetate and 4-ethyl phenol was not dependent on the base wine, since the wine-by-
temperature interaction was not significant. The slope of the line for the change of
perceived fruit intensity with temperature was steeper than the slope of line for the
rate of change of ethyl acetate or 4-ethyl phenol. ANOVA showed that perceptions
of fruit at 5, 10 and 22°C were all significantly different \(p \leq 0.05\); whereas, the
perception of both added compounds only differed between 5 and 10°C, and was not
significantly \(p \leq 0.05\) different at 22°C.

At 22°C there were differences amongst the wine types for perception of ethyl
acetate. Ethyl acetate was perceived more intensely in the white and red wines
(22°C) (Figure 2a). This suggests that Gewurztraminer and Chardonnay wines
contain constituents that masked the perception of ethyl acetate. It might be that
the strong perfumed and oaky notes in these varieties could make perception and/or
recognition more difficult compared to the less aromatic and more neutral wines
(white, red). In contrast, 4-ethyl phenol was perceived more intensely in the white
and Gewürztraminer wines (22°C) (Figure 2b), compared to the red and Chardonnay
wines. While it is possible that these wines have constituents that interfere with the

Figure 2. Mean aroma intensities \(n = 16\) of ethyl acetate and 4-ethyl phenol in
wines with 200 ppm ethyl acetate (2A) and 1000 ppm 4-ethyl phenol (2B) added.
Wines (red, white, Gewurztraminer, Chardonnay) wines at 22°C. For a given
wine, bar charts marked with different subscripts were significantly different
at \(p \leq 0.05\).
perception of 4-ethyl phenol, it is also possible that judges were more familiar with a Brettanomyces character in a red wine or oak aged Chardonnay. This familiarity may have caused them to rate the 4-ethyl phenol defect as less intense.

Whatever the mechanism, the presence or addition of compounds to the mixture changed the response or observed effects. While the change in fruit response was not consistent for the addition of ethyl acetate (data not shown), the effect of added 4-ethyl phenol reduced the perception of fruit at all temperatures for all varieties (Figure 3). This was calculated by comparing the perceived fruit of the treated sample with the compared fruit of the reference sample. The magnitude of the effect was largest for the white and Gewurztraminer wines at 22°C, with a decrease in fruitiness of -2.0 and -2.2, respectively. The size of this effect was larger than the error of measurement (LSD = 1.3 – 1.37) and indicated that 4-ethyl phenol significantly depresses fruit character.

Conclusion

This research showed that perception of ethyl acetate and 4-ethyl phenol in wines increased linearly with increases in serving temperature. The increase in perceived defect took place despite an increase in fruit intensity. In addition to this, the presence of 4-ethyl phenol suppressed fruit character in all four base wines. This suggested that 4-ethyl phenol not only produced its own characteristic odour it suppressed the more desirable fruit character of the wine.

References


