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Relationships between wine quality and substances exceeding the odour threshold produced by *Hanseniaspora*

Andrea Caridi^{1,*}, Marco Poiana¹

¹ Mediterranea University of Reggio Calabria, Department of Agriculture, Via Feo di Vito, 89122 Reggio Calabria, Italy

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*correspondence:
acaridi@unirc.it

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ABSTRACT

Several recent studies propose the use of yeasts from the *Hanseniaspora* genus in winemaking. In this paper, the negative and positive wine components due to the activity of these yeasts are listed and critically analysed. Only the substances produced in amounts exceeding their odour threshold are considered. This review highlights the relationships between the use of *Hanseniaspora* strains in winemaking and the quality of the wines so obtained. First of all, the acetic acid concentration in grape wines is very important; legal limits for its content in wine vary by country and wine type. A moderate production of ethyl acetate positively contributes to the sensory quality of the wines. Isobutanol is related to an unpleasant aroma. Acetoin, 1-hexanol, decanoic acid, octanoic acid, and hexanoic acid: the less, the better. Isoamyl alcohol may positively contribute to the complexity of the aroma of wines. 2-Phenylethanol contributes to fine rose notes in wine aroma. 2-Phenylethyl acetate is a compound that imparts flowery, rosy, and honey-like fragrances with fruity undertones to wines. Isoamyl acetate is one of the esters most markedly contributing to the aroma profile of white wines. Ethyl hexanoate is responsible for tropical fruity attributes. Hexyl acetate, ethyl decanoate, ethyl butyrate, β -citronellol, linalool, ethyl octanoate, β -damascenone: the more, the merrier.

KEYWORDS: *Hanseniaspora*, odour threshold, wine quality

INTRODUCTION

The single most important factor in winemaking is the sensory quality of the final product (Plata *et al.*, 2003). Even if the grape wine flavour cannot be totally predicted, its volatile profile is dominated by the components exceeding their odour thresholds. This is true both for positive and negative effects, depending on the aromatic profile of each component. Consequently, it is important that the positive components are over their odour thresholds and that the negative components are under their odour thresholds. Recently, many strains of the genus *Hanseniaspora* were proposed as starter and/or adjunct cultures for grape wine production; however, the concentration of the crucial volatile components was not always reported. Furthermore, it is important to note that the pure cultures of *Hanseniaspora* are always unable to finish the fermentation, resulting in unfermented sugar in the grape wines. Considering this, several methodologies are listed below to study the fermentative activity of *Hanseniaspora* strains in grape juices.

- Fermentations were carried out for a period of 12 days (Valera *et al.*, 2021). Fermentation kinetics were controlled as CO₂ liberated by daily weighing. After 12 days of fermentation, samples were analysed, and residual sugars were quantified.
- Fermentations were carried out for a period of 14 days (Andorrà *et al.*, 2010). Sugar consumption was monitored daily; fermentations were considered to be finished when the level of reducing sugars was below 2 g L⁻¹. However, the pure *H. uvarum* culture did not finish the fermentation (20 g L⁻¹ of residual glucose).
- Fermentations were carried out for a period of 18 days (Testa *et al.*, 2021). The alcoholic fermentation was monitored considering the variation of reducing sugars and ethanol content.
- Fermentations were carried out for a period of 20 days (del Fresno *et al.*, 2025). Fermentation was monitored daily measuring the decrease in density, which indicated the correct progress of the alcoholic fermentation until its completion.
- Fermentations were carried out for a maximum period of 30 days (Cordero-Bueso *et al.*, 2013). When sugar content was lower than 2 g L⁻¹ or after 30 days of fermentation.
- Fermentations were carried out to dryness for a maximum period of 180 days (du Plessis *et al.*, 2017). The final wine chemical analyses were carried out when the wines showed residual sugar < 4 g L⁻¹.
- Fermentations were carried out without indicating the days of fermentation (de Benedictis *et al.*, 2011). The kinetics of the fermentations were monitored by evaluating daily the loss of weight due to the production of CO₂; when the CO₂ evolution stopped (*i.e.*, at constant weight), the samples were directly analysed or stored at -20 °C.

A quick review about negative and positive components related to *Hanseniaspora* activity in grape wines will now be carried out, reporting, in decreasing order of odour threshold, the components exceeding their odour threshold. Only the values that were higher than those produced by the control have been

reported, *i.e.*, spontaneous fermentation or fermentation using selected strains of *Saccharomyces cerevisiae*.

1. Negative components/off-flavours

1.1. Acetic acid

Several authors have tested yeasts of the genus *Hanseniaspora* in winemaking, but they have not reported the concentration of acetic acid in the produced wines (Bagheri *et al.*, 2018; Hu *et al.*, 2018; Olivera *et al.*, 2024). Since, in our opinion, this parameter is essential for the use of *Hanseniaspora* in winemaking, the results of these papers have not been taken into consideration in this article. The aromatic descriptor of this compound is “vinegar”, its odour threshold is 700 mg L⁻¹, and the presence of acetic acid at levels above the perception threshold is undesirable (Carrau *et al.*, 2023).

The following papers reported acetic acid contents, *i.e.*, volatile acidity, exceeding the odour threshold, thereby negatively affecting the sensory quality of the wine; all the other papers described in this article obtained, using *Hanseniaspora*, wines with acetic acid content below 700 mg L⁻¹.

Andorrà *et al.*, 2010 – Grape wine produced at 20 °C from Macabeo must sterilised by the addition of 250 mg L⁻¹ of dimethyldicarbonate and inoculated with: a) 10⁶ cells mL⁻¹ of *H. uvarum* HuB10 contained 37,500 mg L⁻¹; b) 9 × 10⁵ cells mL⁻¹ of *H. uvarum* HuB10 and 10⁵ cells mL⁻¹ of *S. cerevisiae* QA23 contained 1580 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* QA23) contained 490 mg L⁻¹.

Badura *et al.*, 2023 – Grape wine produced at 22 °C from pasteurised Gewürztraminer grape must inoculated with: a) 10⁷ cells mL⁻¹ of *H. osmophila* NRRL-Y1613 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 1230 mg L⁻¹; b) 10⁷ cells mL⁻¹ of *H. nectarophila* GYBC-283 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 1100 mg L⁻¹; c) 10⁷ cells mL⁻¹ of *H. opuntiae* GYBC-284 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 940 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG) contained 840 mg L⁻¹.

Cordero-Bueso *et al.*, 2013 – Grape wine produced at 20 °C from Malvar grape must filter-sterilised inoculated with 10⁶ cells mL⁻¹ of *H. guilliermondii* CLI 921 contained 900 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae*) contained 140 mg L⁻¹.

de Benedictis *et al.*, 2011 – Grape wine produced at 25 °C from Negroamaro grape must clarified by centrifugation, sterilised by membrane filtration, and inoculated with 10⁶ cells mL⁻¹ of: a) *H. uvarum* 8797 contained 780 mg L⁻¹; b) *H. uvarum* 8799 contained 740 mg L⁻¹; c) *H. uvarum* 8801 contained 750 mg L⁻¹; d) *H. uvarum* 8802 contained 730 mg L⁻¹; e) *H. uvarum* 8807 contained 810 mg L⁻¹; f) *H. uvarum* 8810 contained 880 mg L⁻¹; g) *H. uvarum* 8811 contained 950 mg L⁻¹; h) *H. uvarum* 8813 contained 940 mg L⁻¹; i) *H. uvarum* CBS314 contained 1220 mg L⁻¹; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* CM) contained 550 mg L⁻¹.

du Plessis *et al.*, 2017 – Synthetic wine produced at 22 °C from chemically defined grape juice, filter-sterilised and inoculated with: a) *H. uvarum* H2 contained 720 mg L⁻¹; b) *H. uvarum* H3 contained 840 mg L⁻¹; c) *H. uvarum* H10 contained 880 mg L⁻¹; the control (inoculated with *S. cerevisiae* S3) contained 290 mg L⁻¹.

Filippousi *et al.*, 2024 – Grape wine produced at 16 °C from Sideritis grape must unfiltered, added with potassium metabisulfite to get total sulfur dioxide of 30 ppm and inoculated with 10⁷ cells mL⁻¹ of *H. opuntiae* L1 and, after eight hours, with 10⁵ cells mL⁻¹ of *S. cerevisiae* W7 contained 770 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* W7) contained 640 mg L⁻¹.

Valera *et al.*, 2021 – Grape wine produced at 20 °C from Chardonnay grape must, treated with 200 mg L⁻¹ dimethyldicarbonate and inoculated with 10⁵ cells mL⁻¹ of *H. uvarum* AWRI1280, contained 910 mg L⁻¹; the control (inoculated with 10⁵ cells mL⁻¹ of *S. cerevisiae* ALG804) contained 450 mg L⁻¹.

Zhang *et al.*, 2018 – Icewine produced at 16 °C from Vidal blanc grape juice, added with sulfur dioxide (80 mg L⁻¹) and inoculated with 10⁷ cells mL⁻¹ of *H. vineae* CVE-HV11 and 10⁶ cells mL⁻¹ of *S. cerevisiae* CVE-SC45 contained 1660 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* CVE-SC45) contained 1640 mg L⁻¹.

Final commentary: the acetic acid concentration in grape wines is very important. Legal limits for acetic acid content in wine vary by country and wine type. Sensory detection often starts around 0.6–0.9 g L⁻¹.

1.2. Ethyl acetate

Ethyl acetate is the most abundant ester in wine (Plata *et al.*, 2003); its odour threshold is 7.5 mg L⁻¹ and it can be described as “apple, fruity” (Lai *et al.*, 2023). At low levels, it confers aromatic complexity to the wine, giving it a “fruity” aroma (Godoy *et al.*, 2020); instead, according to Viana *et al.* (2008), ethyl acetate in wine can impart spoilage character at levels of 150–200 mg L⁻¹. Some strains of *Hanseniaspora* were reported to produce ethyl acetate over these levels, thereby negatively contributing to the sensory quality of the wine.

Badura *et al.*, 2023 – Grape wine produced at 22 °C from pasteurised Gewürztraminer grape must inoculated with: a) 10⁷ cells mL⁻¹ of *H. uvarum* DSM2768 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 558.07 mg L⁻¹; b) 10⁷ cells mL⁻¹ of *H. meyeri* NRRL-Y27513 and 10⁶ cells of *S. cerevisiae* Uvaferm CEG contained 332.86 mg L⁻¹; c) 10⁷ cells mL⁻¹ of *H. guilliermondii* NRRL-Y1625 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 318.93 mg L⁻¹; d) 10⁷ cells mL⁻¹ of *H. nectarophila* GYBC-283 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 312.98 mg L⁻¹; e) 10⁷ cells mL⁻¹ of *H. opuntiae* GYBC-284 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 291.07 mg L⁻¹; f) 10⁷ cells mL⁻¹ of *H. osmophila* NRRL-Y1613 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 151.6 mg L⁻¹; the

control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG) contained 115.8 mg L⁻¹.

Cordero-Bueso *et al.*, 2013 – Grape wine produced as previously reported contained 874.4 mg L⁻¹; the control contained 39.5 mg L⁻¹.

de Benedictis *et al.*, 2011 – Grape wine produced at 25 °C from Negroamaro grape must clarified by centrifugation, sterilised by membrane filtration, and inoculated with 10⁶ cells mL⁻¹ of: a) *H. uvarum* 8801 contained 151.7 mg L⁻¹; b) *H. uvarum* 8807 contained 150.6 mg L⁻¹; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* CM) contained 14.3 mg L⁻¹.

Filippousi *et al.*, 2024 – Grape wine produced as previously reported contained 585.87 mg L⁻¹; the control contained 170.04 mg L⁻¹.

Gallo *et al.*, 2023 – Grape wine produced at 18–20 °C from Chardonnay grape must, added with sulfur dioxide (15 mg L⁻¹) and inoculated with 5 × 10⁶ cells mL⁻¹ of *H. vineae* Hv205 and, in sequential inoculation at 30 % of the alcoholic fermentation, with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* LVCB contained 184 mg L⁻¹; the control (inoculated with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* LVCB) contained 142 mg L⁻¹.

Li *et al.*, 2022 – Grape wine produced from Sauvignon blanc grape must added with sulfur dioxide (30 mg L⁻¹) in the form of potassium metabisulfite and 3-isobutyl-2-methoxypyrazine (52 ng L⁻¹), and inoculated with 5 × 10⁶ cells mL⁻¹ of *H. uvarum* H11_G1_2, kept at 20 °C for 5 days, transferred to 16 °C and inoculated with *S. cerevisiae* Lalvin EC1118TM, contained 248.15 mg L⁻¹; the control (inoculated with *S. cerevisiae* Lalvin EC1118TM) contained 74.99 mg L⁻¹.

Final commentary: a moderate production of ethyl acetate positively contributes to the wines' sensory quality.

1.3. Acetoin (*i.e.*, 3-hydroxybutan-2-one)

Acetoin affects the wine bouquet; its odour threshold is 150 mg L⁻¹ and it is described as being “creamy, butter, fat” (Carrau *et al.*, 2023). One strain of *Hanseniaspora* was reported to produce acetoin exceeding the odour threshold, so negatively contributing to the wines' sensory quality.

Cordero-Bueso *et al.*, 2013 – Grape wine produced as previously reported contained 189.2 mg L⁻¹; the control contained 6.9 mg L⁻¹.

Final commentary: acetoin – the less, the better.

1.4. Isobutanol (*i.e.*, 2-methyl-1-propanol or isobutyl alcohol)

At least four different descriptors, all with the odour threshold of 40 mg L⁻¹, were reported: “fusel, alcohol” (Guth, 1997), “wine, solvent, bitter” (Testa *et al.*, 2021), “fusel oil, chemical” (Carrau *et al.*, 2023), and “solvent, chemical alcoholic, malt notes, wineosity notes” (Tarko & Duda, 2024). Some strains of *Hanseniaspora* were reported to produce isobutanol levels exceeding the odour threshold, thereby negatively contributing to the sensory quality of the wine.

Andorrà *et al.*, 2010 – Grape wine produced at 20 °C from Macabeo must sterilised by the addition of 250 mg L⁻¹ of dimethyldicarbonate and inoculated with 9 × 10⁵ cells mL⁻¹ of *H. uvarum* HuB10 and 10⁵ cell mL⁻¹ of *S. cerevisiae* QA23 contained 55.39 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* QA23) contained 24.51 mg L⁻¹.

Badura *et al.*, 2023 – Grape wine produced at 22 °C from pasteurised Gewürztraminer grape must inoculated with: a) 10⁷ cells mL⁻¹ of *H. opuntiae* GYBC-284 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 190.04 mg L⁻¹; b) 10⁷ cells mL⁻¹ of *H. meyeri* NRRL-Y27513 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 161.05 mg L⁻¹; c) 10⁷ cells mL⁻¹ of *H. nectarophila* GYBC-283 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 150.83 mg L⁻¹; d) 10⁷ cells mL⁻¹ of *H. guilliermondii* NRRL-Y1625 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 149.54 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG) contained 141.8 mg L⁻¹.

de Benedictis *et al.*, 2011 – Grape wine produced at 25 °C from Negroamaro grape must clarified by centrifugation, sterilised by membrane filtration, and inoculated with 10⁶ cells mL⁻¹ of: a) *H. uvarum* 8799 contained 54.2 mg L⁻¹; b) *H. uvarum* 8801 contained 53.9 mg L⁻¹; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* CM) contained 12.1 mg L⁻¹.

del Fresno *et al.*, 2025 – Grape wine produced at 18 °C from Albillo Mayor grape must, added with sulfur dioxide at a dose of 4 g hL⁻¹ in the form of potassium metabisulfite, and inoculated with 10⁷ cells mL⁻¹ of *H. vineae* T02/5A contained 42.52 mg L⁻¹; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* CTPL14) contained 34.04 mg L⁻¹.

Domizio *et al.*, 2011 – Grape wine produced by inoculating commercial white grape juice with 10⁷ cells mL⁻¹ of *H. osmophila* Ha32 and 10⁷ cells of *S. cerevisiae* EC1118 contained 83.15 mg L⁻¹; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* EC1118) contained 69.55 mg L⁻¹ (trial 1).

Li *et al.*, 2020 – Grape wine produced at 22 °C from Granoir grape must, added with sulfur dioxide (60 mg L⁻¹) and inoculated with 10⁶ cells mL⁻¹ of *H. uvarum* Yun268 and 10⁶ cells mL⁻¹ of *S. cerevisiae* RV002 contained 130.47 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* RV002) contained 121.644 mg L⁻¹.

Pietrafesa *et al.*, 2020 – Grape wine produced at 26 °C from Merlot grape must sterilised by filtration and inoculated with 10⁷ cells mL⁻¹ of *H. uvarum* H2 and 10³ cells mL⁻¹ of *S. cerevisiae* S3 contained 47.96 mg L⁻¹; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* S3) contained 44.58 mg L⁻¹.

Testa *et al.*, 2020 – Grape wine produced at 18 °C from Fiano grape must cold clarified at 0 °C for 48 h, added with potassium metabisulfite (50 mg L⁻¹), inoculated with 10⁶ cells mL⁻¹ of *H. guilliermondii* BF1 and, after two days, with 10⁶ cells mL⁻¹ of *S. cerevisiae* 404 contained

61.2 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* 404) contained 43.3 mg L⁻¹.

Zhang *et al.*, 2018 – Icewine produced at 16 °C from Vidal blanc grape juice, added with sulfur dioxide (80 mg L⁻¹) and inoculated with 10⁷ cells mL⁻¹ of *H. vineae* CVE-HV11 and 10⁶ cells mL⁻¹ of *S. cerevisiae* CVE-SC45 contained 83.821 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* CVE-SC45) contained 55.944 mg L⁻¹.

Final commentary: isobutanol has an unpleasant aroma (Mestre *et al.*, 2019).

1.5. 1-Hexanol

At least two descriptors were reported: “green, grass” (Guth, 1997) and “herbaceous, grass, woody” (Peinado *et al.*, 2004); the odour threshold is 1.1 mg L⁻¹ (Peinado *et al.*, 2004). Some strains of *Hanseniaspora* were reported to produce 1-hexanol exceeding the odour threshold, so negatively contributing to the sensory quality of the wine.

Badura *et al.*, 2023 – Grape wine produced at 22 °C from pasteurised Gewürztraminer grape must inoculated with 10⁷ cells mL⁻¹ of *H. opuntiae* GYBC-284 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 1431.11 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG) contained 1411.9 mg L⁻¹.

del Fresno *et al.*, 2021a – Grape wine produced in stainless steel barrels at 18 °C using a mixture of 50 % Tempranillo and 50 % Albillo Mayor grapes; the grape must, containing 15.05 mg L⁻¹ of total sulfur dioxide, was inoculated with 10⁷ cells mL⁻¹ of *H. vineae* T02/5A and contained 4.17 mg L⁻¹; the control (inoculated with *S. cerevisiae* Fermivin 3C) contained 4.46 mg L⁻¹.

del Fresno *et al.*, 2025 – Grape wine produced at 18 °C from Albillo Mayor grape must, added with sulfur dioxide at a dose of 4 g hL⁻¹ in the form of potassium metabisulfite, and inoculated with: a) 10⁷ cells mL⁻¹ of *H. vineae* T02/5A contained 4.06 mg L⁻¹ of hexanol, b) 10⁷ cells mL⁻¹ of *H. opuntiae* A56 contained 3.89 mg L⁻¹ of hexanol; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* CTPL14) contained 4.42 mg L⁻¹ of hexanol.

Filippousi *et al.*, 2024 – Grape wine produced as previously reported contained 66.84 mg L⁻¹; the control contained 49.9 mg L⁻¹.

Luan *et al.*, 2018 – Grape wine produced at 25 °C from Cabernet-Sauvignon must added with sulfur dioxide (60 mg L⁻¹) and inoculated with 10⁶ cells mL⁻¹ of *H. opuntiae* CVE-Ho11 and 10⁵ cells mL⁻¹ of *S. cerevisiae* BDX contained 2.21 mg L⁻¹; the control (inoculated with 10⁵ cells mL⁻¹ of *S. cerevisiae* BDX) contained 1.82 mg L⁻¹.

Yan *et al.*, 2020 – Grape wine produced at 25 °C from French Colombard grape must pasteurised and inoculated with 10⁷ cells mL⁻¹ of *H. vineae* 71-97 and 10⁶ cells mL⁻¹ of *S. cerevisiae* var. *bayanus* EC1118 contained 1.19 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* var. *bayanus* EC1118) contained 0.77 mg L⁻¹.

Final commentary: 1-hexanol – the less, the better.

1.6. Decanoic acid (i.e., capric acid)

At least two descriptors were reported: “fatty, unpleasant” (Guth, 1997) and “rancid, fatty” (Carrau *et al.*, 2023); its odour threshold is 1.0 mg L⁻¹ (Carrau *et al.*, 2023). At least three strains of *Hanseniaspora* were reported to produce decanoic acid exceeding the odour threshold, thereby negatively contributing to the sensory quality of the wine.

Gallo *et al.*, 2024a – Grape wine produced using a mixture of 50 % Glera and 50 % Gewurztraminer grapes, added with sulfur dioxide (15 mg L⁻¹) and inoculated with 5 × 10⁶ cells mL⁻¹ of *H. vineae* Fermivin VINEAE and, after 48 hours, with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Fermivin LVCB contained 1.955 mg L⁻¹; the control (inoculated with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Fermivin LVCB) contained 0.726 mg L⁻¹.

Guzzon *et al.*, 2024 – Sparkling wine produced at 20 °C using, in the secondary bottle fermentation, a mixed culture at a ratio of 1:1 made with *H. uvarum* NCYC 2380 and *S. cerevisiae* DV10; sparkling wines after bottle-fermentation from: a) Lambrusco Sorbara grapes contained 10.114 mg L⁻¹; the control (inoculated with *S. cerevisiae* DV10) contained 10.085 mg L⁻¹; b) Lambrusco Marani grapes contained 8.074 mg L⁻¹; the control (inoculated with *S. cerevisiae* DV10) contained 8.014 mg L⁻¹.

Medina *et al.*, 2013 – Grape wine produced at 20 °C inoculating Chardonnay must, added with 30 mg L⁻¹ of sulfur dioxide, with 5 × 10⁵ cells mL⁻¹ of *H. vineae* 02/5AF and, after six days, 2 × 10⁶ cells of *S. cerevisiae* ALG 804 contained 4.607 mg L⁻¹; the control (inoculated with 2 × 10⁶ cells mL⁻¹ of *S. cerevisiae* ALG 804) contained 3.796 mg L⁻¹.

Final commentary: decanoic acid – the less, the better.

1.7. Octanoic acid (i.e., caprylic acid)

Octanoic acid is related to an unpleasant aroma that is described as “rancid, harsh, cheese, fatty acid” (Guth, 1997) and “sweet, cheese” (Carrau *et al.*, 2023); its odour threshold is 0.5 mg L⁻¹ (Carrau *et al.*, 2023). At least two strains of *Hanseniaspora* were reported to produce octanoic acid exceeding the odour threshold, thereby negatively affecting the sensory quality of the wine.

Li *et al.*, 2020 – Grape wine produced at 22 °C from Granoir grape must, added with sulfur dioxide (60 mg L⁻¹) and inoculated with 10⁶ cells mL⁻¹ of *H. uvarum* Yun268 and 10⁶ cells mL⁻¹ of *S. cerevisiae* RV002 contained 1.178 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* RV002) contained 0.919 mg L⁻¹.

Tristezza *et al.*, 2016 – Grape wine produced at 20 °C in pilot-scale vinification, inoculating 90 L of Negroamaro must, added with 20 g hL⁻¹ of potassium metabisulfite, with 10⁷ cells mL⁻¹ of *H. uvarum* ITEM8795 and 10⁵ cells mL⁻¹ of *S. cerevisiae* ITEM6920, contained 4.716 mg L⁻¹; the control (inoculated with *S. cerevisiae* ITEM6920) contained 3.922 mg L⁻¹.

Final commentary: octanoic acid – the less, the better.

1.8. Hexanoic acid (i.e., caproic acid)

At least three different descriptors were reported: “cheese, rancid, fatty” (Guth, 1997), “sweet, acid rancid” (Carrau *et al.*, 2023), and “cheese, fatty, baked potato” (Lai *et al.*, 2023); its odour threshold is 0.42 mg L⁻¹ (Carrau *et al.*, 2023). At least three strains of *Hanseniaspora* were reported to produce hexanoic acid exceeding the odour threshold, thereby negatively affecting the sensory quality of the wine.

Domizio *et al.*, 2011 – Grape wine produced by inoculating commercial white grape juice with 10⁷ cells mL⁻¹ of *H. osmophila* Ha32 and 10⁵ cells of *S. cerevisiae* EC1118 contained 0.72 mg L⁻¹; the control (inoculated with 10⁵ cells mL⁻¹ of *S. cerevisiae* EC1118) contained 0.70 mg L⁻¹.

Li *et al.*, 2020 – Grape wine produced at 22 °C from Granoir grape must, added with sulfur dioxide (60 mg L⁻¹) and inoculated with 10⁶ cells mL⁻¹ of *H. uvarum* Yun268 and 10⁶ cells mL⁻¹ of *S. cerevisiae* RV002 contained 1.709 mg L⁻¹ – the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* RV002) contained 1.323 mg L⁻¹.

Tristezza *et al.*, 2016 – Grape wine produced at 20 °C in pilot-scale vinification, inoculating 90 L of Negroamaro must, added with 20 g hL⁻¹ of potassium metabisulfite, with 10⁷ cells mL⁻¹ of *H. uvarum* ITEM8795 and 10⁵ cells mL⁻¹ of *S. cerevisiae* ITEM6920, contained 2.366 mg L⁻¹; the control (inoculated with *S. cerevisiae* ITEM6920) contained 2.159 mg L⁻¹.

Final commentary: hexanoic acid – the less, the better.

2. Positive components

2.1. Isoamyl alcohol (i.e., 3-methyl-1-butanol)

At least three groups of descriptors were reported, all with an odour threshold of 30 mg L⁻¹: “banana, cheese, sweet” (Guth, 1997; Sanoppa *et al.*, 2019), “alcoholic, fermented, whiskey” (Bartowsky & Pretorius, 2009; Lu *et al.*, 2015), and “banana, fruity, sweet” (Chen *et al.*, 2015). Some strains of *Hanseniaspora* were reported to produce isoamyl alcohol exceeding the odour threshold, thereby positively contributing to the sensory quality of the wine.

Andorrà *et al.*, 2010 – Grape wine produced at 20 °C from Macabeo must sterilised by the addition of 250 mg L⁻¹ of dimethyldicarbonate and inoculated with 9 × 10⁵ cells mL⁻¹ of *H. uvarum* HuB10 and 10⁵ cells mL⁻¹ of *S. cerevisiae* QA23 contained 202.95 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* QA23) contained 167.52 mg L⁻¹.

del Fresno *et al.*, 2021a – Grape wine produced in oak barrels at 18 °C using a mixture of 50 % Tempranillo and 50 % Albillo Mayor grapes; the grape must, containing 15.05 mg L⁻¹ of total sulfur dioxide, was inoculated with 10⁷ cells mL⁻¹ of *H. vineae* T02/5A and contained 108.64 mg L⁻¹; the control (inoculated with *S. cerevisiae* Fermivin 3C) contained 125.4 mg L⁻¹.

del Fresno *et al.*, 2025 – Grape wine produced at 18 °C from Albillo Mayor grape must, added with sulfur dioxide at a dose of 4 g hL⁻¹ in the form of potassium metabisulfite, and inoculated with: a) 10⁷ cells mL⁻¹ of *H. vineae* T02/5A contained 133.92 mg L⁻¹, b) 10⁷ cells mL⁻¹ of *H. opuntiae* A56 contained 119.16 mg L⁻¹; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* CTPL14) contained 137.81 mg L⁻¹.

Domizio *et al.*, 2011 – Grape wine produced inoculating commercial white grape juice with: a) 10⁷ cells mL⁻¹ of *H. osmophila* Ha32 and 10⁷ cells of *S. cerevisiae* EC1118 contained 127.95 mg L⁻¹; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* EC1118) contained 113.21 mg L⁻¹ (trial 1); b) 10⁷ cells mL⁻¹ of *H. osmophila* Ha32 and 10⁵ cells of *S. cerevisiae* EC1118 contained 114.28 mg L⁻¹; the control (inoculated with 10⁵ cells mL⁻¹ of *S. cerevisiae* EC1118) contained 108.42 mg L⁻¹ (trial 2).

Luan *et al.*, 2018 – Grape wine produced as previously reported contained 249.74 mg L⁻¹; the control contained 207.50 mg L⁻¹.

Pietrafesa *et al.*, 2020 – Grape wine produced as previously reported contained 240.74 mg L⁻¹; the control contained 222.62 mg L⁻¹.

Testa *et al.*, 2020 – Grape wine produced as previously reported contained 72.1 mg L⁻¹; the 3-methyl-1-butanol was not detected in the control.

Yan *et al.*, 2020 – Grape wine produced as previously reported contained 105.81 mg L⁻¹; the control contained 64.34 mg L⁻¹.

Final commentary: isoamyl alcohol may contribute positively to the complexity of the wine aromas.

2.2. 2-Phenylethanol (*i.e.*, 2-Phenyl ethyl alcohol)

At least four different descriptors were reported: “flowery, pollen, perfumed” (Guth, 1997), “floral, roses” (Tristezza *et al.*, 2016), “honey, rose, spicy” (Carrau *et al.*, 2023), and “floral, roses” (Lai *et al.*, 2023); its odour threshold is 14 mg L⁻¹ (Carrau *et al.*, 2023). Some strains of *Hanseniaspora* were reported to produce 2-phenylethanol at levels exceeding the odour threshold, thereby positively contributing to the sensory quality of the wine.

Andorrà *et al.*, 2010 – Grape wine produced at 20 °C from Macabeo must sterilised by the addition of 250 mg L⁻¹ of dimethyldicarbonate and inoculated with 9 × 10⁵ cells mL⁻¹ of *H. uvarum* HuB10 and 10⁵ cells mL⁻¹ of *S. cerevisiae* QA23 contained 42.72 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* QA23) contained 30.63 mg L⁻¹.

Badura *et al.*, 2023 – Grape wine produced at 22 °C from pasteurised Gewürztraminer grape must inoculated with: a) 10⁷ cells mL⁻¹ of *H. occidentalis* GYBC-211 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 59.4 mg L⁻¹; b) 10⁷ cells mL⁻¹ of *H. opuntiae* GYBC-284 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 48.52 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG) contained 44.34 mg L⁻¹.

Capozzi *et al.*, 2019 – Grape wine produced at 25 °C, inoculating Negroamaro must, added with 100 mg L⁻¹ potassium metabisulfite, with 10⁶ cells mL⁻¹ of *H. uvarum* ITEM 8795 and 10⁴ cells of *S. cerevisiae* ITEM 17292, contained 17.96 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* ITEM 17292) contained 14.91 mg L⁻¹.

del Fresno *et al.*, 2025 – Grape wine produced at 18 °C from Albillo Mayor grape must, added with sulfur dioxide at a dose of 4 g hL⁻¹ in the form of potassium metabisulfite, and inoculated with: a) 10⁷ cells mL⁻¹ of *H. vineae* T02/5A contained 25.02 mg L⁻¹, b) 10⁷ cells mL⁻¹ of *H. opuntiae* A56 contained 21.45 mg L⁻¹; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* CTPL14) contained 9.66 mg L⁻¹.

Gallo *et al.*, 2024a – Grape wine produced using a mixture of 50 % Glera and 50 % Gewürztraminer grapes, added with sulfur dioxide (15 mg L⁻¹) and inoculated with 5 × 10⁶ cells mL⁻¹ of *H. vineae* Fermivin VINEAE and, after 200 hours, with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Fermivin LVCB contained 14.03 mg L⁻¹; the control (inoculated with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Fermivin LVCB) contained 13.62 mg L⁻¹.

Guzzon *et al.*, 2024 – Sparkling wine produced at 20 °C using, in the secondary bottle fermentation, a mixed culture at a ratio of 1:1 made with *H. uvarum* NCYC 2380 and *S. cerevisiae* DV10; sparkling wines after bottle-fermentation from: a) Lambrusco Sorbara grapes contained 21.047 mg L⁻¹; the control (inoculated with *S. cerevisiae* DV10) contained 19.891 mg L⁻¹; b) Lambrusco Marani grapes contained 12.186 mg L⁻¹; the control (inoculated with *S. cerevisiae* DV10) contained 10.199 mg L⁻¹.

Li *et al.*, 2020 – Grape wine produced at 22 °C from Granoir grape must, added with sulfur dioxide (60 mg L⁻¹) and inoculated with 10⁶ cells mL⁻¹ of *H. uvarum* Yun268 and, after 24 hours, with 10⁶ cells mL⁻¹ of *S. cerevisiae* RV171 contained 45.48 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* RV171) contained 44.94 mg L⁻¹.

Luan *et al.*, 2018 – Grape wine produced as previously reported contained 61.3 mg L⁻¹; the control contained 51.2 mg L⁻¹.

Testa *et al.*, 2020 – Grape wine produced as previously reported contained 160.1 mg L⁻¹; the control contained 92 mg L⁻¹.

Yan *et al.*, 2020 – Grape wine produced as previously reported contained 26.72 mg L⁻¹; the control contained 16.08 mg L⁻¹.

Zhang *et al.*, 2022 – Grape wine produced at 16–17 °C from Petit Manseng must added with sulfur dioxide (60 mg L⁻¹) and inoculated with *H. vineae* CVE-HV6 and, after four days, with *S. cerevisiae* D254 contained 28.05 mg L⁻¹; the control (inoculated with *S. cerevisiae* D254) contained 19.08 mg L⁻¹.

Final commentary: 2-phenylethanol contributes fine rose notes to the wine aroma (Tristezza *et al.*, 2016).

2.3. Hexyl acetate

The aromatic descriptors of this compound are “apple, cherry, pear, floral”; its odour threshold is 0.67 mg L⁻¹ (Peinado *et al.*, 2004). At least two strains of *Hanseniaspora* were reported to produce hexyl acetate exceeding the odour threshold, so positively contributing to the sensory quality of the wine.

Andorrà *et al.*, 2010 – Grape wine produced at 20 °C from Macabeo must sterilised by the addition of 250 mg L⁻¹ of dimethyldicarbonate and inoculated with 9 × 10⁵ cells mL⁻¹ of *H. uvarum* HuB10 and 10⁵ cells mL⁻¹ of *S. cerevisiae* QA23 contained 23.22 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* QA23) contained 6.81 mg L⁻¹.

Lai *et al.*, 2023 – Grape wine produced at 25 °C from Kyoho must filtered and inoculated with 5 × 10⁶ cells mL⁻¹ of *H. uvarum* Pi235 and 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Gr112 contained 8.34 mg L⁻¹; the control (inoculated with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Gr112) contained 2.13 mg L⁻¹.

Final commentary: hexyl acetate – the more, the merrier.

2.4. 2-Phenylethyl acetate (i.e., 2-phenethyl acetate)

The aromatic descriptor of this compound is “fruity, honey, floral”; the odour threshold is 0.25 mg L⁻¹ (Carrau *et al.*, 2023). Some strains of *Hanseniaspora* were reported to produce 2-phenylethyl acetate at levels exceeding the odour threshold, thereby positively contributing to the sensory quality of the wine.

Andorrà *et al.*, 2010 – Grape wine produced at 20 °C from Macabeo must sterilised by the addition of 250 mg L⁻¹ of dimethyldicarbonate and inoculated with 9 × 10⁵ cells mL⁻¹ of *H. uvarum* HuB10 and 10⁵ cells mL⁻¹ of *S. cerevisiae* QA23 contained 4.23 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* QA23) contained 2.99 mg L⁻¹.

Badura *et al.*, 2023 – Grape wine produced at 22 °C from pasteurised Gewürztraminer grape must inoculated with: a) 10⁷ cells mL⁻¹ of *H. osmophila* NRRL-Y1613 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 1.24 mg L⁻¹; b) 10⁷ cells mL⁻¹ of *H. guilliermondii* NRRL-Y1625 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 1.18 mg L⁻¹; c) 10⁷ cells mL⁻¹ of *H. opuntiae* GYBC-284 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.68 mg L⁻¹; d) 10⁷ cells mL⁻¹ of *H. meyeri* NRRL-Y27513 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.49 mg L⁻¹; e) 10⁷ cells mL⁻¹ of *H. uvarum* DSM2768 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.47 mg L⁻¹; f) 10⁷ cells mL⁻¹ of *H. nectarophila* GYBC-283 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.27 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG) contained 0.203 mg L⁻¹.

del Fresno *et al.*, 2021a – Grape wine produced in stainless steel barrels at 18 °C using a mixture of 50 % Tempranillo and 50 % Albillo Mayor grapes; the grape must, containing 15.05 mg L⁻¹ of total sulfur dioxide, was inoculated

with 10⁷ cells mL⁻¹ of *H. vineae* T02/5A and contained 15.38 mg L⁻¹; the control (inoculated with *S. cerevisiae* Fermivin 3C) contained 9.28 mg L⁻¹.

del Fresno *et al.*, 2025 – Grape wine produced at 18 °C from Albillo Mayor grape must, added with sulfur dioxide at a dose of 4 g hL⁻¹ in the form of potassium metabisulfite, and inoculated with: a) 10⁷ cells mL⁻¹ of *H. vineae* T02/5A contained 8.91 mg L⁻¹, b) 10⁷ cells mL⁻¹ of *H. opuntiae* A56 contained 7.78 mg L⁻¹; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* CTPL14) contained 7.44 mg L⁻¹.

Escott *et al.*, 2021 – Grape wine produced from Tempranillo grapes inoculated with 1.3 × 10⁸ cells mL⁻¹ of *H. vineae* HV and, after eight days of fermentation, with 6 × 10⁷ cells mL⁻¹ of *S. cerevisiae* 7VA contained 6.6 mg L⁻¹; the control (inoculated with 10⁸ cells mL⁻¹ *S. cerevisiae* 7VA) contained 5.1 mg L⁻¹.

Filippousi *et al.*, 2024 – Grape wine produced as previously reported contained 78.29 mg L⁻¹; the control contained 29.71 mg L⁻¹.

Gallo *et al.*, 2023 – Grape wine produced as previously reported contained 3.19 mg L⁻¹ – the control (inoculated with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* LVCB) contained 0.19 mg L⁻¹.

Gallo *et al.*, 2024a – Grape wine produced using a mixture of 50 % Glera and 50 % Gewürztraminer grapes, added with sulfur dioxide (15 mg L⁻¹) and inoculated with 5 × 10⁶ cells mL⁻¹ of *H. vineae* Fermivin VINEAE and, after 24 hours, with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Fermivin LVCB contained 4.64 mg L⁻¹; the control (inoculated with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Fermivin LVCB) contained 0.385 mg L⁻¹.

Gallo *et al.*, 2024b – Grape wine produced from Glera grape must, added with sulfur dioxide (15 mg L⁻¹) as potassium metabisulfite, inoculated with 5 × 10⁶ cells mL⁻¹ (98 % of *H. vineae* Fermivin VINEAE and 2 % of *S. cerevisiae* Fermivin LVCB) contained 7.6 mg L⁻¹; the control (inoculated with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Fermivin LVCB) contained 0.12 mg L⁻¹.

Lai *et al.*, 2023 – Grape wine produced as previously reported contained 2.66 mg L⁻¹; the control contained 1.71 mg L⁻¹.

Medina *et al.*, 2013 – Grape wine produced as previously reported contained 4.341 mg L⁻¹; the control contained 0.425 mg L⁻¹.

Tristezza *et al.*, 2016 – Grape wine produced at 20 °C in pilot-scale vinification, inoculating 90 L of Negroamaro must, added with 20 g hL⁻¹ of potassium metabisulfite, with 10⁷ cells mL⁻¹ of *H. uvarum* ITEM8795 and 10⁵ cells mL⁻¹ of *S. cerevisiae* ITEM6920, contained 0.696 mg L⁻¹; the control (inoculated with *S. cerevisiae* ITEM6920) contained 0.517 mg L⁻¹.

Valera *et al.*, 2021 – Grape wine produced at 20 °C from Chardonnay grape must, treated with 200 mg L⁻¹ dimethyldicarbonate and inoculated with 10⁵ cells mL⁻¹ of *H. vineae* 025, contained 10.524 mg L⁻¹; the control (inoculated with 10⁵ cells mL⁻¹ of *S. cerevisiae* ALG804) contained 0.116 mg L⁻¹.

Yan *et al.*, 2020 – Grape wine produced as previously reported contained 2.75 mg L⁻¹; the control contained 0.29 mg L⁻¹.

Zhang *et al.*, 2018 – Icewine produced at 16 °C from Vidal blanc grape juice, added with sulfur dioxide (80 mg L⁻¹) and inoculated with 10⁷ cells mL⁻¹ of *H. vineae* CVE-HV11 and, after two days, with 10⁶ cells mL⁻¹ of *S. cerevisiae* CVE-SC45 contained 8.342 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* CVE-SC45) contained 2.591 mg L⁻¹.

Zhang *et al.*, 2022 – Grape wine produced as previously reported contained 1.55 mg L⁻¹; the control contained 0.20 mg L⁻¹.

Final commentary: 2-phenylethyl acetate is a compound responsible for imparting flowery, rosy, and honey-like fragrances with fruity undertones to wines (Filippousi *et al.*, 2024).

2.5. Ethyl decanoate (*i.e.*, ethyl caprate)

At least four different descriptors were reported: “fruity, fatty, pleasant” (Guth, 1997), “sweet, fruity” (Tristezza *et al.*, 2016), “floral” (Mestre *et al.*, 2019), and “fruity” (Tarko & Duda, 2024); its odour threshold is 0.2 mg L⁻¹ (Ferreira *et al.*, 2000). Some strains of *Hanseniaspora* were reported to produce ethyl decanoate exceeding the odour threshold, thereby positively contributing to the sensory quality of the wine.

Badura *et al.*, 2023 – Grape wine produced at 22 °C from pasteurised Gewürztraminer grape must inoculated with: a) 10⁷ cells mL⁻¹ of *H. nectarophila* GYBC-283 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.666 mg L⁻¹; b) 10⁷ cells mL⁻¹ of *H. uvarum* DSM2768 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.576 mg L⁻¹; c) 10⁷ cells mL⁻¹ of *H. guilliermondii* NRRL-Y1625 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.525 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG) contained 0.468 mg L⁻¹.

Capozzi *et al.*, 2019 – Grape wine produced at 25 °C, inoculating Negroamaro must, added with 100 mg L⁻¹ potassium metabisulfite, with 10⁶ cells mL⁻¹ of *H. uvarum* ITEM 8795 and 10⁴ cells of *S. cerevisiae* ITEM 17293 contained 1.88 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* ITEM 17293) contained 0.95 mg L⁻¹.

Gallo *et al.*, 2024a – Grape wine produced using a mixture of 50 % Glera and 50 % Gewürztraminer grapes, added with sulfur dioxide (15 mg L⁻¹) and inoculated with 5 × 10⁶ cells mL⁻¹ of *H. vineae* Fermivin VINEAE and, after 48 hours, with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Fermivin LVCB contained 0.511 mg L⁻¹; the control (inoculated with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Fermivin LVCB) contained 0.16 mg L⁻¹.

Li *et al.*, 2022 – Grape wine produced as previously reported contained 0.570 mg L⁻¹; the control contained 0.457 mg L⁻¹.

Medina *et al.*, 2013 – Grape wine produced as previously reported contained 0.685 mg L⁻¹; the control contained 0.56 mg L⁻¹.

Mestre *et al.*, 2019 – Grape wine produced at 25 °C from Malbec grape must added with 50 ppm of free sulfur dioxide and inoculated with 5 × 10⁶ cells mL⁻¹ of *H. uvarum* BHu9 and, after two days, with 2 × 10⁶ cells mL⁻¹ of *S. cerevisiae* BSc114 contained 1.14 mg L⁻¹; the control (inoculated with 2 × 10⁶ cells mL⁻¹ of *S. cerevisiae* BSc114) contained 0.59 mg L⁻¹.

Tristezza *et al.*, 2016 – Grape wine produced at 20 °C in pilot-scale vinification, inoculating 90 L of Negroamaro must, added with 20 g hL⁻¹ of potassium metabisulfite, with 10⁷ cells mL⁻¹ of *H. uvarum* ITEM8795 and 10⁵ cells mL⁻¹ of *S. cerevisiae* ITEM6920, contained 0.252 mg L⁻¹; the control (inoculated with *S. cerevisiae* ITEM6920) contained 0.188 mg L⁻¹.

Final commentary: ethyl decanoate – the more, the merrier.

2.6. Isoamyl acetate (*i.e.*, 3-methylbutyl acetate)

The aromatic descriptor of this compound is “banana, fruity, sweet”, the odour threshold is 0.16 mg L⁻¹ (Peinado *et al.*, 2004). Some strains of *Hanseniaspora* were reported to produce isoamyl acetate exceeding the odour threshold, so positively contributing to the sensory quality of the wine.

Andorrà *et al.*, 2010 – Grape wine produced at 20 °C from Macabeo must sterilised by the addition of 250 mg L⁻¹ of dimethyldicarbonate and inoculated with 9 × 10⁵ cells mL⁻¹ of *H. uvarum* HuB10 and 10⁵ cells mL⁻¹ of *S. cerevisiae* QA23 contained 0.7 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* QA23) contained 0.25 mg L⁻¹.

Badura *et al.*, 2023 – Grape wine produced at 22 °C from pasteurised Gewürztraminer grape must inoculated with: a) 10⁷ cells mL⁻¹ of *H. guilliermondii* NRRL-Y1625 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 3.788 mg L⁻¹; b) 10⁷ cells mL⁻¹ of *H. meyeri* NRRL-Y27513 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 2.731 mg L⁻¹; c) 10⁷ cells mL⁻¹ of *H. uvarum* DSM2768 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 2.523 mg L⁻¹; d) 10⁷ cells mL⁻¹ of *H. nectarophila* GYBC-283 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 2.12 mg L⁻¹ – the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG) contained 1.089 mg L⁻¹.

Capozzi *et al.*, 2019 – Grape wine produced at 25 °C inoculating Negroamaro must, added with 100 mg L⁻¹ potassium metabisulfite, with 10⁶ cells mL⁻¹ of *H. uvarum* ITEM 8795 and 10⁴ cells of *S. cerevisiae* ITEM 17292 contained 4.11 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* ITEM 17292) contained 3.77 mg L⁻¹; grape wine produced at 25 °C inoculating *Negroamaro* must, added with 100 mg L⁻¹ potassium metabisulfite, with 10⁶ cells mL⁻¹ of *H. uvarum* ITEM 8795 and 10⁴ cells of *S. cerevisiae* ITEM 17293 contained 3.11 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* ITEM 17293) contained 2.11 mg L⁻¹.

del Fresno *et al.*, 2025 – Grape wine produced at 18 °C from Albillo Mayor grape must, added with sulfur dioxide

at a dose of 4 g hL⁻¹ in the form of potassium metabisulfite, and inoculated with: a) 10⁷ cells mL⁻¹ of *H. vineae* T02/5A contained 3.33 mg L⁻¹, b) 10⁷ cells mL⁻¹ of *H. opuntiae* A56 contained 16.10 mg L⁻¹; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* CTPL14) contained 2.70 mg L⁻¹.

Domizio *et al.*, 2011 – Grape wine produced by inoculating commercial white grape juice with 10⁷ cells mL⁻¹ of *H. osmophila* Ha32 and 10⁵ cells of *S. cerevisiae* EC1118 contained 0.28 mg L⁻¹; the control (inoculated with 10⁵ cells mL⁻¹ of *S. cerevisiae* EC1118) contained 0.21 mg L⁻¹.

Escott *et al.*, 2021 – Grape wine produced as previously reported contained 2.3 mg L⁻¹; the control contained 2 mg L⁻¹.

Gallo *et al.*, 2024b – Grape wine produced as previously reported contained 1.02 mg L⁻¹; the control contained 0.72 mg L⁻¹.

Lai *et al.*, 2023 – Grape wine produced as previously reported contained 0.73 mg L⁻¹; the control contained 0.27 mg L⁻¹.

Li *et al.*, 2022 – Grape wine produced as previously reported contained 7.922 mg L⁻¹; the control contained 4.695 mg L⁻¹.

Li *et al.*, 2024 – Grape wine produced at 14–16 °C using Sauvignon blanc grape must, added with 1 mg L⁻¹ of H₂SO₃ (calculated as 60 mg L⁻¹ of sulfur dioxide), inoculated with 10⁷ cells mL⁻¹ of *H. uvarum* HU4487 and 10⁶ cells mL⁻¹ of *S. cerevisiae* VL3 contained 1.503 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* VL3) contained 1.361 mg L⁻¹.

Medina *et al.*, 2013 – Grape wine produced as previously reported contained 0.948 mg L⁻¹; the control contained 0.871 mg L⁻¹.

Mestre *et al.*, 2019 – Grape wine produced as previously reported contained 3.21 mg L⁻¹; the control contained 2.89 mg L⁻¹.

Tristezza *et al.*, 2016 – Grape wine produced at 20 °C in industrial vinification, inoculating 7 tons of Negroamaro must, added with 20 g hL⁻¹ of potassium metabisulfite, with 10⁷ cells mL⁻¹ of *H. uvarum* ITEM8795 and 10⁵ cells mL⁻¹ of *S. cerevisiae* ITEM6920, contained 2.597 mg L⁻¹; the control (inoculated with *S. cerevisiae* ITEM6920) contained 0.312 mg L⁻¹.

Zhang *et al.*, 2018 – Icewine produced at 16 °C from Vidal blanc grape juice, added with sulfur dioxide (80 mg L⁻¹) and inoculated with 10⁷ cells mL⁻¹ of *H. vineae* CVE-HV11 and 10⁶ cells mL⁻¹ of *S. cerevisiae* CVE-SC45 contained 1.129 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* CVE-SC45) contained 0.964 mg L⁻¹.

Zhang *et al.*, 2022 – Grape wine produced as previously reported contained 2.044 mg L⁻¹; the control contained 1.709 mg L⁻¹.

Final commentary: isoamyl acetate is one of the esters most markedly contributing to the aroma profile of white wines (Plata *et al.*, 2003).

2.7. Ethyl butyrate (i.e., ethyl butanoate)

For ethyl butyrate, at least two different descriptors, both with the odour threshold of 0.02 mg L⁻¹, were reported: “fruity” (Guth, 1997; Tristezza *et al.*, 2016) and “strawberry, apple” (Peng *et al.*, 2013; Li *et al.*, 2020). Some strains of *Hanseniaspora* were reported to produce ethyl butyrate exceeding the odour threshold, so positively contributing to the sensory quality of the wine.

Badura *et al.*, 2023 – Grape wine produced at 22 °C from pasteurised Gewürztraminer grape must inoculated with: a) 10⁷ cells mL⁻¹ of *H. guilliermondii* NRRL-Y1625 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.312 mg L⁻¹; b) 10⁷ cells mL⁻¹ of *H. uvarum* DSM2768 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.272 mg L⁻¹; c) 10⁷ cells mL⁻¹ of *H. meyeri* NRRL-Y27513 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.248 mg L⁻¹; d) 10⁷ cells mL⁻¹ of *H. nectarophila* GYBC-283 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.241 mg L⁻¹; e) 10⁷ cells mL⁻¹ of *H. osmophila* NRRL-Y1613 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.227 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG) contained 0.222 mg L⁻¹.

del Fresno *et al.*, 2025 – Grape wine produced at 18 °C from Albillo Mayor grape must, added with sulfur dioxide at a dose of 4 g hL⁻¹ in the form of potassium metabisulfite, and inoculated with 10⁷ cells mL⁻¹ of *H. vineae* T02/5A contained 4.03 mg L⁻¹; the control (inoculated with 10⁷ cells mL⁻¹ of *S. cerevisiae* CTPL14) contained 1.73 mg L⁻¹.

Filippousi *et al.*, 2024 – Grape wine produced as previously reported contained 22.84 mg L⁻¹; the control contained 19.15 mg L⁻¹.

Li *et al.*, 2020 – Grape wine produced at 22 °C from Granoir grape must, added with sulfur dioxide (60 mg L⁻¹) and inoculated with 10⁶ cells mL⁻¹ of *H. uvarum* Yun268 and 10⁶ cells mL⁻¹ of *S. cerevisiae* RV002 contained 0.233 mg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* RV002) contained 0.204 mg L⁻¹.

Tristezza *et al.*, 2016 – Grape wine produced at 20 °C in pilot-scale vinification inoculating 90 L of Negroamaro must, added with 20 g hL⁻¹ of potassium metabisulfite, with 10⁷ cells mL⁻¹ of *H. uvarum* ITEM8795 and 10⁵ cells mL⁻¹ of *S. cerevisiae* ITEM6920 contained 0.425 mg L⁻¹; the control (inoculated with *S. cerevisiae* ITEM6920) contained 0.425 mg L⁻¹; the control (inoculated with *S. cerevisiae* ITEM6920) contained 0.386 mg L⁻¹.

Zhang *et al.*, 2022 – Grape wine produced as previously reported contained 0.125 mg L⁻¹; the control contained 0.119 mg L⁻¹.

Final commentary: ethyl butyrate – the more, the merrier.

2.8. β-Citronellol

del Fresno *et al.* (2021b) highlight the high impact of *H. vineae* on the formation of fruity and floral terpenes as β-citronellol.

At least two different descriptors were reported: “green lemon” (Guth, 1997) and “citric” (del Fresno *et al.*, 2021b); its odour threshold is $18 \mu\text{g L}^{-1}$ (Čuš & Jenko, 2013). At least three strains of *Hanseniaspora* were reported to produce β -citronellol exceeding the odour threshold, so positively contributing to the sensory quality of the wine.

Badura *et al.*, 2023 – Grape wine produced at 22°C from pasteurised Gewürztraminer grape must inoculated with 10^7 cells mL^{-1} of *H. opuntiae* GYBC-284 and 10^6 cells mL^{-1} of *S. cerevisiae* Uvaferm CEG contained $38 \mu\text{g L}^{-1}$; the control (inoculated with 10^6 cells mL^{-1} of *S. cerevisiae* Uvaferm CEG) contained $27 \mu\text{g L}^{-1}$.

del Fresno *et al.*, 2021b – Grape wine produced at 18°C from Albillo Mayor grape must, inoculated with 10^7 cells mL^{-1} of *H. vineae* followed sequentially by 10^7 cells mL^{-1} of *S. cerevisiae* Fermivin 3C, contained $103 \mu\text{g L}^{-1}$; the control (inoculated with 10^7 cells mL^{-1} of *S. cerevisiae* Fermivin 3C) contained $24 \mu\text{g L}^{-1}$.

Zhang *et al.*, 2018 – Icewine produced at 16°C from Vidal blanc grape juice, added with sulfur dioxide (80 mg L^{-1}) and inoculated with 10^7 cells mL^{-1} of *H. vineae* CVE-HV11 and, after two days, with 10^6 cells mL^{-1} of *S. cerevisiae* CVE-SC45 contained $25.6 \mu\text{g L}^{-1}$; the control (inoculated with 10^6 cells mL^{-1} of *S. cerevisiae* CVE-SC45) contained $20.2 \mu\text{g L}^{-1}$.

Final commentary: β -citronellol – the more, the merrier.

2.9. Linalool

At least four different descriptors were reported: “citrus, floral, sweet, grape-like” (Peinado *et al.*, 2004), “floral, lemon” (del Fresno *et al.*, 2021b), “Muscat, flowery, fruit” (Testa *et al.*, 2021), and “floral, citrus” (Lai *et al.*, 2023); its odour threshold is $15 \mu\text{g L}^{-1}$ (Peinado *et al.*, 2004). Some strains of *Hanseniaspora* were reported to produce linalool exceeding the odour threshold, thereby positively contributing to the sensory quality of the wine.

Badura *et al.*, 2023 – Grape wine produced at 22°C from pasteurised Gewürztraminer grape must inoculated with: a) 10^7 cells mL^{-1} of *H. opuntiae* GYBC-284 and 10^6 cells mL^{-1} of *S. cerevisiae* Uvaferm CEG contained $73.91 \mu\text{g L}^{-1}$; b) 10^7 cells mL^{-1} of *H. guilliermondii* NRRL-Y1625 and 10^6 cells mL^{-1} of *S. cerevisiae* Uvaferm CEG contained $72.93 \mu\text{g L}^{-1}$; c) 10^7 cells mL^{-1} of *H. uvarum* DSM2768 and 10^6 cells mL^{-1} of *S. cerevisiae* Uvaferm CEG contained $72.5 \mu\text{g L}^{-1}$; the control (inoculated with 10^6 cells mL^{-1} of *S. cerevisiae* Uvaferm CEG) contained $72.43 \mu\text{g L}^{-1}$.

del Fresno *et al.*, 2021b – Grape wine produced as previously reported contained $70 \mu\text{g L}^{-1}$; the control contained $18 \mu\text{g L}^{-1}$.

Gallo *et al.*, 2024a – Grape wine produced using a mixture of 50 % Glera and 50 % Gewürztraminer grapes, added with sulfur dioxide (15 mg L^{-1}) and inoculated with 5×10^6 cells mL^{-1} of *H. vineae* Fermivin VINEAE and, after 100 hours, with 5×10^6 cells mL^{-1} of *S. cerevisiae* Fermivin LVCB contained $104 \mu\text{g L}^{-1}$; the control (inoculated with

5×10^6 cells mL^{-1} of *S. cerevisiae* Fermivin LVCB) contained $99 \mu\text{g L}^{-1}$.

Testa *et al.*, 2020 – Grape wine produced as previously reported contained $112 \mu\text{g L}^{-1}$; the control contained $82 \mu\text{g L}^{-1}$.

Testa *et al.*, 2021 – Grape wine produced at $23\text{--}24^\circ\text{C}$ from Aglianico grape must added with potassium metabisulfite (70 mg L^{-1}) and inoculated with 10^6 cells mL^{-1} of *H. uvarum* AS27 contained $69.3 \mu\text{g L}^{-1}$; the control (inoculated with 10^6 cells mL^{-1} of *S. cerevisiae* FE) contained $23.2 \mu\text{g L}^{-1}$.

Zhang *et al.*, 2018 – Icewine produced at 16°C from Vidal blanc grape juice, added with sulfur dioxide (80 mg L^{-1}) and inoculated with 10^7 cells mL^{-1} of *H. vineae* CVE-HV11 and, after four days, with 10^6 cells mL^{-1} of *S. cerevisiae* CVE-SC45 contained $47.2 \mu\text{g L}^{-1}$; the control (inoculated with 10^6 cells mL^{-1} of *S. cerevisiae* CVE-SC45) contained $42 \mu\text{g L}^{-1}$.

Final commentary: linalool – the more, the merrier.

2.10. Ethyl hexanoate (i.e., ethyl caproate)

At least three very similar descriptors were reported: “fruity, apple” (Mestre *et al.*, 2019), “pineapple, fruity” (Lai *et al.*, 2023), and “fruity/anise” (Tarko & Duda, 2024); its odour threshold is $14 \mu\text{g L}^{-1}$ (Ferreira *et al.*, 2000). Some strains of *Hanseniaspora* were reported to produce ethyl hexanoate exceeding the odour threshold, thereby positively contributing to the sensory quality of the wine.

Andorrà *et al.*, 2010 – Grape wine produced at 20°C from Macabeo must sterilised by the addition of 250 mg L^{-1} of dimethyldicarbonate and inoculated with 9×10^5 cells mL^{-1} of *H. uvarum* HuB10 and 10^5 cells mL^{-1} of *S. cerevisiae* QA23 contained $220 \mu\text{g L}^{-1}$; the control (inoculated with 10^6 cells mL^{-1} of *S. cerevisiae* QA23) contained $30 \mu\text{g L}^{-1}$.

Badura *et al.*, 2023 – Grape wine produced at 22°C from pasteurised Gewürztraminer grape must inoculated with: a) 10^7 cells mL^{-1} of *H. guilliermondii* NRRL-Y1625 and 10^6 cells mL^{-1} of *S. cerevisiae* Uvaferm CEG contained $92 \mu\text{g L}^{-1}$; b) 10^7 cells mL^{-1} of *H. uvarum* DSM2768 and 10^6 cells mL^{-1} of *S. cerevisiae* Uvaferm CEG contained $77 \mu\text{g L}^{-1}$; the control (inoculated with 10^6 cells mL^{-1} of *S. cerevisiae* Uvaferm CEG) contained $76 \mu\text{g L}^{-1}$.

Li *et al.*, 2020 – Grape wine produced at 22°C from Granoir grape must, added with sulfur dioxide (60 mg L^{-1}) and inoculated with 10^6 cells mL^{-1} of *H. uvarum* Yun268 and 10^6 cells mL^{-1} of *S. cerevisiae* RV002 contained $396 \mu\text{g L}^{-1}$; the control (inoculated with 10^6 cells mL^{-1} of *S. cerevisiae* RV002) contained $296 \mu\text{g L}^{-1}$.

Li *et al.*, 2022 – Grape wine produced as previously reported contained $968 \mu\text{g L}^{-1}$; the control contained $942 \mu\text{g L}^{-1}$.

Mestre *et al.*, 2019 – Grape wine produced as previously reported contained $600 \mu\text{g L}^{-1}$; the control contained $200 \mu\text{g L}^{-1}$.

Tristezza *et al.*, 2016 – Grape wine produced at 20 °C in pilot-scale vinification, inoculating 90 L of Negroamaro must, added with 20 g hL⁻¹ of potassium metabisulfite, with 10⁷ cells mL⁻¹ of *H. uvarum* ITEM8795 and 10⁵ cells mL⁻¹ of *S. cerevisiae* ITEM6920, contained 561 µg L⁻¹; the control (inoculated with *S. cerevisiae* ITEM6920) contained 510 µg L⁻¹.

Final commentary: ethyl hexanoate is responsible for tropical fruity attributes.

2.11. Ethyl octanoate (*i.e.*, ethyl caprylate)

At least two very similar descriptors were reported: “pineapple, pear” (Mestre *et al.*, 2019) and “fruity/fresh” (Tarko & Duda, 2024); its odour threshold is 5 µg L⁻¹ (Ferreira *et al.*, 2000). Some strains of *Hanseniaspora* were reported to produce ethyl octanoate exceeding the odour threshold, thereby positively contributing to the sensory quality of the wine.

Badura *et al.*, 2023 – Grape wine produced at 22 °C from pasteurised Gewürztraminer grape must inoculated with 10⁷ cells mL⁻¹ of *H. nectarophila* GYBC-283 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 541 µg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG) contained 494 µg L⁻¹.

Lai *et al.*, 2023 – Grape wine produced as previously reported contained 1860 µg L⁻¹; the control contained 1580 µg L⁻¹.

Li *et al.*, 2020 – Grape wine produced at 22 °C from Granoir grape must, added with sulfur dioxide (60 mg L⁻¹) and inoculated with 10⁶ cells mL⁻¹ of *H. uvarum* Yun268 and 10⁶ cells mL⁻¹ of *S. cerevisiae* RV002 contained 380 µg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* RV002) contained 261 µg L⁻¹.

Li *et al.*, 2024 – Grape wine produced as previously reported contained 59.2 µg L⁻¹; the control contained 57.8 µg L⁻¹.

Mestre *et al.*, 2019 – Grape wine produced as previously reported contained 872 µg L⁻¹; the control contained 369 µg L⁻¹.

Tristezza *et al.*, 2016 – Grape wine produced at 20 °C in industrial vinification, inoculating 7 tons of Negroamaro must, added with 20 g hL⁻¹ of potassium metabisulfite, with 10⁷ cells mL⁻¹ of *H. uvarum* ITEM8795 and 10⁵ cells mL⁻¹ of *S. cerevisiae* ITEM6920, contained 661 µg L⁻¹; the control (inoculated with *S. cerevisiae* ITEM6920) contained 476 µg L⁻¹.

Final commentary: ethyl octanoate – the more, the merrier.

2.12. β-Damascenone

For β-damascenone, at least two different descriptors have been reported: “honey” (Tarko & Duda, 2024) and “sweet, exotic flowers, stewed” (Pineau *et al.*, 2007); its odour threshold is 0.05 µg L⁻¹ (Guth, 1997; Langen *et al.*, 2016). Some strains of *Hanseniaspora* have been reported to produce β-damascenone exceeding the odour threshold,

thereby positively contributing to the sensory quality of the wine.

Badura *et al.*, 2023 – Grape wine produced at 22 °C from pasteurised Gewürztraminer grape must inoculated with: a) 10⁷ cells mL⁻¹ of *H. osmophila* NRRL-Y1613 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.7 µg L⁻¹; b) 10⁷ cells mL⁻¹ of *H. opuntiae* GYBC-284 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.69 µg L⁻¹; c) 10⁷ cells mL⁻¹ of *H. occidentalis* GYBC-211 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.64 µg L⁻¹; d) 10⁷ cells mL⁻¹ of *H. nectarophila* GYBC-283 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.61 µg L⁻¹; e) 10⁷ cells mL⁻¹ of *H. guilliermondii* NRRL-Y1625 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.56 µg L⁻¹; f) 10⁷ cells mL⁻¹ of *H. uvarum* DSM2768 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.55 µg L⁻¹; g) 10⁷ cells mL⁻¹ of *H. meyeri* NRRL-Y27513 and 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG contained 0.53 µg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* Uvaferm CEG) contained 0.46 µg L⁻¹.

Gallo *et al.*, 2024a – Grape wine produced using a mixture of 50 % Glera and 50 % Gewürztraminer grapes, added with sulfur dioxide (15 mg L⁻¹) and inoculated with 5 × 10⁶ cells mL⁻¹ of *H. vineae* Fermivin VINEAE and, after 68 hours, with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Fermivin LVCB contained 2.13 µg L⁻¹; the control (inoculated with 5 × 10⁶ cells mL⁻¹ of *S. cerevisiae* Fermivin LVCB) contained 1.43 µg L⁻¹.

Yan *et al.*, 2020 – Grape wine produced as previously reported contained 8.38 µg L⁻¹; the control contained 8.11 µg L⁻¹.

Zhang *et al.*, 2018 – Icewine produced at 16 °C from Vidal blanc grape juice, added with sulfur dioxide (80 mg L⁻¹) and inoculated with 10⁷ cells mL⁻¹ of *H. vineae* CVE-HV11 and, after two days, with 10⁶ cells mL⁻¹ of *S. cerevisiae* CVE-SC45 contained 101.7 µg L⁻¹; the control (inoculated with 10⁶ cells mL⁻¹ of *S. cerevisiae* CVE-SC45) contained 48.1 µg L⁻¹.

Zhang *et al.*, 2022 – Grape wine produced as previously reported contained 11.51 µg L⁻¹; the control contained 9.87 µg L⁻¹.

Final commentary: β-damascenone – the more, the merrier.

CONCLUDING REMARKS

Among the many recent reviews (Padilla *et al.*, 2016; Varela, 2016; Martin *et al.*, 2018; Morata *et al.*, 2020; Tufariello *et al.*, 2021; van Wyk *et al.*, 2024; Wang *et al.*, 2024) exploring the contribution of yeast to wine aroma, this minireview highlights the relationship between the application *Hanseniaspora* yeasts in winemaking and the quality of the wine by considering the odour thresholds of the produced compounds (Figure 1).

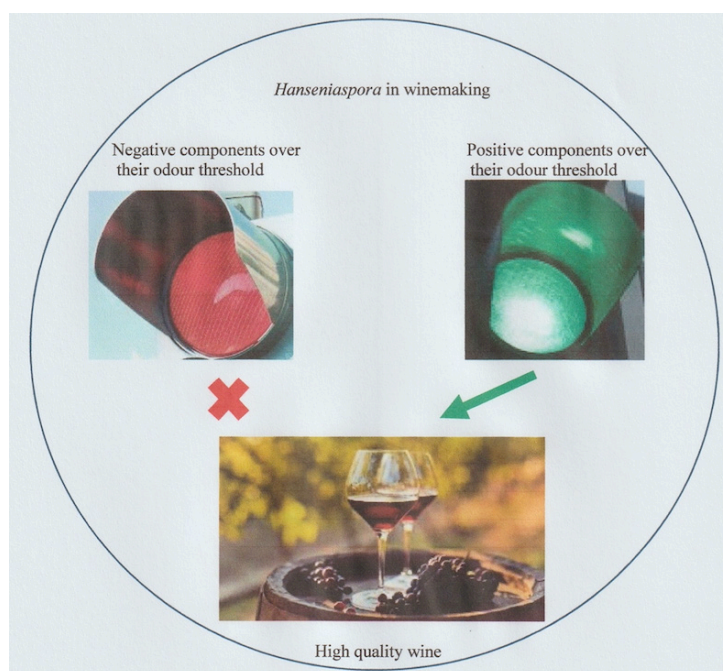


FIGURE 1. Graphical abstract image.

TABLE 1. Negative wine components reported in decreasing order of odour threshold.

Component	Aromatic descriptors	Odour threshold	Reference
Acetic acid	Vinegar	700 mg l ⁻¹	Carrau et al., 2023
Ethyl acetate	Spoilage character	150–200 mg l ⁻¹	Viana et al., 2008
Acetoin	Butter, creamy, fat	150 mg l ⁻¹	Carrau et al., 2023
Isobutanol	Bitter, chemical alcoholic, fusel oil, malt notes, nail polish, solvent, wineosity notes	40 mg l ⁻¹	Guth, 1997; Testa et al., 2021; Carrau et al., 2023; Tarko & Duda, 2024
1-Hexanol	Grass, green, herbaceous, woody	1.1 mg l ⁻¹	Peinado et al., 2004
Decanoic acid	Fatty, rancid, unpleasant	1 mg l ⁻¹	Carrau et al., 2023
Octanoic acid	Cheese, fatty acid, harsh, rancid, sweet	0.5 mg l ⁻¹	Carrau et al., 2023
Hexanoic acid	Acid rancid, baked potato, cheese, fatty, rancid, sweet	0.42 mg l ⁻¹	Carrau et al., 2023

TABLE 2. Positive wine components reported in decreasing order of odour threshold.

Component	Aromatic descriptors	Odour threshold	Reference
Isoamyl alcohol	Alcoholic, banana, cheese, fermented, fruity, sweet, whiskey	30 mg l ⁻¹	Guth, 1997; Bartowsky & Pretorius, 2009; Chen et al., 2015
2-Phenylethanol	Floral, flowery, honey, perfumed, pollen, roses, spicy	14 mg l ⁻¹	Carrau et al., 2023
Hexyl acetate	Apple, cherry, floral, pear	0.67 mg l ⁻¹	Peinado et al., 2004
2-Phenylethyl acetate	Floral, fruity, honey	0.25 mg l ⁻¹	Carrau et al., 2023
Ethyl decanoate	Fatty, floral, fruity, pleasant, sweet	0.2 mg l ⁻¹	Ferreira et al., 2000
Isoamyl acetate	Banana, fruity, sweet	0.16 mg l ⁻¹	Peinado et al., 2004
Ethyl butyrate	Apple, fruity, strawberry	0.02 mg l ⁻¹	Guth, 1997; Peng et al., 2013
β-Citronellol	Citric, green lemon	18 µg l ⁻¹	Čuš & Jenko, 2013
Linalool	Citrus, floral, flowery, fruit, grape-like, lemon, Muscat, sweet	15 µg l ⁻¹	Peinado et al., 2004
Ethyl hexanoate	Anise, apple, fruity, pineapple	14 µg l ⁻¹	Ferreira et al., 2000
Ethyl octanoate	Fruity/fresh, pear, pineapple	5 µg l ⁻¹	Ferreira et al., 2000
β-Damascenone	Exotic flowers, honey, stewed, sweet	0.05 µg l ⁻¹	Guth, 1997

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